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**PROCEEDINGS
OF THE
TWENTIETH ANNUAL SYMPOSIUM ON
SEA TURTLE
BIOLOGY AND CONSERVATION**

29 February through 4 March 2000
Orlando, Florida, U.S.A.

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PREFACE

The 20th Annual Symposium on Sea Turtle Biology and Conservation was held between 29 February and 4 March 2000 in Orlando, Florida, USA, and was hosted by the Sea Turtle Protection Program of the Florida Fish and Wildlife Conservation Commission. The Symposium was, in a word... humbling. It was the largest of the annual sea turtle symposia to date and it was also the largest and most diverse gathering of “sea turtle folks” ever; 960 people attended and 67 countries were represented by active participants.

This proceedings records the essence of the many excellent oral and poster presentations made at the symposium, but a great deal more transpired that cannot be adequately captured in this volume. This list of specific events serves to congratulate the sponsors and volunteers who made the events happen and to help the reader in identifying organizers who could provide additional event information.

- The Seventh Annual Meeting of Latin American Sea Turtle Specialists was held at Camp Challenge, Florida, 25-28 February, and was organized by Hedelvy Guada, Lesbia Montero, and Hector Horta.

- There was a one-day special session on the biology of the loggerhead sea turtle. The session brought together invited experts on loggerhead biology and status and will result in a book entitled “Biology and Conservation of the Loggerhead Sea Turtle,” edited by session organizers, Alan Bolten and Blair Witherington, and published by Smithsonian Institution Press.

- There were workshops held on the physical monitoring of beach nourishment sites, sea turtle anatomy, nest predation mitigation, light management on nesting beaches, Florida sea turtle permit-holder issues, and population modeling (both beginning and advanced), in addition to a colloquium on the taxonomic status of the black turtle. Reports from many of these events were presented in the Marine Turtle Newsletter.

- The symposium banquet featured a retrospective on sea turtle biology and conservation and on the ontogeny of the Symposium. Peter Pritchard reminisced insightfully on the early years when pivotal events were occurring and when only a handful of people worked to understand and conserve sea turtles, and Lew Ehrhart presented a delightful and detailed 20-year walk down Workshop/Symposium memory lane. Also at the banquet, Anders Rhodin presented the Archie Carr Best Student Presentation Awards, co-sponsored jointly by the Sea Turtle Symposium and

Chelonian Research Foundation. Winners chosen by the Student Awards Committee from a field of 90 student presentations were: Best Biology Paper, Jeffrey Semonoff (Wildlife and Fisheries Science, University of Arizona); Runner Up Biology Paper, Melissa Snover (Duke University Marine Laboratory); Runner Up Biology Paper, Barbara Bell (Dept. of Bioscience, Drexel University); Best Biology Poster, Patricia Sposata (Dept. of Biology, Florida Atlantic University); Runner Up Biology Poster, Dana L. Drake (Dept. of Bioscience, Drexel University); Best Conservation Paper, Lori Lucas (Florida Institute of Technology); Best Conservation Poster, William Irwin (Dept. of Biology, University of North Carolina); and Runner Up Conservation Poster, John Wang (Dept. of Biology, University of North Carolina).

- As in other years, there were productive meetings of WIDECAST (organized by Karen Eckert) and of the IUCN Marine Turtle Specialists Group (organized by Alberto Abreu Grobois and Marydele Donnelly).

- A field trip to the Archie Carr National Wildlife Refuge allowed more than 100 people to visit the nesting beach, tour the maritime hammock, and observe the tangle-netting techniques of Lew Ehrhart (who caught five turtles the morning after delivering a late-night banquet address three hours away). The trip was organized by Paul Tritaik and Blair Witherington.

- The Symposium plenary session was well attended. At the session, 10 resolutions, dealing with issues of sea turtle conservation and that had benefitted from the facilitating prowess of Jack Frazier, each passed by a majority vote of the Symposium body. The resolutions were translated for submission to the appropriate international offices and organizations and were published in the Marine Turtle Newsletter.

- A Saturday-night social event was held at the Chelonian Research Institute and was hosted by Peter Pritchard. Socializers experienced an outstanding display of chelonian diversity and bibliography presented in an eclectic old-world style.

As in past years, the Symposium ran amazingly well on generous grants, borrowed equipment, volunteers, and an overall spirit of altruism that is surely uncommon to endeavors of this kind. As many may know, the cost to Symposium attendees is kept as low as possible in order to attract a broad and diverse attendance. Here is how we do it:

- Travel to the symposium for 123 participants, representing 51 countries, was funded by generous grants from the David and Lucile Packard Foundation and from the National Marine Fisheries Service, Office of Protected Resources. Special thanks go to Jack Frazier and Barbara Schroeder for fund-raising efforts and to J. Nichols and the travel committee for strategically disbursing the funding. Details can be found in J's report in the Marine Turtle Newsletter.

- Simultaneous translation (English-Spanish, and for three presentations, French to English & Spanish) was an important, and expensive, facet of the Symposium. Translation expense was offset in part by grants from the Disney Wildlife Conservation Fund and from Boeing Corporation.

- Symposium sustenance was subsidized as well by a generous poster-lunch donation from the Brevard County Sea Turtle Preservation Society and by coffee-break donations from Service Argos, Ripley Entertainment, Florida Power and Light Company, Ecological Associates, D.B. Ecological Services, Caribbean Conservation Corporation, Turtle Time, and Disney's Living Seas Aquarium.

- The audio/visual and computer requirements for the Symposium were heavily subsidized by equipment procured by begging, totaling approximately \$16,380 in rental value.

- USFWS provided some additional funding for compilation of the published Symposium proceedings.

- And perhaps the greatest support for the Symposium was all the people who focused their expertise and hard work on the task.

It was a greatly rewarding experience to preside over this Symposium. My hope is that the rest of the Executive Committee, the Board of Directors, elected officers, and all Symposium participants are as delighted as I am with the quality of presentations and the productivity of communication, and that they share my pride in the heroic efforts that brought the Symposium to fruition.

Blair Witherington, 2000 Symposium President

Andrea Mosier, Allen Foley, and Beth Brost, 2000 Symposium Proceedings Compilers

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A Century of Sea Turtles

ARCHIE CARR, III

Good evening. My name is Archie Carr. More precisely, I am Archie Carr, III. I am the eldest son of Archie Carr, Jr., the famous sea turtle biologist and conservationist. Being among you tonight is a great honor, and I find it impressive indeed, and very encouraging, to see such a large and diverse gathering of sea turtle specialists. But, hastily, I want to confess to you that I myself am not a turtle person. At least not in any exclusive or remarkable way. Most of you are far more involved with sea turtles, professionally or academically, than I am; and so it is with humility, and great respect, that I stand before you tonight.

Of course, by inheritance, I have always respected turtle people. It comes as an unbidden emotion. My father, and the early heroes of my childhood, were turtle people. Some were biologists. But some were coastal dwellers. Fishermen. Turtle hunters- or poachers, as we would say today. Unsophisticated people of the shore; simple, yet able to convey such intimate insights about turtles and the natural world that today, at the age of 54, I am never certain that what I may know about a given subject in turtle biology is science or ancient lore. I garnered a lot of folklore hunched before kerosene lamps on rainy nights in thatched shacks near the beaches of Tortuguero, Costa Rica.

I am a turtle man by association. I'm glad to be associated with you tonight.

The theme of this Twentieth Annual Sea Turtle Symposium has been declared to be "Generation." In a brochure announcing this gathering, Blair Witherington, appropriately notes and applauds the longevity of the event, the symposium, itself. After two decades of gatherings, it is indeed possible to talk about generations and transitions and origins and destinations. I think that is why I was asked to take some your time this evening. To do some reflecting... on my father, inevitably, I suppose, but more to the point, on the progress of sea turtle science and conservation.

Although I dare not claim to be a sea turtle specialist, I can say this: I was there at the beginning. In 1956, when I was 11 years old, I accompanied my father on his second visit ever to the now fabled Tortuguero Beach in Costa Rica. My family was living in the country then, while my father taught biology at the University of Costa Rica.

My father was trying to improve the logistics for the brand new research program on the beach. He had been to Tortuguero once before, and had convinced himself that the beach was, in fact, the motherlode of green turtle nesting. The story of his Caribbean-wide search for this beach, was written in his book, *The Windward Road*, published for the first time in January, 1956. It was later in that same year that I went with him, back to Tortuguero. He was doing advance work for the second turtle tagging season, checking into housing, food and the availability of field assistants.

To launch the first turtle tagging season, in 1955, Archie had asked a remarkable man by the name of Leonard Giovanolli to go to Tortuguero. He was the pioneer on the beach. I knew Leonard well. He taught me how to play the guitar in the key of "C." My brothers and sister called him "Uncle Jo." He was an old acquaintance of my parents, and taught biology for a while at the University of Florida.

The research technique envisioned for the nesting turtles at Tortuguero was to catch the females on the beach, take certain measurements from them, affix numbered tags to the specimens, and release them. The basic procedure is called "mark and recapture." The hope was that if turtles in far away waters captured the marked turtles, the tags would be returned to the scientists with information about the location of capture. In this way, migratory patterns of the nesting colony would gradually come to light.

I'm sure that most of you are familiar with these basic procedures, and, by now, 45 years after it all began, you are aware of the results. You have seen the maps of migratory routes of marine turtles in the Caribbean, and elsewhere. In fact, there being generations of turtle people here tonight- many of you have employed these same methods yourselves on beaches all over the world.

In those days, the tags that Leonard Giovanolli used, the first generation of turtle tags, were oval discs. They were made of a salt-tolerant metal alloy, of course, and they were secured to the terminal scutes of the carapace with stainless steel wire. It was necessary to turn the turtle over, drill holes through the edge of the carapace, pass the wire through the holes and firmly bind the tag to the shell. The tag was inscribed with the now customary numbers and return addresses.

Fortunately, within a year, my father came upon the monel metal cow ear tag, and made a breakthrough in turtle mark and recapture techniques at Tortuguero. The cow's ear and the turtle's fin are sufficiently similar appendages, both being flat and relatively un-eneruated, that the conventional cow ear tag was pre-adapted for use on the turtle. The cow ear tag remains in use today, although numerous other marking devices are available to modern sea turtle biologists. Perhaps there will be further discussion of the relative merits of these tags during the course of this symposium.

But, with all the steps involved in the original technique used by Leonard Giovanolli, the manipulating of the turtle in the dark, often hampered by rain; the drilling of the shell; the threading of springy wire through sand-clogged holes; the measuring of the carapace in the light of a dim flashlight; and of course the careful taking of notes- all of that is made almost improbable when you realize that Giovanolli had only one leg! Yes, it's true. He walked for miles with crutches that plunged into soft, yielding volcanic sand of

Tortuguero. And then he confronted the big green turtles and flipped them over. And then he proceeded to drill the shell and secure the metal oval tags.

Leonard was a pioneer. The first of the turtle taggers at Tortuguero. And, owing to his disability, I can't imagine that anyone has had a tougher time of it in all the years since 1955. So, I say to those of the modern generation, when the beach seems long, and the rain unrelenting; when the rewards of turtle study seem remote and of little consequence as compared to the misery of the moment, remember the strength, grace and determination of Leonard Giovanoli, the first of the turtle taggers, and be encouraged.

Almost every detail of the natural history of sea turtles interested my father. He once explained to me that he became captivated by sea turtle biology during the demanding preparation of his manual, *The Handbook of Turtles*, a taxonomy of the turtles of the New World, published in 1952. It occurred to him that, of all the chelonians, the sea turtles were possibly the most mysterious and intellectually challenging, if only by virtue of the fact that they were out of sight on the high seas for so much of their life histories. Large vertebrates, often abundant, about which science knew very, very little in the early 1950's. So, from that point onward, Archie dedicated the majority of his scientific and literary energies to the marine turtles.

One of the great challenges was what he called the "lost year" mystery. I am going to tell you a story related to the lost year in a moment. The mystery was that after a baby turtle hatched from its sandy nest and left the natal beach, it was not seen again by coastal observers until it had grown to considerable size; until it had become "dinner-plate size," as my father was fond of saying.

Dinner-plate size is a remarkably accurate measure for the smallest green turtles you might encounter on a grass flat. Turtles of this dimension are assumed to be the newest recruits to the grazing schools. Prior to their appearance on the grass flats, they have spent some period of time—as much as three or four or more years, we now believe—in a pelagic habitat, the sargassum weed lines, adrift in the world's oceans. They are carnivorous during this period, becoming herbivorous by the time they are dinner plate sized, and join the adult turtles on the pastures of sea grass, like *Thalassia testudinum*. Perhaps some of you will be able to join Dr. Lew Ehrhart for a field trip on the Indian River Lagoon after this symposium. Lew can show you dinner-plate sized turtles in abundance.

"Dinner plate" is a quaint, if accurate, unit of measure, I've always thought. But, knowing my father, I always worried about the possibility of a double entendre. You see, in the early days, he loved to eat green turtles. He learned to make clear turtle soup, laced with sherry wine in the classic British way, that would have made Winston Churchill salivate. He would commission cooks in Caribbean towns to prepare gelatinous turtle fins for him in

various exotic, and tasty, stews. And so, I was always suspicious that the sight of a dinner-plate sized green turtle evoked in him a culinary appraisal of the young, gleaming, succulent looking reptile.

The lost year begins with a heroic night. The hatchling turtles hurtle down the beach toward the sea, almost always in the dark of night, and enter the boundless ocean. They paddle into the darkness, and in doing so, pose another question in animal behavior: Is their progress through the sea random, or are they navigating, following a discernable course? Do they encounter the distant, floating rafts of sargassum by accident, or do they follow courses that lead them positively out to sea, out to where flotsam and jetsam of suitable make-up are likely to be found?

Open sea navigation by sea turtles intrigued my father perhaps more than any other aspect of the biology of these ancient animals. He designed several experiments to investigate the seamanship of adult turtles, and I will mention some of them in awhile. To examine the capabilities of the hatchling turtles at the beginning of the lost year, Archie gave encouragement to a young woman named Jane Frick. Jane would be with us tonight, I'm sure, had she not died at far too young an age. I think those of us who knew her would agree that it is good and proper to remember her tonight, this evening of "generation" at the sea turtle symposium.

You may have read of Jane Frick's work. She had what my father called an "athletic" research technique. Off the island of Bermuda, where she would take tiny hatchling green turtles from Costa Rica, Jane would swim with fins and a snorkel for hours, for miles, behind a turtle, tracking it. A skiff would follow her, taking periodic bearings from the retreating island. Of course, the plots of the bearings of the swimming turtles turned out to be straight lines, confirming the capability to navigate. But if you follow a straight line for three to four hours away from Bermuda, even at the not-too-slow pace of a hatchling turtle, you find yourself on the way to Europe or South Carolina. Jane said she knew the ways of sharks and the deep blue sea, and was unperturbed. She swam on and on.

One season at Tortuguero I had the opportunity to join forces with this bold and energetic woman. It was in September, a time when the notorious rainy season of the Caribbean coast has passed, a time when some adult turtles are still nesting, but late enough for the first of the season's hatchlings to be emerging as well.

What Jane Frick and I wanted to do was to repeat her Bermuda observations, and try to replicate her findings here on the natal beach of the turtles, Tortuguero. The first challenge was to persuade Jane not to go swimming after the hatchlings. Not at Tortuguero. The place is shark infested. It seems to me that the sharks concentrate off the nesting beach during the season. Hammerheads and bull sharks, and perhaps other species. During the course of a season at Tortuguero, you will encounter numerous wounded green turtles, their flipperless stubs testimony to the toothy

predators out there, beyond the tumultuous surf.

We modified Jane's procedures. We decided to follow hatchling turtles in a small aluminum skiff with an outboard motor, and just hope that our observation platform would not be too great a disturbance to the turtle. We had to try! The weather was perfect. The hatchlings were available. And we were there. We just had to try.

During the night, we walked the beach and encountered a clutch of hatchling turtles. As you probably know, there are about 100 eggs in a green turtle nest. The hatchlings emerge from the sand in a frenzied cluster, and race to the sea. What with the machine-like determination of the little animals, and the great flying flippers, to witness such an emergence is to enjoy one of nature's most delightful moments. At Tortuguero, the new turtles emerge only at night; only in the dark. To hatch by daylight is to run the risk of getting cooked to death on the black, volcanic sand, or, even more likely, to get eaten by birds or fish...as we were soon to confirm.

We collected about 20 hatchling turtles and put them in a bucket with a little sand.

Dawn found the weather still clear. The sun was rising over the sea, making illuminated castles of the clouds on the horizon. The calm weather was crucial to us in our 12 foot skiff as we left the dock of the Green Turtle Station, the research facility of the Caribbean Conservation Corporation-the CCC. The CCC was formed back in the 50's to support the research at Tortuguero, and it is still there. We will here numerous reports sponsored by the CCC during this symposium.

To get to sea, Jane and I had to negotiate the nearby river mouth, a dangerous, tormented place during the stormy rainy season, just passed. But, we glided through without mishap; in fact enjoying the sweet air of morning immensely. Passing through the river mouth, we cruised a half mile back up the beach until we were directly in front of the Station. There, our assistant for the morning, Sheftun Martinez, waited on the beach with the bucket of hatchling turtles. He was to release them on a signal from us.

There was almost no surf at all. Only a regular lapping at the sand at Sheftun's feet. Because it was quiet, the water was also very clear. We would be able to see the experimental turtles with ease. We shouted to Sheftun, and he turned all 20 hatchlings out onto the sand, a meter or so from the water. We could see them right themselves, pause and glance about, orienting themselves, we supposed, and then flapping rapidly the short distance to the water.

The turtles fanned out from their point of departure. As they came through the low swell of the surf line, they became distributed along a front, perhaps 60 or 70 meters across. We could see their little black bodies plainly, even at a distance. They stood out vividly in the otherwise glassy water.

But we were not the only observers on that beautiful morning.

Somewhere, very, very high in the sky there were

frigate birds. We did not see them upon our arrival off the beach. There was nothing there but Sheftun, the quiet water, the bucket of turtles and ourselves. The frigates came from nowhere. From the ionosphere, perhaps. They tumbled out of the sky like black and broken kites, and they descended upon the phalanx of swimming turtles.

There were about six of the long-winged, elegant birds, some with handsome white bibs. Avidly, they plucked the little turtles out of the sea.

Shocked as I was, I was nonetheless able to perceive that the actual kill was an incongruously delicate act. The bird careens down from the heights, zigging and zagging in a vertical plane, and then, just as it reaches the surface, the plunge is arrested, the head dips, the long beak, with its terminal hook, probes downward like a surgeon with a pair of forceps, and the baby turtle is snatched up...flapping wildly, of course.

Jane and I were speechless for a short while. Sheftun, on the beach, raised his hands in mute horror. The frigates caught all of the baby turtles. Pluck, pluck, pluck, pluck, they did their graceful and deadly ballet over the quiet sea.

Finally, in an explosion of pent up emotion, Jane and I began to yell, wave our hands and paddles, and beat the metal boat. The frigates retreated upward. We looked about. All was quiet. No turtles to the south. I glanced the other way. A motion caught my eye right near the boat. A hatchling! The only survivor. Perhaps because he had been so close to us, the frigates had shied away from snatching this last of the 20 turtles.

I called out to Jane, and we quickly collected ourselves, and tried to reorganize our scientific expedition.

But my tale of turtle terror is not over.

With the motor running, we fell in behind the hatchling, perhaps 10 meters astern. Even at idle speed, there was a chance of over running the little animal, so I had to keep it in sight and switch the engine into and out of gear continuously. Jane held a small magnetic compass, a stop watch and her note book. She wore a big straw hat, anticipating a glaring sun as the morning wore on.

The immediate course set by the turtle was one perfectly perpendicular to the shore. Easterly, into the new morning. Assisting us in our own unfolding challenge in coastal piloting was Turtle Mountain. You may have heard about it. The fortunate among you have even seen it, climbed to the top and gazed over the turtle beach and the closed-canopy forest of the Tortuguero National Park. The 100 m high knob is a volcanic relic. It is very distinctive on that coast, the only such protrusion near the beach between southern Costa Rica and El Bluff in Nicaragua. The hill is domed and dark with rainforest trees, and often resonates with the calls of howler monkeys. The saying goes on the beach that Turtle Mountain serves as a navigational aid to migrating sea turtles.

I hesitate to concur, but I think all navigators, regardless of their phylogeny, are inclined to exploit every iota of environmental information that might give direction

and purpose to their current endeavors. Where am I? Where should I go? These questions follow us wherever we may navigate on the sea of life, and we need all the help we can get.

Turtle Mountain was high enough to help me pilot the little boat. It was reassuring to glance back and collect an informal bearing off the mountain, and know we were not wandering in the Caribbean Sea.

Jane and I settled into a routine. We grumbled and marveled at the sudden and complete efficiency of the frigate bird attack on the hatchling turtles. And Jane collected data.

The little turtle would dive about a meter beneath the surface and swim for about a minute, as best I recall. The water was so clear that we could see him level off at depth and swim ahead. Upon surfacing, there was a slight hesitation, a glancing about, the little black head with its white chin rotating, evidently checking the sky. Then another dive, and off the turtle would go.

This pattern continued without much variation for about 60 minutes. I would guess the little animal was swimming at about 4 mi/hour. A brisk walking speed. Sixty minutes directly seaward at 4 mph. I anxiously checked the horizon for squalls, rechecked the fuel tanks, listened for hiccups in the tune of the little motor, and was happy we had two paddles in the boat. To be adrift at sea in a small craft is one of the nightmares of my existence.

Back toward land, the beach had now vanished from sight. The top of Turtle Mountain was still there, but shrinking rapidly. The turtle maintained a beeline navigational track. Was the turtle using the mountain as a cue, a guidepost? We saw no indication of it; no looking toward shore. The turtle was not "coastal piloting" in so far as we could tell. But then it occurred to me that the matter of collecting visual cues from the mainland was already dispelled. Standing in the boat, I could see the mountain top easily, but the turtle couldn't. I asked Jane to think of her eyeball at the height of the turtle's head. What would she see of the mainland? Nothing. The turtle had lost this potential cue beneath the horizon some time before. He was navigating by some other means.

It was quite amazing. It is one thing to be impressed by the abstraction of conquering open sea navigation by birds, fish, marine mammals and reptiles-and even the Navy. But to gaze down on the tiny, brave turtle rushing so resolutely across the glistening bosom of the sea is to be reminded of powers and forces that are, and perhaps, out of awe, should remain... mysterious...spiritual.

The hatchling turtle surfaced dead ahead and made his routine scan of the sky. We were gazing downward, but, somehow-perhaps there was a reflection, perhaps a shadow-just as the turtle violently upended to dive deep, we became aware of another frigate bird careening down upon the little reptile. Instinctively, we shrieked and waved at the bird. He pulled up, and the turtle descended safely. The frigate had dived down from far aloft, in the same way that

the other early morning attacks had occurred. He had been watching us with uncanny vision from incredible heights.

In the next five minutes we learned several fascinating, if unexpected, bits of animal behavior. It became a crash course in the comparative intellects of turtles and birds. First, we noted that the turtle had scanned the sky and had perceived an avian predator. He had taken explosive evasive action. Next, we noticed that the turtle had dived deeper than before and did not resurface for a period of about two minutes. Surveying the sky, he submerged again for another prolonged swim. As I recall the turtle doubled his down time following the attack. After a few such prolonged dives, he resumed his original 1 minute diving frequency. Jane and I chattered about all this, analyzing data almost as fast as we collected it.

But, the frigate was not finished. As we stared after the turtle like infatuated scientists, the bird was revising its own hunting methods, changing its entire strategy to one that exploited the rote behavior of the sky-gazing turtle. I happened to glance behind the boat just as the turtle had made another ascent to the surface. As the little beast gazed aloft, the black bird-rapidly becoming a diabolical fiend to Jane and me-had descended to sea level 200 meters astern, and was streaking toward the turtle from his rear, from his blind side.

I confess I almost tipped over the boat. Jane screamed. Again, we both flapped arms and paddles, and we disrupted the attack. The big bird hesitated just enough for the turtle to escape to the depths yet again. But, clearly, the bird, the feathered dinosaur, had out-smarted the turtle.

Shortly thereafter, I announced that the mountain was almost out of sight, and, compass or no compass, I was not taking the tin dinghy further out to sea. We were in the deep, dark blue Caribbean. The frigate bird had disappeared, frustrated by the hatchling turtle's hysterical escort. The turtle was surging on, certain of his mission and course, sure of his quest, having survived the first morning of the lost year.

Jane Frick and I turned about and began our cruise for shore.

One of my father's distinguished graduate students in the final years of his life was Karen Bjorndal. Karen and Allen Bolten have studied the "lost year" of the young sea turtles in great detail. Adrift on the sargassum rafts, the juveniles find shelter from predatory fish and birds, there is food available in the form of small vertebrate and invertebrate sargassum dwellers, and there is transport. The entire mat of algae is always in motion, and, even if it takes years, like a galaxy in space, the raft is going at a measurable speed toward a predictable place. The turtles have evolved to exploit this ephemeral, and unexpected habitat for the first several "lost" years of their lives.

The navigation capabilities of the adult turtles particularly intrigued my father. Investigating the phenomenon inevitably led to all sorts of unheard of challenges in the use of sensitive equipment in arduous

nautical conditions. However, difficult as instrumenting turtles was to prove to be, biologists of 30 and 40 years ago were encouraged by the broad backs of the turtles, and the potential payload they might carry. Consider the frail delicacy of a homing pigeon, another great long distance navigator, and it's plain to see that the turtle might be the preferable alternative when it came to the heavy hauling of primitive radio gear.

My father himself gained the first opportunity to exploit these powerful, open-sea swimmers for a scientific test. A couple of years ago, I wrote about this unusual mission in a letter to *Conservation Biology*. I'd like to read some of that account to you now. It is about trials and tribulations in the history of science. It goes like this:

"One evening 35 years ago, [Archie] came home to announce that he had been granted an electronic "address" on the Nimbus II satellite. Now it would become feasible to track with great accuracy the route of a sea turtle on the high seas.

Nature had set up a perfect experiment with which to distinguish true navigation from random movement for the green turtle, *Chelonia mydas*: Ascension Island to Brazil. Ascension Island, in the South Atlantic, is, in essence, a point on a plane. The beaches of the island are used for egg-laying by turtles who, by then, through tag-and-recapture studies, were known to reside during the inter-nesting period on feeding grounds along the coast of Brazil. The distance from Brazil to Ascension is approximately 1000 miles, and there are no landmarks between the two locations. The navigational challenge is formidable.

Archie was given access to Nimbus II by NASA, no less, and, as you might imagine, the stature of this man rose to even greater heights among his five offspring. And getting to Ascension Island required mysterious interactions with the Pentagon and the United States Air Force. He arranged for passage on an Air Force cargo plane to make the day-long flight over most of the length of the Atlantic. These preparations caused considerable stir and enthusiasm around the household.

In the meanwhile, consultants began designing a radio transmitter, capable of being hauled behind a sea turtle, and sending signals to the Nimbus satellite. A wonderful machine was eventually delivered to Archie. It was metallic and tubular, equipped with an antenna above and a lead keel below. It was even armed with a little propeller that could record speed through the water. Tremendous amounts of data, including the vital location of the test animal, could be streamed to the satellite, and down-loaded to an earth station in the United States. Our daddy had gone hi-tech...

Archie went off to Ascension Island, and after two weeks, returned to home. The island itself was remarkable, he said, and the turtles were gigantic. Many of them weighed 500 pounds; a much larger body size than those of the famous Tortuguero, Costa Rica, population, with which the entire family was familiar.

But, Daddy, Daddy, what about the transmitter? we

cried. What about Nimbus II? Mother gazed at him with alarm growing in her knowing eyes. The radio flooded, Daddy confessed in disgust. We wired it to the turtle. She walked off the beach, into the sea, and the radio filled with water. It crackled and popped. The radio was not water proof. They forgot to make it waterproof!

Daddy's first round with technology had not gone well."

It would be interesting to hear all your opinions on the contributions of technology to sea turtle research. It was difficult going in the beginning, of course, but it is my impression that biotelemetry, for example, notably the use of satellite transmitters, has developed well, and has led to rather fabulous insights into the routes and speeds of adult turtles on the high seas. With partial support from my own organization, the Wildlife Conservation Society, Anne Meylan has recently been able to use satellite transmitters to track adult male green turtles during the nesting season in Central America. The plotted tracks have led to new inferences about the determined, aggressive reproductive behavior of the turtles.

Other high-tech advances for turtle research came in the latter part of the last century with DNA analysis, and the capability it gave us to distinguish between (or lump, as the case may be) various groups or colonies of sea turtles. As you may recall, this was not only helpful to comprehending the basic biology of the turtles, but vital to the issues raised under the umbrella of the CITES convention, the treaty that governs trade in endangered species. With DNA analysis, monitoring of wildlife and wildlife parts, in trade, can be made more precise than the authors ever imagined when the treaty was drafted in 1973.

This new century will see further advances in technological assistance to data collection for sea turtles, I am sure, but I think we can agree that significant, very helpful, breakthroughs were accomplished before the close of the last. Representing a part-time donor agency, I am almost duty-bound to declare that there is plenty of room for improvement in the costs of this hardware. The price of one satellite transmitter is still equivalent to a round-trip airfare and room-and-board for a field season on almost any turtle beach in the world.

As exciting as the potential may be for advanced technologies to boost turtle work, and most other branches of field biology, there's a lot still to recommend the old ways. There is recent news about sea turtle conservation that is positive, at least guardedly so, and it is based on old fashioned, simple techniques: counting turtle tracks on the beach.

My father initiated regular surveying for tracks and nests along the 20 mile-long Tortuguero beach in 1971. Karen Bjorndal and her colleagues reported on 26 years of data obtained from these surveys in a paper appearing in February, 1999, in *Conservation Biology*. With carefully worded qualifications, these authors conclude that the number of green turtles nesting at Tortuguero has increased

slightly but measurably over the decades. Bearing in mind that these are insights into the largest breeding colony in the Atlantic, it is very good news. In the world of sea turtles, it was a wonderful way to end the century, and my father would have been very happy to have heard about it.

I have some questions about that paper that I would like you to think about. Bjorndal *et al.* generously comment as follows: “The upward trend of the population gives encouragement that the stewardship of the Tortuguero green turtle nesting population by the people of Costa Rica has been successful.” That’s true. The beach was made a national park, and the killing of adults and taking of eggs from that beach has been extremely low for many, many years. Off shore, harpooners persistently killed turtles, presumably of both sexes, throughout this time. (By the way, that practice, too, has been brought to a halt thanks to a court ruling in Costa Rica in 1999). The point is, the mortality at Costa Rica was not negligible, yet the numbers of nesting turtles increased.

Meanwhile, another of the participants at this symposium, Dr. Cynthia Lagueux, began monitoring the off-take of green turtles from the feeding grounds in Nicaragua. I’ll ask you to recall that the majority of turtles nesting at Tortuguero spend the years between nesting trips on the grass flats of northeastern Nicaragua. Mortality in Nicaragua is in excess of 10,000 animals per year. It is possible that it has never been greater. Lagueux’s data suggest the mortality rate has already made inroads into the Nicaragua stocks, as seen by, for example, decreasing average sizes of captured turtles, and increasing difficulty in capturing the turtles in the first place.

The killing at Nicaragua may be at historical heights, yet the arrivals at Tortuguero have increased slightly. How is this explained?

Accepting that it is perilous indeed to speculate about the population dynamics of the slow growing, almost invisible creatures, is it possible that the data at Tortuguero are beginning to reflect the conservation commitments of other Caribbean countries aside from Costa Rica – and certainly not Nicaragua? In the absence of international trade in green turtle products, has the taking of green turtles become reduced in what were minor, depleted grazing colonies? Are these colonies beginning to offset the mortality at Nicaragua?

Given that it takes years to see a response to a given management technique for green turtles, is the apparent increase in arrivals at Tortuguero testimony to the success of CITES? You see, in my father’s early days of turtle study, it was the trade, the European and American demand for soup, that plagued the green turtle. Not local consumption. What is happening in Nicaragua is that the overseas markets have been replaced by enormous markets in coastal cities. I do not believe that has been the case elsewhere in the Caribbean. Conservation in the greater Caribbean Basin may be yielding important benefits for green turtle stocks in spite of the mortality in Nicaragua.

It would be useful to continue to analyze the apparent Tortuguero success story. In our world of conservation biology, good news is rare, and it is vital to identify and commend those responsible for it.

In the same paper by Bjorndal and colleagues where improved trends in green turtle arrivals at Tortuguero are reported, the authors mention that hawksbill turtle nesting has declined over the same period.

Same beach, same time, same management scenario. The green turtle thrives; the hawksbill declines. Just as Costa Rica is commended for the healthier green turtle stocks, should Costa Rica be condemned for the lower hawksbill arrivals? No, I don’t think so, and for the same reasons. This species, like the green turtle, is being subjected to “management,” in this case, killing, out there among what CITES calls the “range states.” The hawksbill is a migratory species whose survival requires cooperation among the states with sovereignty over waters making up the range of the species. Costa Rica, and the Tortuguero National Park, can only do so much. If the Caribbean neighbors do not participate in the recuperation efforts for this species, then it can become extinct – at Tortuguero, and elsewhere.

If CITES was helpful to the green turtle by curtailing trade in that species, then why did the same not happen for the hawksbill, a species that was highly endangered at the time of formulation of the CITES treaty? Well, in fact, the trade was altered, reduced in volume and scope, perhaps, but it never ceased. Some of the trade went underground, as they say. It continued illegally. Non-CITES states continued to buy and sell the tortoiseshell product. The most insatiable of all markets, Japan, continued to buy shell until 1992. At that time, Japan agreed to a moratorium on importation. A moratorium means a pause. It carries with it the presumption of resumption of the commerce.

Because the trade did not cease, as was the case for the green turtle, the hawksbill in the Caribbean is worse off now, at the beginning of a new century than when my narrative began, almost a half-century ago.

Meanwhile, among the tortoiseshell “producing” nations here in the New World, after years of reluctance, and with a few aggravating exceptions still lingering, we have seen the range states gradually closing ranks against the Japanese demand. When I was a graduate student, the quantity of shell leaving Panama was measured in tons, for example. That has stopped. Haiti remained for years a favorite interpot for transshipment of shell derived from numerous locations in the Caribbean. I don’t hear so much about that anymore. If it hasn’t stopped, the trade has become more furtive. Yet hawksbill populations remain depressed. There has been no bounce back.

When Japan opted to accept a moratorium on shell buying in 1992, instead of shutting down the tortoiseshell industry altogether, a window was left open. A hope. A chance that the market might one day resume. One state in particular in the Caribbean acted on that possibility.

Hawksbill turtles in Cuba have been slaughtered consistently throughout the years since the moratorium, and the tortoiseshell hoarded, warehoused, until a small mountain of hawksbill scutes has arisen outside of Havana.

We may conclude unhappily that as a measure to restore the abundance of a species, the CITES moratorium on hawksbill trade failed to help. The turtles are dead. Whether the shell is sold or not is another matter. The turtles are already dead. The moratorium failed.

But things could get even worse for the hawksbill. As of this hour, there is a proposal before CITES, to be reviewed in Kenya at the next CITES meeting in April, to allow Cuba to sell this stockpile of tortoiseshell. The proposed recipient is, of course, Japan. There is concern that such action by CITES might lead to resumption of exploitation of hawksbill throughout the Pacific and Atlantic. It is particularly distressing that the Cuban proposal is at odds with the strongest possible recommendations of biologists from throughout the region, who, like my own organization, the Wildlife Conservation Society, are anxious to find ways to assist the Cuban scientific community resolve problems in biological conservation. This becomes difficult in an atmosphere where the principles of conservation biology are flaunted.

I went to Cuba once. It was in 1955. As you might imagine, I was with my father and the rest of the family, looking for turtles. We drove in a new red and white Dodge station wagon. There were a total of six children in the car—five Carr kids and one friend. We crossed from Key West to Havana on the ferry boat, and then drove down one coast to Santiago, and back on the other coast. My father indulged himself in his favorite research technique: Roaming through the central markets of coastal towns and villages, looking for turtles for sale, and all manner of other biota from land and sea. And interviewing fishermen. As you may know, his adventures with this style of inquiry in the nooks and crannies of the Caribbean and other places in the world were the stuff of several books during the course of his life.

Within a short while, such a trip to Cuba by an American scientist and his car load of kids would not be possible. A door was slammed. A neighbor isolated. Archie maintained a meager correspondence with some increasingly lonesome scientists, but the chance to start a robust sea turtle program on that large island vanished in 1959.

I reflect on those years, and those politics, because, had the regional scientific community been able to maintain cohesive, collegial, mutually supportive relations with Cuba, I doubt that the tortoiseshell proposal would be threatening the CITES treaty today. The proposal defies science and reason. There are scientists here tonight, friends to Cuba, who have, during the past few weeks run DNA tests on hawksbill turtles nesting at Tortuguero, Costa Rica. The haplotypes of some of these were the same as for samples taken from Cuban waters. Cuban turtles are Costa Rican turtles. Costa Rican turtles are Cuban turtles. It's a

migratory species, a shared species. No one state has exclusive sovereignty over *Eretmochelys imbricata*, nor the right to impair its survival in our common waters.

I hope the Cubans will set aside their dangerous proposal to CITES. I hope that the entire hemisphere can unite on the mission of saving the hawksbill, allowing it to recover its unique role on the coral reefs of the Caribbean. For the sake of turtles, and for numerous other reasons, I hope that very early in this century the doors to Cuba will reopen, and that scientists from all over will be able to work together freely to address the plight of the hawksbill, and the panoply of other environmental perturbations that cloud our shared horizon.

I would like to close with words written by my father a long time ago. I found some remarks in his first book, *A Handbook of Turtles*, that have to do with turtles, of course, and with time, and change, and its opposite, evolutionary conservatism. They are words about generations—the theme of this convention.

Before I start, let me be sure the younger generations know a certain famous name. Man o' war. I will use the name, Man o' war in this passage, and it is important for you to know that Man o' war was possibly the fastest, most successful American race horse bred in the 20th Century.

Here Archie muses over the origins of turtles, and their destinations. Where they might be going. They are words we might want to carry with us into the new, 21st Century.

“The Cenozoic came, and with it progressive drought, and the turtles joined the great hejira of swamp and forest animals to steppe and prairie, and watched again as the mammals rose to heights of evolutionary frenzy reminiscent of the dinosaurs in their day, and swept across the grasslands in an endless cavalcade of restless, warm-blooded types. Turtles went with them, as tortoises now, with high shells and columnar, elephantine feet, but always making as few compromises as possible with the new environment, for by now their architecture and their philosophy had been proved by the eons; and there is no wonder that they just kept on watching as Eohippus begat Man o' War and a mob of irresponsible and shifty-eyed little shrews swarmed down out of the trees to chip at stones, and fidget around fires, and build atom bombs.”

Ladies and gentlemen, we are those irresponsible, shifty-eyed little shrews in contemporary form. We built the atom bomb. But, before the century was over, we set it aside...almost. We entered a cold war, galvanized by the horror of a global, nuclear holocaust, and we, as a civilization, did not cross that line into devastation, as Archie hints that we might do in his words of 1952. We did that, we saved ourselves, and yet I say to you that we are in as much peril now as we ever were in the 20th Century. This will be the century of the environment. In these next few years, we, the participants in the 20th Sea Turtle Symposium, and conservation biologists like us, will hold the fate of civilization, in our hands...and in our minds. Unlike the Cold War, it is not a wrong decision, or an aggressive act,

that will spell our doom. It is our inaction that will spell our doom. The agents of destruction are in motion now. We can see that in our turtles, in the appearance of mysterious cancers, or fibropapillomas, on their bodies, derived from what was the benign sea; the very crucible of life. The turtles provide us with windows into the health of the oceans, and we already know the view through those windows is murky with biospheric danger.

This is our century. We are the conservation biologists, and this is our time, our unique opportunity to serve mankind and the natural world we love. It is a time for a new, very forceful generation of turtle people, and their allies in related fields, to use their knowledge and passion to alter the status quo of world environmental degradation. Otherwise, this will become our last century. Otherwise there will not be another chance to save our place to live.

Green Sea Turtles (*Chelonia mydas*) in a South Texas (USA) Developmental Habitat

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Green sea turtles (*Chelonia mydas*) were commercially exploited in Texas waters during the mid-to-late 1800's. Today, south Texas waters serve as important developmental habitat for this species. Relatively few studies have been undertaken of green turtles in Texas waters. Furthermore, knowledge of green turtles in developmental habitats is limited, but has been growing through the use of directed capture studies. Entanglement netting was used to capture green turtles at the Mansfield Channel jetties, located in south Texas, on at least one day per month, year-round, from June 1989 to December 1997. Two hundred fifty-eight juvenile green turtles (n = 383

captures) were netted during 1,149 hours of netting effort. The overall catch-per-unit-effort of 3.63 turtles/km-hour was higher than recorded during other similar green turtle studies conducted elsewhere during recent years. To date, this has been the only long-term, directed capture study of green turtles in Texas. Final results of this study will be presented. Results will be compared to data collected by the Sea Turtle Stranding and Salvage Network for 471 green turtles found stranded in Texas from 1989 to 1997. Information on the sizes, sex ratios, seasonal trends, and yearly trends of green turtles sampled using the two methods will be presented and compared.

Morocco and Western Sahara: Sites of an Early Neritic Stage in the Life History of Loggerheads?

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The coastline of Morocco and Western Sahara was surveyed in July 1999 to determine the status of sea turtles in this region. Turtles encountered were measured and tissue samples were collected for mtDNA analyses. No evidence of nesting was found; only carcasses stranded on the beach and carapaces with fishermen and at museums were seen during the survey. The size distribution of the turtles suggests that they were juveniles in transition between the oceanic and the neritic stages. Preliminary genetic analyses indicate that the predominant haplotypes in the Atlantic are well represented in the region. The findings of this study, the presence of a large fishing

industry, and the absence of laws protecting sea turtles in this region emphasize the need to formulate a conservation plan for sea turtles in Morocco and Western Sahara.

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Origin of Juvenile Loggerhead Turtles (*Caretta caretta*) in Developmental Habitat in Caribbean Panamá

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INTRODUCTION

The migratory lifestyle and temporally protracted life history of marine turtles present difficulties for the effective conservation and management of these species (Carr *et al.*, 1978; Bowen and Avise, 1995). All sea turtles

examined to date show a pattern of strong population subdivision in mitochondrial DNA (mtDNA), indicating that genetic exchange among nesting populations is rare (reviewed in Bowen and Karl, 1997). Despite subdivision of populations on the nesting beaches, extensive migration of post-hatchling, juvenile and adult turtles provides

opportunity for these reproductively isolated genetic stocks to mix in foraging habitats (Carr *et al.*, 1978; Bowen and Karl, 1997). This mixing makes it difficult to assess how exploitation of turtles on feeding grounds will affect reproductive populations.

Differences in mtDNA haplotype frequencies among nesting populations provide genetic markers that have proven to be powerful tools for the identification of the natal origin of turtles captured away from the nesting beach (reviewed by Bowen and Karl, 1997). Maximum likelihood-based techniques of mixed stock analysis (MSA) (Pella and Milner, 1987) are now widely applied in the estimation of nesting beach contributions in marine turtle feeding grounds (reviewed in Bowen and Karl, 1997). Such information has provided valuable insights into migration, dispersal, and recruitment of juvenile turtles, and is of particular conservation interest because incidental and direct take on feeding grounds have the potential to affect many widespread reproductive populations (Bowen and Karl, 1997).

In the present study we sequenced the mtDNA control region from 45 immature loggerhead turtles (*Caretta caretta*) captured in developmental habitat in Chiriquí Lagoon, Panamá, and use these data to estimate the contribution of Atlantic Ocean stocks identified by Encalada *et al.* (1998) to this feeding aggregation. The questions of migration and settlement patterns of immature loggerhead turtles are relevant to their conservation because the ongoing subsistence fishery for marine turtles in Chiriquí Lagoon has the potential to reduce nesting populations elsewhere in the Atlantic. If recruitment is biased toward small, local populations, then even a small fishery such as the one in Chiriquí Lagoon may disproportionately affect demographically vulnerable, nesting populations.

METHODS

Chiriquí Lagoon is located on the Caribbean coast of Panamá in Bocas del Toro Province, at 09° 00' N, 81° 50' W. The Lagoon provides developmental habitat for loggerheads, green turtles (*Chelonia mydas*), and hawksbill turtles (*Eretmochelys imbricata*) (Meylan and Meylan, 1997). During May-June of 1993 and 1994, 45 immature loggerhead turtles were captured in Chiriqui Lagoon using tangle nets. Blood samples for genetic analysis were collected from the cervical sinus as described by Owens and Ruiz (1980), and preserved in a lysis buffer. Genomic DNA was isolated from blood samples using standard phenol:chloroform extraction techniques (Hillis *et al.*, 1990), and stored at -20°C.

A ~390 base pair (bp) segment of mtDNA control region was amplified by the polymerase chain reaction (PCR) using the primer pair TCR5, TCR6 (Norman *et al.*, 1994). Standard precautions, including the use of positive

and negative controls, were taken to avoid contamination. PCR products were sequenced at the DNA Sequencing Core Lab at the University of Florida or at the DNA sequencing facility at the University of California, Davis. Sequences were aligned with previously published loggerhead mtDNA CR sequences (Encalada *et al.*, 1998; Bolten *et al.*, 1998). For all sequences showing ambiguity, and for all sequences that did not match a previously published sequence, both forward and reverse strands were sequenced.

Contributions of nesting beaches to the Chiriquí Lagoon feeding population were obtained using three different Mixed Stock Analysis programs, CONSQRT, UCON (Masuda *et al.*, 1991) and SHADRACQ (Xu *et al.*, 1994). Expected nesting beach contributions were calculated from numbers of nesting turtles or nests recorded at each colony (Turtle Expert Working Group, 1999). These expected contributions were compared with estimated contributions using Monte Carlo simulation as implemented in the program Monte Carlo RxC (W. Engles, University of Wisconsin).

RESULTS AND DISCUSSION

We identified seven mtDNA CR haplotypes among the 45 turtles examined. Five of these match haplotypes found on Atlantic nesting beaches (Encalada *et al.*, 1998). A sixth haplotype, L, has not been found on any nesting beach, but was described by Bolten *et al.* (1998) in pelagic habitat in the Northeastern Atlantic Ocean. One additional haplotype, R, which has not been described in any previous study, was found in one individual in Chiriquí Lagoon. Haplotype R differs from the common haplotype B by a G-A transition at nucleotide position 259.

Haplotype frequencies in Chiriqui Lagoon differ significantly from the Atlantic nesting beaches surveyed by Encalada *et al.* (1998), indicating that the Chiriqui Lagoon feeding aggregation is likely to represent a mixture of individuals from at least two different nesting beaches. Estimated nesting population contributions are very similar for the three maximum likelihood programs. Results indicate that approximately 70% of the turtles in Chiriquí Lagoon are from South Florida beaches, and 30% are from Mexico; no other nesting beaches make significant contributions.

In order to test whether factors other than the size of the nesting population are important in determining its contribution to the Chiriquí Lagoon feeding population, we calculated expected nesting beach contributions based on numbers of nests recorded at all major Atlantic nesting beaches (Turtle Expert Working Group, 1998). Contributions estimated by each of the three programs differ significantly from expected values due to the large contribution of Mexican nesting beaches to the Chiriquí Lagoon feeding ground. This pattern of non-random

settlement into developmental habitats seems to be a general phenomenon in loggerhead turtles (Sears *et al.*, 1995).

Demographic models for loggerhead turtles indicate that harvest of just a few hundred large sub-adult individuals from a small population can lead to population decline (Heppell *et al.*, 1996). There is a small but unquantified subsistence turtle fishery in Chiriquí Lagoon. The persistence of small nesting populations in Mexico could be threatened if turtles from this small demographically vulnerable population are concentrated in this and other developmental habitats in the Caribbean where they are subject to harvest in small-scale fisheries. It is possible that other small nesting populations from the Caribbean region (Amorrocho *et al.*, 1999; Carr *et al.*, 1982) for which no genetic data are available are also contributing to Caribbean feeding grounds and would be similarly adversely affected. An important area of future research is the quantification of the level of harvest in Chiriquí Lagoon and other Caribbean developmental habitats and the estimate of the contributions of other poorly known populations to these habitats.

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Current Status of Marine Turtle Conservation Programmes in Sarawak, Malaysia

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The marine turtle management and conservation programme at the Talang-Satang Islands in Sarawak is among the oldest in the world and very complex. Various government agencies are involved and five laws are relevant to turtle conservation in Sarawak. However, the number of marine turtles nesting in Sarawak has declined by 90% in the past 50 years. Various reasons have been put forward for such decline. In view of this, and to ensure that the population of turtles does not decline further, the Sarawak Government has undertaken several major steps such as forming the Talang-Satang Turtle Research Working Group and the Sarawak Reef Balls Project, conducting the extensive scientific studies, gazettement of the turtle nesting beach as Totally Protected Areas and strengthening of existing laws.

EXTENDED ABSTRACT

Four species of sea turtles, the leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and olive ridley (*Lepidochelys olivacea*), nest along the sandy beaches of both East and West Malaysia. Threats to the survival of marine turtles in Malaysia include commercial exploitation, habitat destruction and alteration, accidental catch by fishers, marine debris, and pollution, while protection is often ineffective (Chan, 1991). As a result, leatherback and olive ridley populations in Terengganu are critically depleted and in imminent danger of extinction (Rahman, 1996; Chan and Liew, 1996). Over the last few decades, dramatic declines in population have occurred for all the turtle species found in Malaysia (Chan and Liew, 1995); according to Sharma and Salam (1999), due to the various threats, marine turtle nesting populations in Malaysia have declined by 60 to 99% since the 1950s.

In Sarawak, Leh (1989) noted that the history of turtle egg collection dates probably to the Sixteenth century when eggs were a barter trade item with China. In the 1950s, the annual number of green turtle eggs collected and sold in the local market was around two million. He also stated that the local residents did not eat turtles, but only their eggs. Banks (1986) wrote that the mean number of eggs exported from 1900-1927 was 300,000 per year. He also summarised the annual take of green turtle eggs from 1927-1985, showing that 1-3 million eggs were collected per year until 1960, roughly 500,000 eggs per year during the 1960s, and less than 300,000 eggs have been collected per year since. He quoted Sarawak Museum data showing that in 1989 and 1990, 185,461 and 117,701 eggs, respectively, were collected, less than 5% of peak yields in the mid-1930s. Chin (1975) showed that 1,194,391 eggs

were collected from the three Turtle Islands from 1971 to 1975.

Six laws are relevant to the turtle conservation in Sarawak. The Turtle Trust Ordinance 1957, Land Code 1958, Turtle Protection Rules 1962, Fisheries Prohibited Areas under section 61 of the Fisheries Act 1985 and Wild Life Protection Ordinance 1958 superceded and improved as the Wild Life Protection Ordinance 1998. Green turtles, hawksbill turtles and leatherback turtles are fully protected by law since 1958.

Four agencies are responsible for marine turtles in Sarawak. The Turtles' Board formed under the Turtle Trust Ordinance 1957 is in charge of the three Turtle Islands (Talang Talang Besar Island, Talang Talang Kechil Island and Satang Besar Island). Its jurisdiction only extends for half a nautical mile from each of the island. The Sarawak Museum has traditionally been responsible for turtle research on the three Turtle Islands as the Director of Sarawak Museum is the Executive Officer of the Turtles' Board. The Marine Fisheries Department is responsible for turtles when they are swimming in the sea, but not on the land as lead out under the Marine Fisheries Act.

Under the Wild Life Protection Ordinance 1998, all marine turtles are totally protected. Section 29(1) stated that any person who hunts, kills, captures, sells, offers for sale, imports, exports, or is in possession of, any totally protected animal or any recognizable parts or derivative thereof, or any nest thereof, except in accordance with the permission in writing of the Controller of Wild Life for scientific or educational purposes or for the protection and conservation of such totally protected animal, is guilty of an offence. The penalty is imprisonment for two years and a fine of twenty five thousand ringgit (US \$6579).

The Sarawak Museum has recorded the number of green turtles landing on each of the three Turtle Islands every year since 1946. Long term research and hatchery management has been conducted by the Sarawak Museum since 1951 yet, the number of marine turtle nesting on the Sarawak Turtle Islands has declined by 90% in the past 50 years. Various reasons have been put forward for such a decline such as: trawling, over harvesting of eggs; coastal development; natural predation; and various environmental causes. However, no detailed long-term scientific studies have been carried out to investigate this problem.

The State Government has long agonized over the problem of Sarawak's dwindling marine turtle population. It recognizes the need for a detailed and extensive scientific and conservation study with comprehensive management applications. In 1995, therefore, the Sarawak Forest Department started its rookery management programme by opening a hatchery at Tanjong Datu National Park.

The various agencies responsible for marine turtle working together on a research programme for the Sarawak Turtle Islands, thus forming the Talang-Satang Turtle Research Working Group (TSTRWG). TSTRWG comprises Sarawak Turtles' Board, Sarawak Museum, Marine Fisheries Department Sarawak and Sarawak Forest Department as the leading agency. This group meets monthly to review research and make management recommendations for marine turtles at the Sarawak Turtle Islands. In addition, the group monitors enforcement of the various laws concerning marine turtles. This is effective because most members are actively in the field conducting research so are able to be the eyes and ears of enforcement.

Since 1996, many research projects started. Collaborative studies with SEATRU Universiti College Terengganu-Universiti Putra Malaysia, were started in 1998. The objective is to determine the population dynamics, and ranging and behaviour of the nesting population of marine turtles in Sarawak, and to identify appropriate conservation measures necessary to enable the natural population to increase back toward former level. Studies are still ongoing and preliminary results are available in our journal "Hornbill".

***IN SITU* AND HATCHERY SUB-PROJECT**

The aim is to obtain the baseline data necessary to design a rookery management plan. The technique used includes double tagging, carapace measurements, incubation temperature measurements, hatchling measurements, timed ecological observations, DNA analysis, computer analysis and recording of nesting locations.

RADIO/ ULTRASONIC SUB-PROJECT

The study aim is to determine the diving patterns and behavior of green turtles during inter-nesting periods. Results will be used to protect marine turtles when they are offshore during nesting seasons.

SATELLITE TRACKING SUB-PROJECT

The study aim is to determine the migratory paths and destination (feeding grounds) of green turtles after nesting seasons. The information will be used as a basis for protection and development of a regional ASEAN marine turtle conservation plan.

The reef balls project was initiated to conserve marine turtles in Sarawak: significant numbers of adult marine turtles were found dead because of trawler nets. The reef balls have sharp textured surface which is capable of ripping trawlers nets. Clusters of reef balls have proven very effective in damaging trawlers nets. Five hundred reef balls have been seeded around the marine turtles nesting season

resting areas. Through radio/ultrasonic study, it was found that the inter-nesting resting areas lies within a kilometer from the mainland. These areas are also the favorite sites for illegal trawling. A number of dead turtles were found washed on the beach, which were suspected to have been caught in trawlers nets. Reef balls were seeded in the inter-nesting site and publicized. Trawlers have avoided these areas and since deployment of the reef balls no dead turtle from these areas have been recorded.

CONCLUSION

Turtle management in Sarawak is complex for historical and legal reasons. Sarawak is tackling this on many fronts, including protection of reserves, improvement of hatcheries management, use of in-situ protection and research on ranging of animals. The Sarawak Turtle Islands were gazetted as Talang-Satang National Park in September 1999. Together, this will allow the turtles to be conserved both around the nesting beaches and also at all other areas within their range.

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Brothers-in-Arms: Working Towards the Survival of the Sipadan Sea Turtles (Sabah, Malaysia)

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Sipadan Island (04°05'N, 118°35'E) is an open-oceanic island which originated from a volcanic atoll. Located on the east coast of North Borneo, it has a land area of approximately 123,000 m² (Universiti Kebangsaan Malaysia, 1990). Sipadan supports a large density of nesting sea turtles, second only to the Turtle Islands Park in Sandakan, in the Malaysian State of Sabah, which is located on the island of Borneo. Turtles are abundant in the clear waters around the island and have been reported to nest on the beach of this island all year round with peak months believed to be between July and December for green turtles, and January through June for hawksbills (Mortimer, 1991). This island is located in a designated Security Zone and is being monitored by the National Security Council of Malaysia.

Sipadan was designated as a bird sanctuary in 1933 under the Land Ordinance of 1930 and a turtle eggs' native reserve in 1964. It is now a world renowned tourist destination mainly for its diving activities where divers are able to observe the relatively tame turtles in their natural habitat. Apart from sea turtles, other underwater attractions include the magnificent hard and soft corals, colorful fish of various shapes and size as well as amazing crustaceans and molluscs. The minute organisms in the water, when carefully observed are just as spectacular.

Sea turtle eggs being deposited on Sipadan shore were collected for many generations by a Bajau family living there. The Sultan of Sulu gave customary rights to the sole resident of the island by virtue of his traditional right as the original occupant of Sipadan since the 1930s to collect these eggs (Universiti Kebangsaan Malaysia, 1990). In recent years, efforts were made by the Game Branch of the Sabah Forestry Department which was later upgraded to the Sabah Wildlife Department in 1988 to monitor and conserve the sea turtle resources of Sipadan.

Records from the department show that from 15 January 1990 a minimum of one nest per night was taken for conservation. If the number of nests exceeded six, then two

nests were left *in situ* and if more than 10 nests were deposited in any one night, the number of nests taken for conservation purposes was three. This system was revamped on 4 November 1993 where all eggs deposited in Sipadan were incubated in natural nests. By this time, the total number of both green and hawksbill turtle nests had reached 642 (Sabah Wildlife Department, unpublished data).

Financial aid to purchase the turtle eggs was provided by three of the five dive resorts operating in Sipadan, namely Borneo Divers & Sea Sports (Sabah) Sdn. Bhd., Pulau Sipadan Resort and Sipadan Dive Centre. A total of RM 50,000.00 (US \$13,200.00) was given each year to the family of the egg collector in lieu of the eggs. Presence of the resorts also helped decrease fish bombing incidents, a widespread destructive fishing method practiced in the vicinity of Semporna.

A total of 4612 nests were incubated in natural nests until March 1997 when it was found that poaching was too serious a problem (Sabah Wildlife Department, unpublished data).

Using funds from the private sector, the Wildlife Department constructed a beach hatchery on the southern tip of the island to transfer all the eggs deposited on the island. The department's tagging program for female turtles coming ashore to nest commenced in 1995, was briefly stopped due to technical reasons and has since resumed to saturate tag all the turtles nesting in Sipadan.

Other agencies that were involved with sea turtle conservation in Sipadan include Universiti Kebangsaan Malaysia (UKM) and World Wildlife Fund Malaysia, or as it is now known, World Wide Fund for Nature Malaysia (WWFM). Several recommendations given by Jeanne Mortimer, during her term as WWFM's sea turtle consultant, in her report (Mortimer, 1991) to the Sabah's Ministry of Tourism and Environmental Development have been adhered to over the years. They include ceasing the harvest of eggs; stopping further development of the island

and decreasing the number of chalets and visitors to the island; proper disposal of rubbish; and minimizing the amount of artificial light from the resorts. Other measures taken by the Sabah Wildlife Department include limiting the hours the tourists are allowed to walk on the beach, carefully monitoring turtle watching activities and ensuring that the turtles are not disturbed by the divers in their natural habitat. The Sabah Fisheries Department and Marine Police, a section of the Royal Malaysian Police, also provide assistance to prevent destructive fishing methods such as fish bombing and cyanide fishing in the vicinity of Sipadan.

Universiti Malaysia Sabah is now working closely with the Sabah Wildlife Department to keep an accurate record of nesting activities as well as to design a management program that will benefit both turtles and human inhabitants of Sipadan. It is hoped that through the concerted efforts of all the agencies involved in preserving the natural resources of this island, the sea turtle population of Sipadan will continue to survive and multiply.

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permission to conduct research in Sipadan; and staff from the Sabah Wildlife Department and Borneo Divers & Sea Sports (Sabah) Sdn. Bhd. for the endless efforts in collecting data on the Sipadan sea turtles. The first author would also like to thank the David and Lucille Packard Foundation for travel assistance and Universiti Malaysia Sabah for travel assistance and permission to present her work at the symposium as well as partial funding and permission to conduct sea turtle research in Sabah. Logistical support in Sipadan provided for the first author by the Sabah Wildlife Department and Borneo Divers & Sea Sports (Sabah) Sdn. Bhd. is gratefully acknowledged. Special thanks also go out to Assoc. Prof. Dr Saleem Mustafa of the Borneo Marine Research Unit, UMS for comments on the draft of this manuscript.

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Approaches for an Integrated Conservation and Development Program in the Philippine Turtle Islands

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In 1996, WWF-Philippines, forged an agreement with the Department of Environment & Natural Resources (DENR) through the Pawikan Conservation Project (PCP) to implement a program through an integrated approach. Since then, WWF-Philippines in collaboration with the PCP has implemented a number of activities towards the realization of this task. An environmental & ecological study was completed. The studies were basis for the formulation of a management plan for protected area declaration and an ecotourism development plan to anticipate effects of future developments. These activities contributed to the enactment of policies for conservation. In August 1999, the Turtle Islands Wildlife Sanctuary was established through Presidential Proclamation No. 171 and DENR Administrative Order 99-31 implementing the Turtle Islands Ecological Destination Development Guidelines was promulgated last July 30, 1999. In the same manner, an intensive social research was undertaken to understand the dynamics of the community for a more active role in conservation. The results of these activities were presented to the community as an imperative process for the formulation of a program for an integrated

conservation and development initiative with emphasis on the active participation of all stakeholders. The framework developed identified four major components for implementation namely: enforcement; livelihood; education and health. Initial activities regarding these components are underway with the support of local authorities. Conservation efforts in the area evolved from a species approach to an integrated and a multi-stakeholder approach. This is regarded as the only alternative to address the long-term conservation needs of the Turtle Islands.

INTRODUCTION

The Turtle Islands have a high conservation value for sea turtles and have been subject to Government control and management since 1948. In 1979, the Government identified the need to establish a specific agency, The Pawikan Conservation Project of the Department of Environment and Natural Resources (DENR), to oversee the conservation of sea turtles in the Philippines. Since 1984, the PCP has been implementing the Government's

efforts to conserve turtles in the Turtle Islands, through regulation of egg collection as well as the management of Baguan Island as a strict sanctuary. Substantial work on sea turtle research has been undertaken by the PCP since its creation. In 1991, the GEF Funded Integrated Protected Area System (IPAS) was initiated. The Turtle Islands was chosen as one of the ten priority sites that would benefit from the project, and the project's final aim is to establish the area as protected area. This project is implemented by the DENR through its established Conservation of Priority Protected Area Project (CPPAP) and its NGO counterpart, the NGOs for Integrated Protected Area Inc (NIPA), mainly mandated to facilitate the establishment of the Turtle Islands under the NIPAS. The first transfrontier protected areas for sea turtles was also established through the Turtle Islands Heritage Protected Area between the Governments of the Philippines and Malaysia.

WWF-Philippines started to get directly involved in 1996, in collaboration with the DENR, the management authority through the PCP. An agreement was forged by WWF-Philippines and DENR for the implementation of the Turtle Islands Integrated Conservation and Development Project. This report focuses on the activities undertaken by WWF-Philippines in collaboration with the DENR, and highlights the two-pronged approach to conservation, in which biological assessment and community and social assessment are used to formulate a long term integrated conservation plan in collaboration with the stakeholders.

MANAGEMENT PLANNING PROCESSES

Due to its high conservation value as an important sea turtle nesting area, a comprehensive management plan has to be developed to address the conservation needs of the area. As an initial activity baseline data on the resource undertaken to understand what needs to be conserved. Through this, extensive research on the resources was undertaken focusing on sea turtles and its habitat. Work was done on three primary components, the marine benthic communities, terrestrial flora and fauna and physical characterization of the island. Upon completion of data gathering, an environmental ecological characterization was developed to define the Turtle Islands as a management unit. Another important component of this process is the continuous monitoring of the above mentioned habitats to detect changes over time and provide the management timely information for appropriate response. This is made possible through the establishment of a monitoring scheme along side with the training of concerned personnel involved in the management of the area.

To facilitate and assist in the planning process, a GIS database for the islands is currently being developed starting with the acquisition of a satellite spot map of the area. The development of this data base will ensure that all

the information gathered over time through the monitoring scheme can be easily accessed and safeguarded thereby facilitating planning.

The above mentioned activities served as a vital input in the declaring of the Turtle Islands as Wildlife Sanctuary under the National Integrated Protected Areas System (NIPAS) through Presidential Proclamation 171 in August 1999 and the promulgation of the Turtle Islands Ecological Destination Development Guidelines through Department Administrative Order 31-99.

COMMUNITY DEVELOPMENT INITIATIVES

The social analysis and implementation of Integrated Conservation and Development Projects (ICDP) in the Turtle Islands Heritage Protected Area was an effort to understand the socio-economic and political dynamics in island communities. The ICDP has been adopted as an approach to conservation because unless the root causes of poverty are addressed, which are the focal problem of the island communities, unsustainable utilization of marine resources and pressure on the green and hawksbill turtle population will remain high.

The Social and Institutional Assessment of the Turtle Islands is considered the most crucial phase, since this activity is to set the direction towards the implementation of ICDP. Aside from the initial inputs documented by previous KKP involvement in the area, the study is designed to understand the dynamics of the community, as well as to provide inputs on how to effect ICDP in the present social setting. This activity is taken in the context of a systematic view of a situation by specifying the cause and effect relationship for the purpose of explaining and predicting. A goal defined in this ICDP framework is to make a protected ecosystem an essential component of the local peoples' economic, cultural and social survival and growth.

The social and institutional analysis has three major components namely: the social analysis; gender analysis; and stakeholders analysis. This analysis was undertaken with the following goals (Cola, 1998): to pinpoint development beneficiaries being the users of critical resources; to characterize their needs and absorptive capacity; and to assist in design and implementation of activities responsive to their needs and absorptive capacity in the context of conservation goals,

As a result of the activity, a program with four major components (livelihood, enforcement, health and education) was identified through a long process of consultations and planning with the community and its leaders. The consultations also become a venue to impart to the communities the results of the ecological studies. The social analysis will become the basis for developing the specific plans for livelihood, information and education, health and protected area management through enforcement activities. The most notable highlight of this initiative

is the process of consultation and processing of information that was gathered as basis for community planning in setting the conservation agenda.

INTEGRATED APPROACH TO CONSERVATION

The initiative was able to evolve from the species-focused program into a multi-disciplinary activity. Key to the implementation of ICDP in the area was the relevance and contribution of each of the different activities and initiatives under the program. The integration of undertaking parallel activities on the biological/ecological and social and development concerns will play an important role towards the attainment of ICDP in the area. Of chief importance to the process was the constant feedback of the results to the communities, for the purpose of information as well as validation as a continuing cycle for planning and implementing ICDP. In this particular case, we realized that an integrated approach to conservation was not just a singular event, but rather a long-term process that will take 15-20 years before the overall goals can be achieved. The realization of addressing the root causes of these issues confronting the sea turtles and not just focused on sea turtles and its habitat is seen as a milestone in the addressing the conservation needs in the area.

CONCLUSIONS

It is an acknowledged fact there is an urgent need to address conservation issues in the Turtle Islands. Over the past few decades most, if not all, initiatives were focused on a single species, specifically the sea turtles, and their

habitats. However, in recent years it has also been realized that, to be effective, conservation need to go beyond the mere protection of a species and its habitat. The participation of people and communities is as important and critical in determining the fate of the resources one tries to conserve and manage and, ultimately, the only way to sustain conservation over the long term. At this juncture, we have witnessed the evolution of a conservation program from a species-focused to a multi-stakeholder, multi-disciplinary initiative. Conservation is not merely a science but an art that requires striking a creative balance between species and habitats and the different stakeholders that regard the species as their resource.

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Conservation and Management of Sea Turtles in the Southeast Asian Region

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INTRODUCTION

Sea turtles are one of the important protected marine animals under the CITES agreement in the southeast Asian region. This region has been recognised as one of the major landing and nesting locations for sea turtles in the world. Most of the SEAFDEC/ASEAN Member Countries have established national programmes on the conservation and management of sea turtles. Six of seven living sea turtle species recognised in the world were confirmed to nest in this region. These are leatherback turtles (*Dermochelys coriacea*), green turtles (*Chelonia mydas*), olive ridley turtles (*Lepidochelys olivacea*), hawksbill turtles (*Eretmochelys imbricata*), loggerheads (*Caretta caretta*) and flatback turtles (*Natator depressus*). All these species are commonly found in Southeast Asian region except the

flatback, which is restricted primarily to Eastern Indonesia.

The ASEAN Ministers on Agriculture and Forestry (AMAF) signed a memorandum of understanding (MOU) on ASEAN Sea Turtle Conservation and Protection on 12 September 1999. In conjunction of this matter, the Southeast Asia Fisheries Development Center (SEAFDEC) has been recognized as a competent technical regional organization on marine issues in the region by the ASEAN member countries. Marine Fishery Resources Development and Management Department (MFRDMD) Kuala Terengganu has been appointed by SEAFDEC to gear up the regional research and technical activities on the sea turtle conservation and protection program. In line with this recognition, SEAFDEC's MFRDMD has prepared the ASEAN Sea Turtle Conservation and Protection Program and Work Plan. While Malaysia has been designated as the

Regional Coordinator to lead a Technical Experts Working Group, SEAFDEC/MFRDMD Kuala Terengganu was given responsibility to play a key role in the implementation of the MOU. In this regard, SEAFDEC will seek close cooperation and collaboration with the ASEAN Member Countries. As a Regional Technical body, ASEAN Member Countries have given a mandate to SEAFDEC/MFRDMD to stimulate Conservation and Protection Program of sea turtles in future.

SPECIES DISTRIBUTION

The occurrence of sea turtle nesting in Southeast Asia is shown in Table 1. Indonesia has the most species of marine turtles compared with other countries in the region. Due to uncontrolled exploitation during past decades, all species of sea turtles in this region are now threatened with extinction. In response to the rapidly declining (and realizing the importance of) sea turtle populations to the marine environment in the region, steps have been taken to obtain closer cooperation amongst the nations. Subsequently, the First ASEAN Symposium on Marine Turtle Conservation was held in 1993 at Manila and was followed by a workshop that was conducted in January 1996 at Kuala Terengganu, Malaysia.

REGIONAL SYMPOSIA, WORKSHOPS, MEETINGS AND TRAINING

- The First ASEAN Symposium-Workshop on Marine Turtle Conservation was held from December 6-10, 1993 in Manila, Philippines.
- The First SEAFDEC Workshop on Marine Turtle Research and Conservation was held from January 15-18, 1996 in Kuala Terengganu, Malaysia.
- The First Meeting on the Regional Tagging Program and Data Collection On Sea Turtle was held from December 21–23, 1997 in Kuala Terengganu, Malaysia.
- The First ASEAN Workshop on Sea Turtle Conservation and Management was held from December 21-24, 1997 in Jakarta, Indonesia.
- Regional Training Course on Sea Turtle Research and Conservation was conducted from August 24-30, 1998 in Kuala Terengganu, Malaysia
- The First SEAFDEC-ASEAN Regional Workshop on Sea Turtle Conservation and Management was held from July 26–28, 1999 in Kuala Terengganu Malaysia.

REGIONAL RESEARCH ACTIVITIES

MFRDMD/SEAFDEC started a three year regional research program on sea turtle conservation management in 1998. The Government of Japan, through SEAFDEC,

funded these research programs. The research programs are listed below:

Population Genetics of Sea Turtles in Southeast Asia

The objective is to identified stock or management unit(s) of sea turtles population in Southeast Asia.

Sea Turtle Statistics in Southeast Asia

The objectives are to compile all available sea turtle population statistics in the region and to collate, update and disseminate the information to countries inside and outside the region. Format on the population census and statistics was distributed to the turtle researchers of ASEAN member countries for their action to obtain the current status of marine turtles in the region. The list of the format is shown in Table 2.

Regional Sea Turtle Tagging Program

A tagging program has been implemented intensively in Malaysia as well as the Philippines and had been already started in Thailand and Indonesia. The objectives are to understand the migration, growth, mortality and reproduction of sea turtles in the region. Starting in 1998, SEAFDEC member countries had agreed to implement a standard tagging code for sea turtle tagging program in the region. The details of tagging code are described in Table 3.

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Table 1. The occurrence of sea turtles in the southeast Asian countries.

Country	Leatherback	Green	Hawksbill	Loggerhead	Olive ridley	Flatback
Brunei		X	X		X	
Indonesia	X	X	X	X	X	X
Malaysia	X	X	X		X	
Myanmar	X	X	X	X		
Philippines	X	X	X	X	X	
Singapore						
Thailand	X	X	X	X	X	
Vietnam	X	X	X	X	X	

Table 2. The data format of the population statistics collected in the Southeast Asia Region.

Format code	Descriptions
Statistics 01	Turtle nesting site
Statistics 02	Annual landing
Statistics 02A	Annual nesting
Statistics 03	Monthly landing
Statistics 03A	Monthly nesting
Statistics 04	Number of in-situ and artificial hatcheries
Statistics 05	Total of annual production, egg incubation, hatchlings and emergence success
Statistics 06	Total annual egg incubation, hatchling and emergence success by in-situ hatcheries
Statistics 07	Total annual egg incubation, hatchling and emergence success by artificial hatcheries
Statistics 08	Monthly statistics on egg production at every nesting site
Statistics 09	Monthly statistics on egg production, egg incubation, hatchling and emergence success.
Statistics 10	Monthly record on mortality for every species

Table 3. The standard tagging code for sea turtle tagging programs in the southeast Asian region.

Country code	Institution	Serial number
MY: Malaysia	DOF	MY0001-MY1000
	Sabah Park	MY(S)0001-MY(S)1000
	S'wak F. Dept.	MY(Sa)0001-MY(Sa)0500
TH: Thailand	Queen Project	TH0001-TH0500
	PMBC	TH(P)0001-TH(P)0500
PH: Philippines	DOE	PH 0001-PH1000
	North Vietnam	VN(N)0001-VN(N)0100
VN: Vietnam	South Vietnam	VN(S)0001-VN(S)0100
	Central Vietnam (RIMP)	VN(C)0001-VN(C)0100
	PHPA	ID0001-ID1000
ID: Indonesia	PHPA	ID0001-ID1000
BN: Brunei	DOF	BN0001-BN0200

New Directions for Sea Turtle Conservation in the Republic of Palau, Micronesia

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In 1994, the Republic of Palau, located in western Micronesia, became an independent nation, freely associated with the United States through what is known as the Palau-US Compact of Free Association. Through this process, Palau terminated its Trust Territory ties to the US, its agencies, and programs, and is now relying on its own internal processes for decision making, policy setting, and program implementation. Some of these processes still involve some level of US-based assistance; however, responsibility for national-level natural resource management, including endangered species protection, has now turned completely to the Palau government. Over recent decades, the national government has faced challenges to protecting the viability of turtle populations from threats ranging from local exploitation for traditional, subsistence, and commercial use to increasing impacts related to tourism and infrastructure development. The recent

evolution and involvement of locally-based conservation NGO's create new opportunities for sea turtle management and conservation efforts. Similarly, the enhancement of government programs to improve resource management and environmental protection may prove beneficial. Existing opportunities will be described to illustrate how progress may be made in the conservation of Palau's threatened sea turtle populations. These include policy revisions governing turtle harvesting; the design and implementation of state level or community based conservation initiatives, and educational and awareness programs. Local experiences with these approaches will be described. This summary will also summarize current threats to sea turtle population recovery in Palau, as well as possible alternatives for national conservation strategies, local initiatives for sea turtle protection, and cooperation with local communities.

Familial Relationships among Nesting Female Leatherbacks Examined with Genetic Markers

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Genetic data from nine microsatellite loci and control region mtDNA sequences were used to construct profiles of female leatherbacks, *Dermochelys coriacea*, that have nested over a 17-year period between 1981 and 1998 at Sandy Point, St. Croix in the U.S. Virgin Islands. PIT tagging and photo-identification have enabled us to identify potential new recruits and long-term remigrants and compile their reproductive histories. This nesting population has grown significantly in the last six years, and theoretically the new 'recruits' may be the offspring of the older remigrants. Pairwise relatedness (R) was calculated across all nine loci among the 172 female leatherbacks analyzed to date using methods described in Queller and Goodnight (1989), and UPGMA trees constructed to visualize potential family groupings. First-order relations ($R \geq 0.5$) were common and groupings based on microsatellite data were consistent with mtDNA haplotype

data, suggesting that individuals were related maternally, either as mother-daughter, or sisters. By examining reproductive histories and allele distributions it was possible to identify the mother of a group of siblings that came from the same clutch, or clutches produced during the same season. This approach provides direct evidence for natal homing in leatherbacks. Further analysis will be carried out to identify mother-daughter relations. By examining reproductive histories of mothers and their daughters, it should be possible to gain insights into age of maturity for this species.

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Use of Single Locus Polymorphic Markers to Elucidate Multiple Paternity in the Endangered Leatherback Sea Turtle

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When genetic diversity is depleted, alleles become fixed and a population becomes highly susceptible to extinction (Frankham, 1995). Paternity studies provide an excellent means of analyzing the genetic diversity of populations because they serve as a tool to assess the number of fathers contributing to the gene pool. Leatherback turtles are an endangered species and worldwide population declines have been tirelessly documented. We collected blood samples (50-100 μ l) from 36 adult females nesting on Playa Grande, Costa Rica during the 1998/1999 nesting season. For 20 of these 36 females, we collected at least four successive clutches and relocated them into a hatchery. For each nest examined, we took blood samples of approximately 20 μ l from the dorsal cervical sinus of up to 28 hatchlings. We rejected the null hypothesis of single paternity in four out of the 48 clutches examined. All families examined exhibited the same paternal alleles in successive clutches indicating the presence of sperm storage. Both polygyny and polyandry, to a lesser extent, appear to coexist in this leatherback mating system. Multiple paternity is indeed present in this

leatherback population, however it is infrequent. Because of its low occurrence we infer that multiple paternity does not contribute significantly to the genetic variation of this population. We identified 26 mutational events in both maternal and paternal lineages and 50% of these mutations were greater than single step changes. Excessive mutation rates substantiate the need to use several loci to identify multipaternal patterns.

ACKNOWLEDGMENTS

We would like to thank MINAE and the Costa Rican government for permits to work in Parque Marino Nacional Las Baulas during the 1998/1999 leatherback nesting season. Earthwatch, Betz Chair Endowment, Drexel University, and NIH provided funding. We imported samples under U.S. CITES Permit PRT-816777. We thank Jocelyn Behm, Barbara Bell, Dana Drake, Seth Goldberg, Matthew Hamilton, Lene Henrickson, Dave Reynolds, and all the Earthwatch volunteers for their help in sample collection, support, and assistance. Nancy FitzSimmons

and Peter Dutton developed primers set sequences. Finally, I would like to personally thank Packard for providing me with travel assistance for my trip to the Twentieth Annual Sea Turtle Symposium.

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Leatherback and Loggerhead Turtles in Nova Scotia (Canada) Waters: Preliminary Work on Genetic Structure and Relatedness to Nesting Populations

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Prior to 1996 very little data was available on the abundance of sea turtles in Nova Scotia (NS). Nova Scotia is located on the eastern coast of Canada-northeast of the state of Maine. With the formation of the NS Leatherback Turtle Working Group (NSLTWG), a conglomeration of fishermen and their families, community volunteers and scientists, spearheaded by my colleague Michael James, leatherbacks (*Dermochelys coriacea*) and loggerheads (*Caretta caretta*) have been documented to occur predictably in these waters.

To expand on these sighting data, we have decided to include genetic analysis of individuals found in NS waters. I will be sampling leatherback and loggerhead turtles at sea as well as collecting samples from strandings. Other leatherback turtle samples will come from James' concurrent study of movement.

The objectives of my thesis work include investigating mitochondrial DNA (mtDNA) sequences and nuclear DNA (nDNA) fingerprinting of leatherback and loggerhead turtles to assess relatedness among individuals and to assign beach of origin. To accomplish this, I will establish and refine methods for collection at sea, analyse samples and compare these data to nesting populations. The details of my study include pelagic sampling of individual leatherback and loggerhead turtles in NS, sequencing mtDNA and doing microsatellite analysis on nDNA to investigate relatedness among the NS turtles. Then I will compare data with nesting beach population data to assign

likelihood that an individual came from a certain nesting beach or region. Results from this study may lend more information to what is known about pathways of migratory marine animals and may hopefully result in effective management strategies to decrease mortality at sea.

To date four samples have been collected from the carapaces of pelagic leatherbacks. Since in this study we do not share the luxury of sampling nesting females in their 'trance-like' egg-laying state nor do we have warm tropical waters in which to snorkel, we have sampled from the carapace-the most easily accessible region of a swimming leatherback.

I used Chelex/liquid nitrogen extraction methods described by Glenn for museum specimens to recover DNA from the leatherback carapace. I then amplified the supernatant in a Polymerase Chain Reaction testing *Caretta caretta* primers Cc7 and Cc117 from Nancy FitzSimmons. Results were obtained using Cc7. When primers were initially developed, it was not expected they would be useful across species, however this finding allows for increased efficiency in the laboratory. This is a significant accomplishment pertinent to my research. The capability of extracting DNA from the leatherback cartilaginous carapace decreases some of the logistical difficulties of sampling at sea.

Concentrated sampling efforts will begin during the summer of 2000. Further analysis will continue.

Conservation Genetics of the Olive Ridley Sea Turtle (*Lepidochelys olivacea*) on the East Coast of India

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INTRODUCTION

The conservation of olive ridley sea turtles (*Lepidochelys olivacea*) on the east coast of India, particularly Orissa, has been a matter of concern due to large scale trawling mortality over the past five years

(Pandav *et al.*, 1998). In recent years, the development of molecular techniques has offered a new range of tools to answer questions of ecological interest (Bowen, 1996). One of the few remaining olive ridley mass nesting sites in the world is found in Orissa on the east coast of India. The arribada nesting sites of the olive ridley in Orissa at

Gahirmatha, Rushikulya and Devi River mouth have received considerable attention over the past few years. Much of this attention has been centered around the threat to the nesting population, believed to be largely due to drowning in illegal trawl nets. The olive ridley nests sporadically along the entire east coast of India, and other nesting populations though smaller have been equally threatened by drowning of adult turtles and poaching of eggs.

In recent years molecular genetic techniques have been used successfully to answer questions relating to population structure and migration ecology in sea turtles which could not be addressed using conventional techniques (Norman *et al.*, 1994; Bowen 1996). The evidence for population structure in this species, as in other sea turtles the world over, is extremely poor, due to a variety of factors. The money and effort required in tracking adult sea turtles using radio or satellite telemetry is prohibitively high and results are frequently inconclusive for a pelagic species. However, these questions can be addressed easily and can be adequately answered with even a short term study using molecular genetic techniques. Various nesting aggregations of olive ridleys on the east coast of India were studied to enable the formulation of conservation strategies.

METHODS

Muscle and skin tissue was collected from nesting sea turtles and mating pairs was stored in 90% ethanol (Dutton, 1996). DNA was extracted from tissue by proteinase K digestion, and contaminating proteins were removed by chloroform-isoamyl alcohol (24:1) extraction, and precipitated using sodium perchlorate and 90% ethanol. The DNA was quantitated both using visual quantification on 1% agarose gels and spectrophotometry. Many samples could not be used for DNA fingerprinting because of the low quantity of DNA, while others contained a high level of impurities. Samples were diluted to a standard concentration of 500 ng/ml for multilocus fingerprinting and 50 ng/ml for PCR based analysis. Following preliminary analysis and standardisation, a subset of 38 samples, equally representing the four populations, was chosen for further analysis.

MOLECULAR ANALYSIS AND RESULTS

RAPD (Random Amplified Polymorphic DNA) Thirty six RAPD primers (Operon Inc. USA) were used for PCR (Polymerase Chain Reaction) on two test samples. PCR components included DNA template, PCR buffer, 2.0 mM Magnesium Chloride, PCR nucleotide mix, RAPD primer and DNA taq polymerase. The cycling conditions were denaturation at 94°C for 0.5 minutes, annealing at 35°C for one minute, and extension at 71°C for 2 minutes, for a total

of 35 cycles, followed by extension at 71°C for seven minutes. The amplified bands were visualised on 1.5% agarose gels. Four primers (OPAD-01, OPC-03, OPC-05, OPC-07: Operon Inc. USA) showed variation and were then used for PCR amplification on 38 samples. Though each primer amplified several bands, the level of variation between individuals was very low using this technique.

Mitochondrial DNA Sequencing

A 350 base-pair sequence of the mitochondrial d-loop region was amplified using the turtle specific primers LDCM1 (Allard, 1994) and TCR5 (Norman *et al.*, 1994) for 15 samples. Standard protocols were used for amplifying the sequences and purifying the PCR products. Purified samples were then dissolved in loading dye and electrophoresed in 5% long ranger using ABM prism 377 automated DNA sequencer. Sequencing analysis and autoassembler software were used for further analysis. Three haplotypes were found, of which two have been reported from Sri Lanka (Bowen *et al.*, 1998) and one is new.

Multilocus Minisatellite Fingerprinting

Standard procedures were followed for restriction digestion, southern blotting and hybridisation (Lang *et al.*, 1993). Following test digestions with several enzymes, 38 samples were digested using three enzymes (Hae III, HinfI, BstNI). The digested samples were run on 1% agarose gels and transferred to a Hybond N+ membrane using capillary transfer. The blots were then hybridised with ³²P labelled Bkm 2(8) probe and visualised using a Phosphor Imager and Autoradiography. There was a high level of polymorphism and variation between individuals.

Microsatellite Analysis

Seven turtle specific microsatellite primers (Fitzsimmons *et al.*, 1995) were synthesized. The PCR amplification of the samples using these primers was standardized using two samples. Five primers (Cc 7, Cm 3, Cm 72, Cm 84, and Ei 8) were used for PCR amplifications of 34 samples. Standard PCR conditions were followed (Fitzsimmons, 1995). Following amplification, polymorphism was studied by running the PCR products on 4% polyacrilamide gels. Two alleles (Ei 8 and Cm 84) showed high polymorphism with 11 and 12 alleles.

DISCUSSION

Preliminary results suggest that the population structure along the coast is weak. This supports field data that turtles in Orissa use more than one nesting beach, and demands a very different conservation strategy. The experiments conducted so far indicate that the above techniques can be used to derive much valuable information about the population biology of the sea turtles on Indian coasts. While multilocus fingerprinting and microsatellite

analysis can reveal intra and interpopulation variation, mitochondrial DNA sequencing may reveal regional haplotypes which can then be used to trace the feeding grounds of these populations.

The elucidation of the population structure of olive ridleys on the coasts of India would facilitate the development of a management strategy for this endangered species. Conservation priorities need to be assigned on the basis of genetic diversity and population size. The migration routes and origin of these populations would help in the identification of agencies, both national and international which would have to collaborate to ensure the survival of this species. Identifying molecular markers for various species would help in the molecular resolution of marine turtle stock composition in fishery bycatch and in the forensic identification of meat, shell and other products. The first phase of this project has amply demonstrated the usefulness of these techniques in providing answers to conservation related questions. The preliminary results suggest that a comprehensive study is required to provide guidelines for the conservation of olive ridleys in India. Preliminary results also suggest that questions related to behavior and mating systems can be answered using these techniques.

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Population Genetics and Molecular Systematics of the Eastern Pacific Green Turtle (*Chelonia agassizii*) in the State of Michoacan, Mexico

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During the last decade, research on the genetics of sea turtles has increased considerably, but there are still few fine resolution studies. This type of research is necessary

to enhance conservation efforts at a regional scale. Genetical studies, along with demographic assessments, are important to determine conservation priorities for

marine turtle populations. We present results of the analyses of 135 DNA sequences (400 bp) of the control region of mitochondrial DNA, obtained from females observed in the main continental nesting beaches for the eastern Pacific green turtle (*Chelonia agassizii*) in the state of Michoacan, Mexico. From these analyses we present the levels of genetic variability (gene diversity H and nucleotide diversity p) found in two nesting seasons (1996-1997 and 1997-1998). We also report the values of

the population genetic structure obtained with an Analysis of Molecular Variance (AMOVA), in order to evaluate the temporal and spatial differentiation between four nesting beaches in Michoacan. Finally, to contribute to the discussion on the molecular systematics of the genus *Chelonia*, we present a phylogenetic analysis using the haplotypes found in the present study, together with published haplotypes from other populations of the genus in the Atlantic and Pacific oceans.

Raising Funds and Public Awareness in Sea Turtle Conservation in Malaysia

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Sea turtle conservation programs in Peninsular Malaysia are cost intensive because of the necessity of purchasing nests from licensed egg collectors for incubation. Government conservation programs dependent on government budget allocation frequently conserve less than the critical levels required for population sustainability. In order to augment egg protection programs undertaken by the government, the Sea Turtle Research Unit (SEATRU) of University College Terengganu-UPM initiated an *in situ* egg incubation program at Chagar Hutang beach, Redang Island in 1993. The program is now carried out yearly on a long-term basis. This contribution is considered to be significant since Chagar Hutang is the major nesting beach for green turtles in Peninsular Malaysia. SEATRU is responsible for raising all funding requirements. We describe in this paper the Sea Turtle Outreach Program (S.T.O.P.) which has been developed to help raise funds as well as increase public awareness in turtle conservation and biology. Nest and turtle adoption schemes, a volunteer program, turtle camps for village kids, a turtle encounter and awareness (TEA) project, as well as SEATRU products are highlighted.

NEST ADOPTION SCHEME

The scheme enables members of the public to help SEATRU purchase nests for incubation. Cost for one nest adoption is RM200.00 (or US\$70.00 for foreign adoptions). Sponsors receive an adoption certificate, a SEATRU gift and relevant information about the nest adopted, such as date deposited, number of eggs in nest, date of hatchling emergence, number of healthy hatchlings produced and hatching success.

Our nest adoption scheme has been quite well received, with 240 and 495 nests adopted in 1998 and 1999 respectively. The names of all nest sponsors with their nests are listed in the SEATRU website.

TURTLE ADOPTION SCHEME

In our turtle adoption scheme, a donation of RM100.00 (or US\$35.00 for foreign adoptions) is collected for the adoption of one turtle. Sponsors receive an adoption certificate, and information about the turtle adopted (i.e., her ID, tag numbers, nesting history in previous seasons, current nesting activities and the fate of her nests for the season). An exclusive gift is provided, with the option of naming the turtles adopted.

When we started this scheme in 1998, all the turtles monitored for the season were adopted. Last year, 113 of

the 120 turtles monitored were adopted. The names of all sponsors along with their turtles are also listed in the SEATRU website.

THE VOLUNTEER PROGRAM

As in other similar programs, members of the public are provided an opportunity to learn about sea turtles and interact with them in a non-intrusive manner. They experience hands-on conservation work, fall in love with turtles and learn to appreciate nature and care for the environment. Many of them also develop friendship with our workers who are island villagers.

Each volunteer slot accepts up to six volunteers only and lasts for a week. We charge RM450.00 for working professionals and RM300.00 for students. Foreigners are charged US\$150.00. This cost includes a complimentary nest adoption, and all meals, accommodations, and round-trip ferry transfer to the island. We have maintained these low charges to encourage local Malaysians to participate in the program.

Over 100 Malaysians and a few foreigners have participated in the program over the last two years. Most were in the 18-35 age group, with over 60% of them being students. The others were from a wide spectrum of professions. We can conclude that the volunteer program, tested for the first time in Malaysia, has been reasonably successful.

CHILDREN'S TURTLE CAMPS

These are called Kem SiPenyu in the Malaysian language. Penyu is the Malay name for turtle. The camp is open to children from the Redang Island village only. Two to three camps per year are conducted for 11-12 year-olds. In the long run, it is hoped that every child from the village would have participated at least once in the camps. The kids learn about turtles in a fun way, through story-telling, games, play acting, singing, and art. They are allowed to watch one nesting turtle, see hatchling emergences and natural release to the sea, as well as the excavation of hatched nests. They also do a beach cleanup and learn about the dangers of debris to marine animals.

TURTLE ENCOUNTER AND AWARENESS (TEA) PROJECT

This one-night camp is conducted for hotel guests at Berjaya Beach resort who have adopted nests at the SEATRU booth in the hotel. Participants are given a

briefing and shown around the project site. They also get to choose the nest they would adopt. They are allowed to watch one nesting turtle and hatchling emergence if any. They spend the night at Chagar Hutang and return to their hotel early next morning.

SEATRU PRODUCTS

A variety of products ranging from batik sarongs to pouch bags, sling bags, keychains, postcards, turtle pendants have been developed to help raise additional funds.

These products are marketed mostly during exhibitions and appear to be quite popular among tourists.

FUND RAISING THROUGH THE NET

All the schemes and programs outlined above are prominently featured in the SEATRU website at <http://www.uct.edu.my/seatru>. We hope to be able to use this media to further publicise our efforts and improve our fund raising capabilities.

Project Dublar Char: Sea Turtles Conservation and the Dubla Fishermen Group, Bangladesh

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Dublar Char is located in the Sundarbans forest [the largest mangroves forest in the world, Lat: 19°52' N Long: 86°07' E (Fig. 1)] and is the coastal central point of the forest. This place is about 228 nm away from the major nesting site of olive ridley at Urrissa, India and 155 nm from the identified nesting sites in Bangladesh (i.e., Narikel Jinjira and Innani-Cox's Bazar beaches). There is no systematically monitored data on the nesting of sea turtles in Sundarbans area. It was revealed from the interviews with the fishermen of the Sundarbans and associated coastal area that an appreciable number of sea turtles are nesting on the sandy beaches. It appeared from the interviews that most of the turtle eggs are eaten up by the lizards and wild bores. It was also reported that turtles are also caught in the set bag nets placed around the nesting beaches.

Dubla Fishermen Group, the largest fishing community of Bangladesh, a group of about 50,000 members active on 20 beaches in the Sundarbans for post harvesting activities. They remain on the beaches from the late September to early March every year. This huge group was discussed for the first time about sea turtles conservation and they were encouraged in the conservation activities.

INTRODUCTION

Dubla Fishermen Groups are involved mainly in seasonal fishing in adjoining seas of the Sundarbans forest area. Set bag nets is their major fishing gear, placed at sea with long logs. They place their nets starting from 5 m depths to 20 m depths. For fishing and post harvesting activities about 50,000 people are coming in that area and making temporary huts.

Around Dublar Char there are nine nesting beaches. The most important one is Dimer Char (eggs island), Tiger Point, Kotka, Sapra Khali, Nilbariar Char, Hiron Point, Putney Island, Alor Pole and NilKomol Char. While turtles

coming to these nesting sites are caught in the set bag nets and mostly they die.

In 1999 during the fishing season fishermen in that area were informed about sea turtles conservation for the first time. They could not be assisted with proper technology and gears.

Dubla Fishermen Groups Activities in Sea Turtles Conservation

The groups fishing around Dimer Char and Alor Pole area were requested to rescue sea turtles from their nets if caught and carry those to the Dublar Char by boat. There is a pond in Dublar Char, which has a canal linking with sea. These rescued turtles were kept in the pond for two to three days and then these released in the sea. The fishermen found quite enthusiastic in these activities. They have rescued 597 turtles alive and 203 turtles were found dead in the nets.

DISCUSSION

The activities were carried out their did not have any set time. The fish landing boats, which are slow, carried rescued turtles, and movements were restricted with tide. Especially it was difficult when the turtles came at night. On the other hand turtles in the pond were surfing in very short interval. This might have happened due to the murky water of the pond.

Dubla fishermen group needs training in conservation of sea turtles and TED is an essential item to fix the set bag nets. Nesting beach monitoring training and necessary back up to set hatchery is also a basic need for them. Turtle species could not be monitored since Dubla Fishermen Group did not have any biologist. In general the whole group is conservation minded may be since they live in the forest area and very close to the nature.

RECOMMENDATION

Technology for sea turtle conservation needs to be transferred. Input required improving the life standards for the fishing community like health care sanitation and water supply etc. Education in conservation and motivation programmes needs to be implemented.

CONCLUSION

The largest and best organised groups in Bangladesh, Dubla Fishermen Group may easily adapt an action conservation programme of sea turtles.

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Fig. 1. Dublar Char, India.



The Use of Non-releasable Turtles in Public Education

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The term non-releasable can be generally used to indicate sea turtles that would be unable to survive outside of captivity because of a debilitating condition. This term is applied on a case-by-case basis as to whether or not an individual turtle would be releasable after coming into captivity. In most cases non-releasable status results from an injury, but others may be born with a condition that reduces survivability in the wild.

Non-releasable turtles can be used by facilities as an important tool in the educating the public about all aspects of sea turtle biology and ecology. These turtles can be used to show the differences in sea turtle characteristics. Concepts such as the differences between sea turtle species, sea turtle life stages and size classes, sea turtle morphology, and sea turtle anatomy can all be best portrayed with living examples. Non-releasable turtles are also valuable in displaying the importance of sea turtle rehabilitation. Types and causes of injuries, diseases, and treatment are facets of sea turtle rehabilitation that are enhanced by the use of non-releasable turtles. Dangers facing sea turtles such as habitat loss, predation, fishing gear, boats, and marine debris can be witnessed first hand by the public when injured turtles can be viewed. Non-releasable turtles also allow for the promotion of sea turtle conservation by describing local monitoring, tagging, and

beach lighting programs.

Once a sea turtle is classified as non-releasable, it becomes an important resource for an educational facility. These turtles are a way of obtaining live specimens that can be used for educational displays without removing viable turtles from wild breeding populations. Non-releasable turtles allow facilities to have specimens of various species, which may otherwise not be an option because of prohibitive laws. Because non-releasable turtles result from a debilitating condition, keeping these turtles in captivity for educational exhibits prolongs the life of an animal that would not survive in the wild. Each case also allows veterinary staff to learn valuable information about sea turtle medicine and treatment.

However, holding non-releasable turtles in captivity has certain disadvantages. Such turtles require constant feeding, medical treatment, and water quality that is time and labor intensive. Once the commitment is made to keep a non-releasable turtle in captivity, it must remain in captivity for the remainder of its life and can not be released into the wild-even if a facility can no longer care for the animal. Another concern is the amount of space within a facility that non-releasable turtles occupy. As more and more non-releasable turtles accumulate, space becomes limited, possibly hindering future rehabilitation efforts.

Sea Turtle Conservation: A Case Study of Conservation Learning at the Center for Coastal Studies, Puerto San Carlos, Baja California Sur, Mexico

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The Center for Coastal Studies is located on the Pacific coast of Baja California Sur in the small town of Puerto San Carlos. Puerto San Carlos is a fishing community whose economy is dependent on the adjacent waters of Bahía Magdalena. This bay is home to many marine species including five of the seven species of the world's sea turtles during critical points of their life cycle. It is biologically a highly productive bay that is in danger of losing much of its biodiversity due to over harvesting and poor management of its natural resources.

At the Center, students learn about aspects of natural resource management, ecology, and the regional environmental concerns of a natural resource-dependant human communities, by using the real-life problems of this area as a case study. During the summer sessions, the studies focus primarily on the conservation of sea turtles. The students divide themselves into different directed research groups and choose an area of study within the project. In the end, the research groups bring all of their results together and invite the community to a presentation of their findings.

This case study approach used at the center can be an effective way of providing education for students and influencing conservation efforts and awareness within the community. An example of one directed research project that currently takes place at the center is titled, "Assessing the Effect of Environmental Education on Environmental Knowledge Levels and Attitudes Toward Resource Use". The goal of this study is to create an elementary level environmental education curriculum that uses sea turtles as the mechanism to engage students. For this DR and the others, the students from the center are not only required to understand biology of the sea turtles and different aspects of their conservation, but they also must bring their

enthusiasm into the town in order to involve the community and make a lasting impression on sea turtle conservation.

For the Center for Coastal Studies' students, this approach introduces information about ecology, politics, economics, community values, biology, and conservation, and also teaches how to deal with sensitive cultural issues by interacting with the community in a way that benefits both themselves and the people of Puerto San Carlos. This often results in the need for the students to reevaluate their own culturally-based ideas and values in order to understand alternative worldviews.

Perhaps the most essential aspect of this case study approach to conservation learning is the relationship that is created between the students, teachers, and the community during the project. This process requires the students to work with the community resulting in the opportunity for a learning experience for both. Exchange of knowledge, ideas, and cultural values is an important component of working together towards solutions to environmental problems.

ACKNOWLEDGMENTS

I would like to thank the School for Field Studies and all of the staff and students at the Center for Coastal Studies, especially director Susan Gardner. I would also like to thank the town of Puerto San Carlos for all of the help and support they have given to the turtle and conservation projects in the area. The Packard Foundation and Virginia Tech provided funding and made it possible for me to attend the symposium which is also greatly appreciated.

"Adopt a Sea Turtle" Environmental Education Program for the Protection of the Sea Turtle of Los Cabos, Baja California Sur, Mexico

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INTRODUCTION

The discontinuance of the Environmental Education Programs applied to the conservation and integral management of the sea turtle populations that nest in Baja California Sur, promotes the lack of interest of the society

towards the efforts dedicated for the preservation of this resource. The absence of comprehension and interest from the coast communities related to the conservation of the sea turtles, is due in part to the inadequacy of well-coordinated and efficient environmental education programs.

In order to promote the participation of the community in the application of solutions to the ecological problems, it is important that the community knows and understands the sources of such problems, their magnitude, consequences and the actions that individuals may take to attenuate, stop or even resolve some of the damage caused to the environment, especially to the sea turtles. Due to this, ASUPMATOMA has been carrying out an Environmental Education Program addressed mainly to medium level schools and the community in general, as well as supporting the conservation and protection of the environment in general in the region of Los Cabos, Baja California Sur.

RESEARCH AREA

The State of Baja California Sur is located in the northeast portion of the country and occupies the south half of the Baja California Peninsula. Its location is established within parallels 22 grades 52 minutes 17 seconds in Cabo Falso and 28 grades 00 minutes 00 seconds of north latitude, and between 109 grades 24 minutes 47 seconds to the east part of the Los Frailes Hill and 115 grades 04 minutes 53 seconds longitude of Punta Eugenia. The area of Los Cabos is located in the south part of the state peninsula. Its population is 120,000 inhabitants approximately distributed in two main regions, San José del Cabo and Cabo San Lucas.

Baja California Sur has experienced an extraordinary demographic growth, in relation to the rest of the Country, due mainly to the boom of the tourist industry of Los Cabos area, based principally on foreign visitors. Such region is currently one of the most populated of the State with an approximate 75% of the State's total population in combination with La Paz and Ciudad Constitucion. This is why it is so important to operate coordinated Integral Environmental Education Programs, at local, regional and state levels, to promote the participation and incorporation of the communities and the society in general towards the conservation of the sea turtles and the environment.

METHODS

ASUPMATOMA renders three kinds of Environmental Education Programs directed to different levels:

1. Environmental Education (schools-elementary, junior high, and high schools; community in general; and tourists - This program is called "Adopt a Sea Turtle").
2. Training based on rendered Environmental Education (thesis level students; social workers; voluntaries; and hotel executives or employees).
3. Incorporation of massive means of communication (e.g., radio, newspapers, magazines).

The first one consists basically of providing general information on the sea turtles to the students, including subjects such as morphological aspects, distribution and

biology of the species, as well as an introduction on the turtle camps operation. Didactic support material such as posters, drawings, slides and videos is used during the seminar and part of this is elaborated in an interactive manner where the participant provides solutions to the problems presented and exposed by them. Once the interactive part is over, the participants are invited to adopt a baby sea turtle to which they give a name and liberate on the beach afterwards. During the process of liberation, each adoptive father is responsible for their daughters to arrive safe and sound to the ocean. With this we are fulfilling our commitment of creating good conscience towards the conservation of the sea turtles and the environment in general. As soon as the education activities are over, the participants receive a Certificate of Adoption that includes the name of the adopter, the name of the adopted baby turtle and the liberation date. They also receive at that moment a Credential that, in a symbolic way, turns them into Ecological Inspector, and makes an oath where they commit themselves to protect the environment and to transmit what they just learned to others.

The second program consists of providing training on the handling of nesting female turtles, eggs and hatchlings to the people who decide to participate in the association's activities (volunteers, thesis level students and social workers). It is also given to the people that work or are involved in the hotels located on the beaches where occasional nesting occurs and they request it to us; in this particular case, ASUPMATOMA staff goes to the hotel facilities to provide training on *in situ* nest protection.

Massive means of communication, such as the radio and newspapers, are incorporated to these programs by presenting information through these means on sea turtles, problems, solutions and reports on results achieved by ASUPMATOMA.

RESULTS

A total of 19 schools have collaborated with this program with a participation of 1,613 students (Table 1).

In cooperation with Dr. Scott Eckert, Senior Biologist of the Hubbs Research Institute at Sea World in San Diego, California, and Biologist Laura Sarti (National Institute of Fishing, Mexican Autonomous National University), a satellite tracking transmitter was placed on a leatherback turtle at the beaches of Agua Blanca in Baja California Sur. Such transmitter was placed on January 19, 2000 at 4:00 a.m. and this turtle is currently migrating towards the south at a distance of 370 km from where it was originally marked.

Between the community in general and the tourists as well we have registered a total of 90 visitors per season to our Turtle Camp. Each visitor usually comes along with two to five people resulting in a total average of 270 visitors per season.

In regards to the people that have participated with ASUPMATOMA, there has been a total of nine thesis level

students and 18 social workers that have basically worked on research studies on comparatives of *in situ* versus hatchery nesting and surviving percentage.

Each season we receive 45 volunteers, national and foreign, who participated and stay with us in the turtle camp for a period of one week to two months, resulting in a total of approximately 225 people.

Regarding the training provided to maintenance and security personnel of the hotels located on the beach, ten hotels of the area have participated during the last five seasons. Of these ten hotels, five requested this program to be provided on an annual basis, resulting in a total of four to five training sessions provided per season.

Participation of the means of communication is very important to us since it represents a significant support to present, information, results and invitations to our turtle camps. The newspapers that supported us are: Gringo Gazette, Cabo Life, Los Cabos News, Heraldo de Los Cabos, Tribuna de Los Cabos, El Sudcaliforniano, Diario Peninsular, El Forjador, as well as the Los Cabos local radio station Cabo Mil.

RECOMMENDATIONS

To carry out permanent Environmental Education programs containing elements that will improve the quality and application of educational actions directed to promote

the participation of the society in the conservation activities through; (1) permanent Environmental Education Programs for all schools; (2) diffusion of basic information on the sea turtles; (3) promotion for the incorporation of the sea turtles situation to the contents of the educational projects of schools located in the nearby communities; (4) promoting visits of people from the community (especially children and young people) to the Centers for the Research and Protection of the Sea Turtles located in Punta San Cristobal; and (5) incorporating the participation of the massive means of communication.

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Table 1. Students who have received Environmental Education at the Turtle Camp located in San Cristobal, Baja California Sur.

Location	School	Groups	Students
Cabo San Lucas	12	41	1165
San Jose del Cabo	5	7	306
La Paz	4	5	142
Total	19	52	1613

Turtles in Cyberspace: the Successful Melding of Science, Education and the Internet

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INTRODUCTION

Caribbean Conservation Corporation (CCC) is a Gainesville, Florida based non-profit organization dedicated to the study and protection of sea turtles and their habitats throughout the Caribbean. CCC was founded in 1959 to support the pioneering work Dr. Archie Carr.

In 1993, CCC established the Sea Turtle Survival League (STSL) program to begin directly engaging in issues affecting marine turtles in the U.S. The program complements CCC's four decades of experience in research and conservation. STSL's mission is to improve the survival outlook for sea turtles in the US, especially in Florida, through education and advocacy.

DISCUSSION

In 1996, STSL decided that the most efficient way to reach numerous students at once would be through a web site on the very new and interesting Internet. The site could

be utilized by the ever increasing number of teachers and students gaining access to the World Wide Web as schools began to realize the possibilities of the WWW as an educational tool.

The web site cccturtle.org went online in March of 1996. This graphics oriented web site is filled with all types of information that students and teachers might want to know about sea turtles and their conservation. And even though the Internet was young and every site was attracting some kind of attention just because it was there, STSL wanted to encourage teachers and students to begin using the site as a fun and interesting resource.

The Sea Turtle Migration-Tracking Education Program was created to become an educational program using cutting edge research, easy to understand information and the Internet to raise awareness about sea turtles and the threats to their survival. The Sea Turtle Migration-Tracking Education Program, one of the most successful educational tools, continues to grow both in content and popularity. The program uses the research of the migration routes of sea turtles by satellite-tracking as a Ahook@ for getting

students and others interested in learning about sea turtles.

In the first year of the web based education program, CCC partnered with Barbara Schroeder and Dr. Llew Ehrhart who were continuing their effort to track the migration of green turtles after nesting in the Archie Carr Refuge on Florida's east coast. Schroeder and Ehrhart were very generous in letting STSL use the location data to plot the movements of four green turtles on digital maps, created by Andrea Mosier, that could be accessed by visitors to the STSL web site.

Along with the information and maps on the web site, educators were able to request a free 40 page Educator's Resource Guide. The Guide helped teachers incorporate the program into their classroom with activities and handouts that could be used to help teach their students about sea turtle research, biology and conservation. In the last year, the Guide was expanded to include information on coastal habitats, full lesson plans and new activities.

The class room activities in the Guide include drawing the outline of the different sea turtle species to compare the length of the turtle with the height of the students, seeing how many students it took to weigh the same as a leatherback and how many students could fit into the outlined shape of a leatherback. The sea turtle outlines could then be colored close to their natural color. Other activities include writing stories about turtles, using data to determine distance traveled by the turtle, dividing into user groups and having debates on different controversial topics related to sea turtles, a cooperative learning lesson, sea turtle pictorial as well as worksheets that could be photocopied.

The program helps educators incorporate the web site and activities into their classroom. Students can follow the movements of the turtles during the course of a project. Student can plot the movements themselves using a set of data points and downloadable maps. There are interactive games and puzzles for students to have fun while learning. Teachers can have their students test their knowledge with STSL's online quizzes.

In addition to the tracking maps and educational material, the web site provide electronic bulletin boards so that students and teaches could post questions about the program for either the researchers or STSL staff to answer. Between both boards, several thousand questions and comments with responses have been posted.

Since that first year, the program has grown in popularity and complexity. The success of the program can be seen in the number of visitors and the number of educator's using the program. To date, web site has received nearly two and a half million hits and currently averages over 3,000 hits a day. The education program has reached more than 8,000 educators from over 30 countries, representing about 240,000 students.

Because the program takes pure scientific research,

that is generally not available to or is unknown to the public, melds it with eye-catching graphics, maps and educational materials, and provides the information to people worldwide through the inexpensive medium of the Internet the STSL education program has become a model for similar web sites world wide. The program is a great model because it can reach a very large and diverse audience, web sites can be very inexpensive to set up, maintain and promote, uses the Internet, which continues to become more and more popular and accessible, it is an interactive way to get students interested in sea turtles and conservation, activities cross curriculums for both level of study and subject, and it accomplishes the goal of creating turtle advocates who are more aware of the issues.

As the program finishes its fourth year, the education program has worked with 12 different projects following the movement of 52 sea turtles representing four species. The website has received much recognition from groups such as the 21st Century Teachers Network, CNN, Yahoo, and the National Science Teachers Association. But in addition to teachers, the program has received the greatest recognition from other sea turtle groups worldwide. In the past couple of years the Sea Turtle Migration-Tracking Education Program has been used as a model by sea turtle groups who are adding a satellite tracking education program to their websites and making sea turtle research more available, interesting and understandable to the public while increasing support for sea turtle conservation.

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First Satellite Tracking of a Male Leatherback Turtle (*Dermochelys coriacea*) Captured at Sea off Nova Scotia, Canada

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Leatherback turtles (*Dermochelys coriacea*) nest on beaches in tropical and subtropical areas, however these turtles migrate seasonally to northern latitudes, including the temperate waters off eastern Canada. While leatherbacks range further than any other marine turtle, very little is known about the basic biology of this species beyond the nesting beach. In recent years, there has been increased effort to learn more about the behaviour and movements of free-ranging leatherbacks. Studies of live leatherbacks in temperate waters have largely been limited to aerial and shipboard surveys, as it is logistically difficult to both locate and capture leatherbacks at sea. In Atlantic Canada, the Nova Scotia Leatherback Turtle Working Group, a fishermen-centred marine turtle research group,

has been instrumental in monitoring the presence of leatherback and cheloniid sea turtles in coastal and offshore waters. In 1999, we engaged several members of the Working Group to assist us in the design and application of a safe method for capturing and tagging leatherbacks at sea. In August and September 1999, three leatherbacks were successfully captured and PIT tagged, and one turtle, an adult male, was equipped with a satellite tag. This event represents the first successful satellite tagging of a leatherback at sea and the first time an adult male leatherback has been tracked via satellite. Clearly, techniques to safely sample free-ranging leatherbacks will provide valuable opportunities to investigate the habitat use and movements of these turtles.

Long Distance Migration of Green Turtles from the Sarawak Turtle Islands, Malaysia

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Since 1947, the Sarawak Museum has embarked on a long-term management and conservation research effort with green turtles, studying their breeding; copulation; egg hatching; rearing of hatchlings; predation; ectoparasites; temperature related sex phenomena in young hatchlings; and population dynamics, including a tagging programme (Leh, 1989). More recently, major steps have been taken by the Sarawak Forest Department to conserve Sarawak's marine turtles. Collaborative studies between the Sarawak Forest Department and Sea Turtle Research Unit, Faculty of Science and Technology, University College Terengganu-University Putra Malaysia on hatching success, turtle nesting behaviour, tagging and nesting data collection at Talang-Talang Kecil Island were conducted every year since 1997 (Bali, 1998). Current conservation practices in Sarawak focus on protecting the turtles while they are on the beach and within Malaysian waters. It is becoming increasingly apparent that turtle protection confined to the territory of one state is insufficient, as they may be killed elsewhere. Apart from scanty tag return data, little information is available on the extent of the movements of green turtles nesting in Sarawak. Thus, female turtles were tracked by satellites to determine their return migratory routes to their feeding grounds after completion of their nesting activities on Sarawak Turtle Islands.

The study was conducted on female green turtles nesting on Talang-Talang Besar Island (1°55'N, 109°46.4'E) and Talang-Talang Kecil Island (1°53.8'N 109°45.8'E). A long-term tagging and nesting program started in 1996 by the Sarawak Forest Department provides detailed information on the nesting chronology of each individual turtle nesting there. Telonics ST-14 Platform Transmitter Terminals (PTTs) were deployed on a total of four females turtles from each of Talang-Talang Kecil Island and Talang-Talang Besar Island in September and October 1999. The turtles chosen for the study were identified as those about to leave for their foraging grounds, based on their nesting records for the season. The locations as the turtles migrated were obtained through the Argos satellite system based on the signals received by their satellites from each of the coded PTT when the turtles surfaced for air.

Turtles 1 to 4 (TTB1, TTB2, TTB3 and TTB4) were tracked from Talang-Talang Besar Island and Turtles 5 to 8 (TTK1, TTK2, TTK3 and TTK4) from Talang-Talang Kecil Island.

For Turtle TTB1 (named Puteri Limbang), the PTT was deployed on 30 September 1999 and the turtle started migration on 31 October 1999. TTB1 took 45 days to swim a distance of 1506 km, or at an average speed 33.5 km per day heading north-east from the Sarawak Turtle Islands to Philippine waters.

PTT deployment for Turtle TTB2 (Puteri Talang) was on 30 September 1999 with migration commencing on 30 October 1999. TTB2 took 22 days to swim a distance of 975 km, or at an average speed 44.3 km per day. Also heading north-east before ending her journey at Bangi Island, near the northern tip of Sabah.

PTT deployment for Turtle TTB3 (Puteri Miri) was made on the 6 October 1999 with migration commencing on the same day. She also headed north-east from Sarawak Turtle Islands and continued her journey to the Sulu sea. She passed Sabah Turtle Islands off Sandakan, Sabah, and completed her journey at a patch of reef near Pulau Sibutu, south-west of Tawi-Tawi Islands in Philippines. She took 49 days to complete her journey with a distance of 1354 km or at an average speed 27.6 km per day.

PTT deployment for Turtle TTB4 (Puteri Bintulu) was on 6 October 1999 and she started to migrate, heading north-east on the same day. She then headed towards the Sabah Turtle Islands off Sandakan, Sabah. She did not stop there but continued on towards the Celebes Sea. She continued beyond Sipadan Island into the waters of Indonesia and reached some coral islands in the Celebes Sea near Padjang Island, Indonesia. TTB4 took 38 days to swim a distance of 1864 before ending her journey, or at an average speed 49.1 km per day.

For Turtle TTK1 (Puteri Kapit), the deployment was on 8 October 1999, and she started migration on 4 November 1999. TTK1 took 30 days to swim a distance 1469 km, or at an average speed 49.0 km per day to Indonesian waters, passing beyond Sipadan Island.

PTT deployment for Turtle TTK2 (Puteri Sibiu) was on 1 October 1999, but she only started her migration on 5 November 1999. She travelled very close to the shore; indeed, she appeared to travel inland, due to errors in the fixes for this turtle. She reached her feeding ground near Bangi Island, Sabah in 35 days with a distance of 1089 km or at an average speed 31.1 km per day.

A PTT was deployed for of Turtle TTK3 (Puteri Sarikei) on 7 October 1999, but no signals were received from this unit.

PTT deployment for Turtle TTK4 (Puteri Simanggang) was on 19 October 1999, with migration commencing on 21 October 1999. She seemed to follow the others by heading towards north-east, then to the Sulu Sea before ending her journey to the east towards the Philippines. She took 36 days to swim a distance with 1345 km or at an average speed 37.4 km per day.

Results obtained in this study reinforced the notion that green turtles were travelling long distances between feeding and nesting grounds. All the seven turtles tracked took the same route: north-east from Sarawak Turtle Islands along the Sarawak coast to the northern tip of Borneo, then radiating out to various destinations. The green turtles nesting at Sarawak Turtles Islands migrated across international boundaries into waters within South East Asian countries. This study has shown that the breeding population of green turtles in Sarawak Turtle Islands,

Malaysia, were recruited from feeding grounds within territorial waters of different nations bordering South China Sea, Sulu Sea and Celebes Sea. While in Malaysia, the green turtles populations in Sarawak Turtle Islands nest on protected beaches and are provided adequate refuge in their inter-nesting habitats through the enforcement of the Turtles Trust Ordinance 1957, Turtles Protection Rules 1962, Land Code 1958, Marine Park Fishing Regulations, National Parks and Nature Reserves Ordinance 1998, and the Wild Life Protection Ordinance 1998. However, the extent and effectiveness of protection during their migration and in the feeding grounds which have been identified in this study is not known. It is clear that Malaysia has to develop and enter into bilateral agreements with these countries to ensure that the turtles and their feeding habitats are protected. It is also timely that Malaysian, Indonesian, Bruneian and Filipino scientists initiate relevant collaborative research and management strategies in turtle conservation. The present study has provided the necessary information to serve as the impetus for regional cooperation in the conservation of sea turtles in South East Asia through the SEAFDEC-Asean Regional Sea Turtle Conservation and Management group.

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Surfacing and Submergence Behavior of the Green Turtle (*Chelonia mydas*)

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Recent studies using satellite telemetry have demonstrated the at-sea movements of sea turtles, including those of turtles that are resident in nearshore habitats and those undertaking long-distance migrations. However, only a few of these studies have made use of the dive data that are also frequently included in the transmissions from the satellites. This study examined the submergence and surfacing behavior of six green turtles (*Chelonia mydas*): three subadults from developmental habitat in Bermuda, and three adult males from Bocas del Toro, Panama. Platform Transmission Terminals (PTT's) used in the study were configurations ST-6 and ST-14. Submergence and surfacing data parameters examined were number of submergences/12-hour period, mean submergence time/12-hour period, mean surface interval/12-hour period, and total time at the surface/12-hour period. Turtles with transmitters were monitored between 1995 and 1999.

The submergence and surfacing behavior of these turtles during their tracking periods appeared to be affected by migratory versus non-migratory movement, as well as by temperature. During migration, the number of submergences/12-hour period increased significantly for

an individual turtle compared to non-migratory periods. mean submergence time/12-hour period and mean surface interval/12-hour period decreased significantly during migration compared to non-migratory periods. Total time at the surface did not change significantly between migration and non-migratory periods for individual turtles. Submergence behavior correlated significantly with temperature for the two subadult green turtles that remained resident on the Bermuda Platform. As temperature increased, number of submergences/12-hour period increased significantly, and mean submergence time/12-hour period and mean surface interval/12-hour period decreased significantly for both turtles. For one of the turtles, total time at the surface/12-hour period also increased significantly with increasing temperature.

Satellite telemetry is an effective tool for monitoring sea turtle submergence and surfacing behavior over extended periods of time and away from the nearshore habitat. More studies of this kind are needed to further understanding of submergence and surfacing behavior during migration, in response to annual temperature change in areas of residency, and for comparisons among sea turtle species.

Things to Do, Places to Be: Internesting Diving Behavior of Caribbean Hawksbill Turtles Elucidated Through Archival Tags

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We used data-storing devices (DK600 series, Driesen & Kern, D-24576 Bad Bamstedt, Germany) to elucidate aspects of the underwater ecology of hawksbill turtles (*Eretmochelys imbricata*) during inter-nesting intervals. Between mid-July and mid-September 1999, six female hawksbill turtles, nesting at Buck Island Reef National Monument (17.7°N, 64.4°W), U.S. Virgin Islands, were successfully equipped with devices attached to the upper anterior carapace of the turtles (second central scute) using a combination of two different types of epoxy (see attachment protocol in Mitchell, 1998). By using a new, specially-designed base plate that worked as a quick-release, we were able to exchange devices on previously-equipped turtles without additional epoxy-attachment procedures. Thus, devices could be exchanged during

nesting as well as during emergences where egg laying did not occur. This base plate system proved particularly beneficial for animals such as the hawksbill turtle which re-nest multiple times per season. At the end of the nesting season, the plate was easily removed from the carapace. The devices recorded data on dive duration, dive depth, surface interval, water temperature, swim speed, swim direction and body inclination at user-defined intervals. Direction and inclination was measured by three Hall-sensors detecting the position of a magnet in an integrated miniature ship's compass. Vectorial analysis of the data, recorded at 8 s intervals, revealed the three-dimensional movements of the turtles (Fig. 1) and thus enables identification of visited reef spots and specific routes taken by the turtle. Based on

changes of turtle orientation (derived from the compass) we could distinguish between resting behavior (no angular velocity) and active phases (variation in compass signal) (Jeschke *et al.*, This volume). Thus, we could classify different dive types using both the dive profile and actual underwater movement (Fig. 2). For example, during V-shaped dives (Fig. 2a), turtles spent a similar amount of time in each depth-class, moving continuously down and up the water column. In contrast to this, U-shaped dives had extended bottom-phases between the descent and the ascent with peaks in time spent per depth-class at the bottom of the dive (Fig. 2b). Resting status during the bottom phase was clearly identified through compass data and typically restricted the peak to a single depth class (Fig. 2b), whereas an active bottom phase with a broader range of depths was primarily interpreted as swimming behavior (Fig. 2c). Some intermediate dive types were also observed (Fig. 2d), however, the resting U-shaped dives predominated in interesting females. In contrast to the routine dives described above with turtles diving to between 8 and 12 m, one individual in our study performed 11 sequential dives between 30 and 70 m. During these exceptional dives the turtle repeatedly spent about 15 minutes at around 50 m with the compass data revealing that the animal was active all the time. Consideration of the features of these dives led us to conclude that the turtle was feeding at the reef, a behavior that is exceptional for an adult female hawksbill turtle during the inter-nesting interval off Buck Island. We classified a dive as 'active' when 80 % or more of the total number of data points of the dive showed activity. Based on this classification we calculated the percentage of active dives relative to the total number of submergence events during specified periods over the diel cycle (Fig. 3). In the case considered, the turtle showed a generally increased percentage of active dives during dawn and dusk. However, due to the extremely short duration of twilight at low latitudes the number of dives considered in the 4 phases are very unbalanced. Looking at the pattern of daily activity over the whole 16 day inter-nesting interval, animal QQD 401 had an intermediate level of activity directly after nesting and then a phase of very low activity (Fig. 4) followed by a marked increase, (found in all individuals within this study) after the thirteenth day, when the percentage of active dives reached levels of up to 87%. The level of activity remained high until the next nesting event. The results of the 1999 nesting season again underline that the use of compasses in loggers enormously enhances our understanding of behavioral patterns in turtles that would otherwise be inaccessible.

ACKNOWLEDGMENTS

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Fig. 1. Three dimensional route of QQD 384, plotted for one day. The device was exchanged during an emergence without successful nesting activity. The start (left) was 9 August 1999 at 1:45 am and the end (right) was on the same day at 4:35 am.

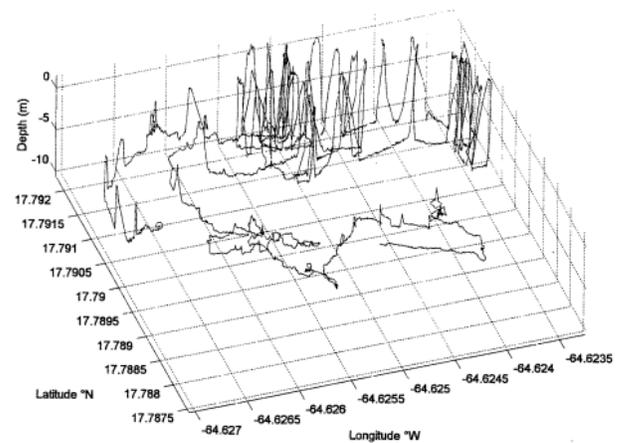


Fig. 2. Different dive-types classified by the shape of the dive profiles (solid line), time spent at depth (horizontal bars) and activity (shading of horizontal bars). Width of depth class was 1 m. Data recorded at 8 second intervals.

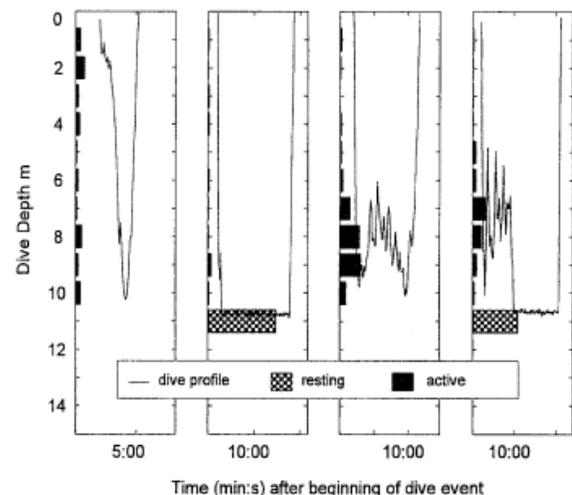


Fig. 3. Diel activity pattern in turtle QQD 401 over a 16 day inter-nesting interval with respect dawn (0501-0600 hour), daylight (0601-1800 hour), dusk (1801-1900 hour), and night (1901-05:00 hour). The total number of dives considered is 1048.

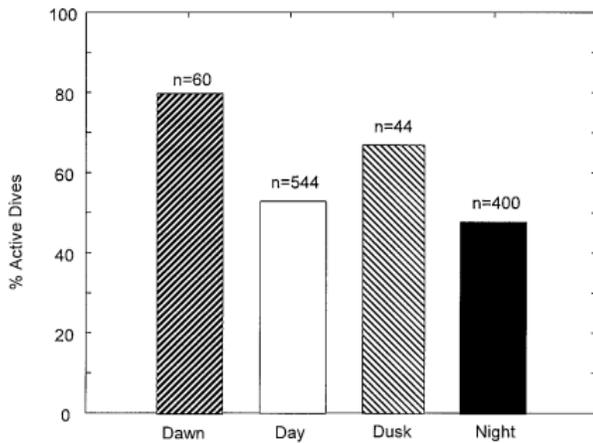
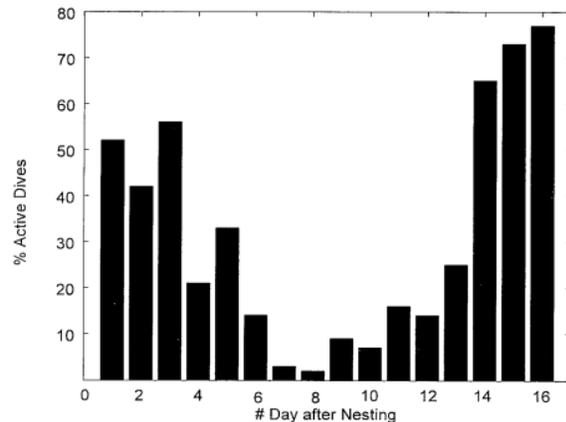


Fig. 4. Activity pattern of QQD 401 during a 16 day inter-nesting interval, showing periods of higher and lower levels of daily activity. The total number of dives considered is 1048.



Movement and Home Range of the East-Pacific Green Turtle at a Gulf of California (Mexico) Feeding Area

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INTRODUCTION

Our greatest understanding of the movements of sea turtles is based on adult females in the inter-nesting environment and post-nesting migrations. Little is known of the movement ecology of sea turtles upon settling in nearshore foraging habitats. In studies of *Chelonia mydas*, Mendonca (1983) tracked movements in a Florida lagoon and Ogden *et al.* (1980) examined diurnal foraging patterns in Bermuda. Arms *et al.* (unpublished) studied home range of *C. mydas* in the Gulf of Mexico. However, the only study of local movements of *C. mydas* in non-seagrass habitats was carried out by Balazs (1987) in Hawaii.

The east Pacific green sea turtle (a.k.a. black sea turtle), *C. mydas*, occurs throughout the eastern Pacific ocean (Alvarado and Figueroa, 1992; Clifton *et al.*, 1982). Migratory links between nesting areas in Michoacan, Mexico, and feeding grounds in the Gulf of California, Mexico, have been established through tag returns (Alvarado and Figueroa, 1992; Nichols and Seminoff, unpublished), mtDNA analysis (Nichols *et al.*, 1999) and satellite telemetry (Nichols *et al.*, 1999). In this migratory cycle few data are available on near-shore movements. Alvarado and Figueroa (1992) studied local movements of *C. mydas* in the inter-nesting habitat, however, data on local movements in feeding areas are lacking.

Knowledge of the location and spatial use of foraging grounds is important because sea turtles assembled there for feeding activities are extremely vulnerable to exploitation. Development of effective conservation measures for *C. mydas* in these areas requires an understanding of its habitat requirements and movement patterns. Data on these life history components are important when evaluating the effects of local fisheries and commercial algae harvest. The objectives of this study were to acquire information on the critical habitats of *C. mydas* within this nearshore feeding area, its movements and spatial requirements, and habitat affinities.

METHODS

Fieldwork was conducted from May 1996 to September 1999 at the Bahia de los Angeles foraging area of the central Gulf of California, Mexico (28°58'N, 113°33'W). We captured a total of 25 *C. mydas* (18 immature, four adult female, three adult male) along nearshore margins of the feeding area using large-mesh entanglement nets (100 m x 8 m, mesh size = 60 cm stretched). Distance from shore and water depth of netting sites ranged from 50 to 750 m, and 2 to 27 m, respectively. Nets were set during both day and night periods and

monitored at 0.5 hour to 12 hour intervals. Entangled turtles were removed upon encounter and transferred to the Centro Regional de Investigacion Pesquera Sea Turtle Research Station (CRIP-STRS) in Bahía de los Angeles, Baja California, Mexico.

Turtles were fitted with a transmitter package consisting of a very high frequency (VHF) radio transmitter and a sonic 'pinger' tag. All turtles were equipped with VHF transmitters (17-MOD 400, 7-MOD 600 MOD, and 1-MOD 050, Telonics, Inc. Mesa, Arizona). Starting in 1997 turtles ($n = 22$) were additionally equipped with sonic transmitters (5-V16-6H, 10-V32P-8H, Vemco Ltd., Nova Scotia, Canada, and 2-CHP-87, 5-DT-96, Sonitronics, Tucson, Arizona).

Home range areas were estimated using the minimum convex polygon (Mohr, 1947), and Kernel estimator (Worton, 1989) methods. Linear home range size was calculated as the direct distance between the two most distant biotelemetry fixes. Home range areas were plotted with ArcView 3.1

RESULTS

Of the 25 tracked turtles, the mean SCL of immatures was 69.23 cm (SE = 1.26, range = 50.9 to 76.2 cm, $n = 18$); that for adult males was 83.6 cm (SE = 3.09, range = 77.5 to 87.3 cm, $n = 3$) and for adult females was 78.8 cm (SE = 2.68, range = 77.4 to 82.5 cm, $n = 4$). In total, 283 turtle days were logged (days in which at least one turtle's position was recorded) and 1101 relocations were made.

We define home range as the total area used by an animal in normal daily activities, excluding migrations or unusual erratic wanderings. Due to a lack of sufficient data from periods outside of the May-September time period, home range estimates are provided for summer periods only. Fourteen (11 immature, two females, one male) turtles relocated at least 15 times (mean = 74.6 relocation events, range = 16 to 139) over an interval >30 days were used to estimate home range areas and lengths. Five telemetered turtles were relocated at intervals >1 year; final position for each turtle was determined through net recapture.

Mean minimum convex polygon (MCP) home range size was 1607 ha (SE = 275.27, range = 584 to 3908 ha, $n = 14$). Kernel home range estimates had a mean of 3367.33 ha (SE = 738.94, range = 409 to 4000 ha, $n = 14$). Range length averaged 6937 m (SE = 738.94, range = 3189 to 1191 m, $n = 14$). Of the 14 home ranges, all showed >1 activity center.

Movement of eight (six immature, one adult male, one adult female) turtles was monitored for 24-hour blocks to determine daily distance traveled and daily home range. Twenty-four hour tracking occasions occurred during 1998 and 1999 between 13 July and 3 September. Mean distance traveled was 9535 m (SE = 1322.69, range 5118 to 15,340 m). Sleeping behavior was apparent in 87% of turtles. This

behavior was evidenced by longer dive intervals and an absence of lateral movement within the study area. The behavior was evident during both day and night hours. Depth of sleeping sites ranged from 1.8 m to 13.5 m.

Movements of turtles in deep water areas appears to have strong directionality. This apparent shuttling behavior often resulted in turtles moving to off shore island regions. While in nearshore areas, particularly in areas of high marine algae abundance, turtles exhibited a less distinct directional movement. Turtles moved during both day and night periods.

DISCUSSION

Home range has been defined as the area that is traversed by an animal during its normal daily activities excluding long distance migrations or erratic movements. All turtles in this study had affinities to multiple activity centers that overlapped at least two distinct habitat types. The fact that these habitats have different floral and faunal assemblages suggests that the turtles may have a dichotomous foraging strategy utilizing both soft bottom marine algae pastures and rocky, benthic invertebrate rich habitats.

C. mydas in Bahía de los Angeles move expansive distances during both day and night periods. This behavior is contradictory to a number of studies on *C. mydas* that noted turtles return to specific sleeping sites. The primary feeding pastures are near shore and in regions of heavy boat traffic. The nocturnal foraging in these habitats may be an avoidance response to this temporally limited human presence.

Our study did not demonstrate the presence of grazing crops at specific microsites within the feeding pasture as noted by Bjorndal *et al.* (1980) and Ogren *et al.* (1980). The reason for the observed differences in grazing strategy are unknown, but it is possible that the lack of philopatry to observed grazing microsites is due to the physical nature of the target food items. Bjorndal (1980) indicated that mature *Thalassia* blades were commonly fouled with epibionts and that the cropping and revisiting to specific blades was a strategy which benefitted green turtles by providing a constant source of fresh, non-encrusted food matter. Though all turtles demonstrated fidelity to *Gracilariaopsis lemaneiformis* algae pastures in our study, their lack return to a specific site may be due to the fact that *G. lemaneiformis* is apparently not as susceptible to encrustation, thus strategies to return to specific microsites for feeding would not be as beneficial.

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Research on East Pacific Green Sea Turtles on Baja California Feeding Grounds: A General Life History Model

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INTRODUCTION

East Pacific green turtles (*Chelonia mydas*), also known as black turtles, are known to inhabit the coastal waters of the Baja California peninsula. The origins of turtles foraging in Baja California waters have been proposed by several authors (Carr, 1961; Caldwell, 1962; O'Donnell, 1974; Olguin, 1990; Nichols *et al.*, 2000). The recovery of flipper tags from Michoacan nesting beaches (Alvarado and Figueroa, 1992) on Baja California feeding grounds suggests that these waters are important for foraging adult turtles as well as developing juveniles (Seminoff *et al.*, This volume). Molecular genetic analyses

suggest that the majority of turtles foraging in Baja California waters originate on Michoacan (Nichols *et al.*, 2000). Due to its proximity, the Islas Revillagigedo rookery is also likely to be a source population. Baja California's Pacific lagoons and Bahía de los Angeles and Loreto on the Gulf of California, were once important centers of turtle fishing (Caldwell 1962; Cliffon *et al.*, 1982). Research based at the Sea Turtle Research Station, Instituto Nacional de la Pesca, in Bahía de los Angeles, BC has produced new information on the occurrence and origins of adult turtles on Baja California feeding areas and the migratory pathways between foraging areas and their main rookeries in Michoacan, Mexico emphasizing the

importance of the Baja California feeding grounds to the recovery of the East Pacific green turtle (Nichols *et al.*, 1998). These combined data allow us to propose a general life history model for the Baja California population of this vulnerable green turtle population.

METHODS

Turtles were captured with entanglement nets (100 m x 8 m, mesh size = 60 cm stretched) placed along the near-shore coastline of Bahía de los Angeles, BC and Loreto, BCS between May 1995 and October 1999. Turtles were also captured along Pacific coast feeding areas in Bahía Magdalena, Laguna San Ignacio and Laguna Ojo de Liebre, BCS. Size measurements and other physical data were recorded, flipper tags applied and tissue samples collected for genetic analyses. To a subset of animals, we attached satellite transmitters (Telonics ST-6 and Wildlife Computers) using a modified version of the attachment technique described by Balazs *et al.* (1995). We utilized a thin layer of Marine-Tex two-part epoxy in place of Silicone Elastomer. Turtles were generally released at the site of capture.

Lack of procedures such as radioimmunoassay or laparoscopy required the use of external morphological data in order to assess maturity and sex. The mean size of nesting females at the Michoacan, Mexico, rookery (82 cm CCL/77.3 cm SCL; Figueroa *et al.*, 1993) was used to distinguish maturity status. Turtles with SCL < 77.3 cm were classified as immature and those with SCL ≥ 77.3 cm, adult. Any turtle with an elongated tail (TLC ≥ 10 cm), measured from the trailing edge of the carapace to the tip of the extended, straightened tail was identified as male. Because the accuracy of sex assessment based on tail size is greatest in the large size classes, sex ratios were determined only for adult-sized turtles.

RESULTS AND DISCUSSION

Results for three homing green turtles tracked with satellite telemetry from Gulf of California feeding grounds to nesting beaches in Michoacan, Mexico are reported here (Table 2). Two turtles departed feeding grounds during the months of September and November 1998. The third turtle had been captured locally and captive-raised prior to being released in January 1997. This turtle immediately departed the Bahía de los Angeles area. Reported results utilize positions with location classes (LC) > 1 (error factor < 1000 m).

Green Turtle 03850

This 74.3 cm (SCL) turtle was equipped with a transmitter on 23 November 1998 and released in Bahía de los Angeles. This turtle crossed the Gulf of California and followed the mainland Mexico coast south, arriving in the

vicinity of green turtle nesting beaches in Michoacan on 13 January 1999. Mean swim speed for the entire track was 39.7 km/day and minimum distance traveled was approximately 2,011 km.

Green Turtle 05523

This 89.9 cm (SCL) turtle was equipped with a transmitter on 11 August 1997 after being captured in Bahía Juncalito, BCS. After crossing to the east side of the Gulf of California, this turtle also remained relatively close to the mainland coast. The turtle was confirmed nesting in Michoacan on 10 October 1997. Mean swim speed for the entire track was 45 km/day and minimum distance traveled was approximately 1620 km.

Green Turtle 01084

This 75.6 cm (SCL) turtle was equipped with a transmitter on 25 January 1997 after being raised in captivity. The turtle had been initially captured on Bahía de los Angeles feeding grounds. The turtle traveled along the mainland coast for 90 days prior to reaching the vicinity of Colola, Michoacan where it remained until transmission ceased. Mean swim speed for the entire track was 18.5 km/day while the mean swim speed for the migratory portion (not including movements near the nesting beach) of the track was 22.5 km/day.

The overall mean swim speed for homing adult green turtles was 32 km/day (n = 3). The mean swim speed for the non-captive turtles was 42 km/day (n = 2).

A total of 152 green turtles were captured in Bahía de los Angeles from 1994-1999. The mean SCL of the 152 turtles was 75.1 cm (SE = 0.79, range 46.0 to 96.6 cm) and there was no evidence of variation in mean SCL between years. Both juvenile and adult-sized green turtles occur in Bahía de los Angeles. Juveniles were slightly more abundant (n = 83, 55%) than adults (n = 69, 45%), and the juvenile:adult ratio did not differ significantly from an expected 1:1 ratio. This is significantly larger than the mean SCL of Pacific coast green turtles where 87% of the turtles had SCL > 77.3 cm (mean SCL = 61.6 cm, range = 35.6-94.2, n = 284). A total of 19 Bahía de los Angeles turtles had TLC ≥ 10 cm and were thus assumed mature males. All were in the adult size range (SCL > 77.3 cm) and had a mean SCL of 83.9 cm (SE = 0.89, range = 77.3 to 89.2 cm). The sex ratio (undetermined: male) of the 69 adult-sized turtles was 2.6:1, differing significantly from a 1:1 ratio (P < 0.0005).

These results indicate that Gulf of California coastal waters provide both juvenile developmental habitat for post pelagic turtles greater than 46 cm (SCL) and adult foraging habitat for turtles as large as 96 cm (SCL). They also indicate that Pacific coast foraging grounds provide habitat for a relatively higher percentage of juvenile turtles and a size class (35 to 45 cm SCL) not yet encountered in the Gulf of California. Size class data suggest that juvenile turtles may move directly from pelagic to neritic foraging grounds on Baja California's Pacific coast, whereas recruitment to

Gulf of California foraging grounds may occur several years after the shift to benthic foraging. Recaptures and radio tracking data on both Gulf of California and Pacific foraging areas suggest high seasonal site fidelity among juveniles (Seminoff, This volume). However, several tag returns suggest possible southward movement associated with cooling waters.

The mean swim speeds for satellite tracked green turtles (22 km/day to 45 km/day) are similar to the highest swim speeds reported by (Alvarado and Figueroa 1992) for post nesting movement based on flipper tag recovery. The lower mean swim speed for turtle 01084 may have been due to lower winter water temperatures. Notably, higher swim speeds were recorded for turtle 05523 the largest turtle and the one migrating during the warmest season.

Migratory routes of homing adult-sized turtles follow the mainland Mexico coastline and approximate the straight-line path between feeding and nesting areas with accommodation for land masses. Turtles migrating from feeding grounds on the Pacific coast of Baja California or from southern California likely migrate near the coast, crossing the mouth of the Gulf of California to the mainland and continuing south to Michoacan. The approximate straight-line distances from major green turtle feeding grounds to nesting beaches in Michoacan and the Islas Revillagigedos are compared in Table 1. The remote Revillagigedos archipelago lies nearer to most Baja California green turtle foraging areas.

Based on these mean swim speeds, in order to arrive in Michoacan waters prior to the nesting season which lasts from September through January and peaks in November (Alvarado and Figueroa, 1991), turtles must depart BLA feeding grounds during the late summer months (August and September). A post-nesting return to feeding grounds would not be expected until spring (March or April). Seasonal currents and swimming speeds will effect the timing, however these data allow us to create a rudimentary life history model.

Juvenile green turtles recruit to the coast of Baja California at sizes between 35 and 45 cm (SCL). Juvenile turtles demonstrate seasonal site fidelity but may move to the north and south as water temperatures fluctuate, particularly in more temperate areas such as Bahía de los Angeles. Juvenile turtles spend at least 16 year at foraging areas prior to reaching maturity (Seminoff, unpublished data). Mature turtles must depart northern feeding grounds in late summer (August) and southern feeding grounds in early fall (September) to arrive at the rookeries for the reproductive season. After the nesting season, green turtles return to foraging grounds as water temperatures are increasing. Migrations between major rookeries and important adult feeding areas typically require movements in excess of 1000 km and more than a month of sustained swimming. The energetic expenditure required to undertake this migration combined with the temperate waters of the main Californian green turtle feeding areas, where during winter months water temperatures regularly

drop to 11°C, may partially explain the three year remigration period, slow growth rates and delayed maturity described for this population (Alvarado and Figueroa, 1991). This scenario should be kept in mind as managers work towards the recovery of East Pacific green turtles over the next several decades. Further, fisheries interactions with turtles in Baja California waters and along the migratory routes, which occur primarily on the continental shelf and pass through areas of intense fishing activities, will clearly impact both juvenile and adult green turtles. The timing of such migrations should be taken into account when managing these fisheries.

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Table 1. Minimum distance and swimming duration between eastern Pacific green turtle rookeries and important foraging areas of the Californias. Swimming duration is based on a minimum mean swim speed (32 km/day) calculated using data from three satellite tracked homing green turtles. [SD = San Diego, California, USA; LOL = Laguna Ojo de Liebre, Baja California Sur, Mexico; BMA = Bahía Magdalena, BCS, Mexico; BLA = Bahía de los Angeles, BCS, Mexico; Loreto, BCS, Mexico].

Rookery	Californian feeding areas				
	Pacific Coast			Gulf of California	
	SD	LOL	BMA	BLA	Loreto
Islas	1648 km/	1043 km/	672 km/	1210 km/	805 km/
Revillagigedos	51.5 days	32.6 days	21 days	37.8 days	25.2 days
Colola,	2108 km/	1518 km/	1150 km/	1584 km/	1173 km/
Michoacan	65.9 days	47.4 days	35.9 days	49.5 days	36.7 days

Table 2. Size, duration of track, distance traveled and speed of three east Pacific green turtles satellite tracked migrating from feeding grounds to nesting beach during 1997-1999. This turtle remained in the vicinity of the nesting beach for more than two weeks prior to the final transmission, average speed traveled is given for the transit period.

PTT ID Code	SCL (cm)	Duration of track (days)	Minimum distance traveled (km)	Average speed traveled (km/d)
03850	74.3	51	2,011	39.7
05523	89.9	36	1,620	45.0
01084	75.6	113*	2,027	22.5

The Value of Sea Turtles: Choices in Contingent Valuation and Sustainability

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Sea turtle conservation and management programs eventually must address the questions of 'How many turtles do we need?' and 'Are their populations sustainable?' The various answers to these questions depend upon many factors, including the purpose of the conservation or management program and the economic value placed upon sea turtles. There has been much interest lately in Contingent Valuation to determine the economic value of various aspects of the earth's environment. Earlier interest centered on evaluating economic impact for purposes of awarding financial damages or assessing fines in environmental litigation following events such as the Exxon Valdez disaster. More recently, economists are considering how to determine the economic value of

biodiversity and natural resources outside of court cases. Among the issues being considered are both 'use value' and 'non-use value.' Use value includes consideration of consumptive value, non-consumptive value, and option (potential future use) value. The determination of non-use value includes issues related to existence value (i.e., the perceived value of living in a world with sea turtles as opposed to living in a world without them) and bequest value (i.e., the perceived value of leaving to our children a world that has sea turtles in it). Additional questions as to whether sea turtles are sustainable as a natural resource depend upon how we choose to define sustainability-whether in an economic, ecological, biological, cultural, or spiritual context.

Olive Ridley Sea Turtle Egg Decimation by Coastal Erosion and Human Appropriateness at an Estuarine Area at the Chococente Wildlife Refuge, Nicaragua

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INTRODUCTION

Chococente, located in the SW Pacific of Nicaragua, is one of the few preferred nesting site for the olive ridley sea turtle (*Lepidochelys olivacea*) the most common migrating sea turtle in the country. A series of natural and human-born factors substantially reduce the population threatening the survival of the species.

NATURE OF THE PROBLEM

Egg clusters laid in the estuarine seashore of the Chococente creek are swept as a result of high sand erosion processes associated with temporary overflows normally occurring during the heavy rains of October-November each year. Sand erosion reaches down at near 2 m deep and up to 200 m wide, dragging the nests and exposing the eggs to scavenger animals, mainly vultures, leaving behind the empty shells only. The intensity of river flows has been calculated for the three tributaries of the Chococente creek. Considering the unavoidable and repetitive nature of that destruction as well as the social importance of sea turtle eggs as a highly demanded source of food and communal trade, the Ministry of the Environment and Natural Resources, has permitted the extraction of up to 8-

10% of egg clusters during the whole critical period of September-October each year. The control of this permission, informal in nature, is not only difficult but socially conflictive in an area where poverty, education facilities, and work sources are scarce in the communities surrounding the Chococente Wildlife Refuge.

PROPOSED REMEDIAL ACTIONS

1. Identify, create and promote agri-silvo-pastoral activities among rural communities close to Chococente.
2. Study the possibilities for the establishment of permanent or temporary drainage structures to avoid the rupture of the estuarine sand banks.
3. Collect recently laid egg clusters and transfer them to controlled egg hatching areas.

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collaborators (Giovanni and Roberto Peña, Alejandro
Romero, Mario and Larry W. Vaughan); and Ramon Del
Moral Universidad de Puerto Rico-Humacao, Sea Grant.

Commercialization Routes of the Sea Turtles on Margarita Island, Nueva Esparta State, Venezuela

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In spite of being legally protected, the sea turtles on Nueva Esparta State have been exposed to commercial exploitation by local fishermen for subsistence purposes. They have done this for many years. This is the reason why the Nueva Esparta State and mainly the Margarita Coche and Cubagua islands are considered as the principal black market on a national level. However, this situation has not been carefully studied, and that is why we decided to carry

out a detailed study. For the realization of the study, a model of survey was utilized and applied in four levels that were involved within the chain of commercialization. The first level was the fishermen. The second level was the middlemen. The third level was the restaurants and small food stands. The fourth level was the artisans and sales of crafts. For the present report, the results of 300 surveys were evaluated and divided among the first three levels.

Ban and Benefits: Tortuguero at 2000

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The objective of this presentation is to report on the progress on two recent challenges for sea turtle conservation at Tortuguero National Park, Costa Rica: 1) illegal harvest of nesting females; and 2) developing alternative livelihoods for former turtle consumers.

Tortuguero Conservation Area increased protection activities during the green turtle nesting seasons of 1998 and 1999. Enforcement efforts included more beach patrols by park rangers and by staff borrowed from police and coast guard. Weekly track surveys show that the illegal harvest decreased substantially over 1997 levels, indicating that the presence of more personnel on the nesting beach has been effective in deterring poaching. Enforcement was made considerably easier by unambiguous legislation that completely prohibits the harvest of green turtles.

Since 1993, Tortuguero villagers are no longer allowed to harvest any green turtles for subsistence use. Efforts to develop an alternative income source for former turtle consumers were initiated by CCC and the Costa Rican National Park Service in 1990 with the establishment of a tour guide training program. Tourists wishing to see nesting

turtles at night must now be accompanied by a licensed tour guide. The number of visitors paying to go on turtle walks has increased dramatically since 1990, reaching 20,885 tourists in 1999. The revenue from the turtle walks amounts to a minimum of US\$104,425 for 150 licensed guides.

Expanded cooperation between the Tortuguero community, conservation NGOs including CCC, and government agencies (MINAE) is suggested in order to ensure continued success for sea turtle conservation in Tortuguero.

ACKNOWLEDGMENTS

Tortuguero Conservation area staff provided support in preparing this talk. Caribbean Conservation Corporation provided the funding for the authors to participate in this symposium. Eddy and Alonso Rankin conducted track surveys to monitor illegal harvest 1997-1999. Many thanks to the Tortuguero tour guides for showing the world that a turtle is worth more alive than dead.

Ban on Green Turtle Fishing Results in Increased Cooperation Between Fishermen and Conservationists

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The cooperation between conservationists and turtle fishermen in Limón, Costa Rica has traditionally been limited due to opposing views on turtle exploitation. In 1989, an effort was made to increase the communication between the sides but these activities were temporary and the dialog stopped. In 1998, a multi-institutional commission comprising NGOs, local and national government agencies was set up to review the use and protection of sea turtles in Limón. After visits to the licensed turtle slaughterhouse and discussions with fishermen, the commission concluded that enforcement of the quota for green turtle harvest was insufficient. Fishermen could sell turtle products openly, with or without permits. Hence there was no incentive for them to seek cooperation. In February 1999, the Constitutional Court of Costa Rica ruled to ban the green turtle fishery. Increased communication began after the court ruling. Two fishermen participated in a regional sea turtle conservation workshop in April 1999. Additional meetings between conservationists and fishermen followed. A joint proposal to seek government compensation for the turtle fishermen was developed and other cooperative projects were

identified. To date, the Ministry of Environment has approved the proposal and funds are expected to be made available to the affected fishermen in the near future. A joint awareness campaign with posters and TV advertisements has been implemented. Possible future activities include the construction of a cooperative run processing plant for sea food produce, turtle watching by boat, a national awareness campaign, a nesting beach project, construction of a museum/visitors' center, sale of legally harvested turtle eggs from Ostional, education for fishermen with regards to sea turtles and sustainable fishing techniques.

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Population Dynamics of Hawksbill Turtles at Mona and Monito Islands, Puerto Rico

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A large aggregation of hawksbill turtles inhabits the waters surrounding Mona and Monito Islands, Puerto Rico. In-water studies conducted by us since 1992 have yielded detailed information on individual juvenile and adult turtles.

An assessment of capture-recapture data, annual abundance of recruitment size turtles, and measured somatic growth rates, form the basis for the present analysis of hawksbill population dynamics.

Convergence of Green Turtles (*Chelonia mydas*) on the Cuban Shelf

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INTRODUCTION

The Cuban platform constitutes an area of reproduction, feeding and migratory path for different species of sea turtles, in which populations from Cuba and other regions converge, as is the case for the green turtle *Chelonia mydas*. This can be found in this work, from tag-recapture data and results from DNA studies.

METHODS

Information was obtained from 36 green turtles recaptured from the tagging activities in Cuba between 1989 and 1997, and from 129 green turtles tagged in other regions, that were recaptured in the Cuban platform between 1959 and 1998. The information was based in the data given by Cuban fishermen and in data obtained from the institutions that tagged the animals (Table 1). For the genetic work 15 green turtle embryos were analyzed from nests collected between June and August of 1998, by the Biology School from Universidad de La Habana, in Playa Antonio, Peninsula de Guanahacabibes. Each embryo was fixed in 70% ethanol and transported to the laboratory in which the total DNA was extracted. A fragment of the control region in the mitochondrial DNA was amplified using the primers TCR-5 and TCR-6 from Norman *et al.* (1994). From this fragment 385 bp were sequenced, the sequences were compared with those obtained from numerous green turtle colonies of the Atlantic and Pacific by Encalada *et al.* (1996). Since the sequenced fragment does not coincide exactly with those obtained by the referred authors, only the common segment was analyzed. Therefore, the haplotypes I, III and XVIII from Encalada *et al.* (1996) are included in the haplotype Cuba II, since in the fragment flanked by TCR-5 and TCR-6, all 385 bp are alike (Espinosa *et al.*, 1999).

RESULTS AND DISCUSSION

From 36 recaptures (22 females, two males and 11 unknown), 21 were recovered within the Cuban platform and 15 in other areas, in U.S., Honduran, Nicaraguan, Costa Rican and Panamanian waters. From the 129 recaptures in Cuba of turtles tagged in other places, individuals were found tagged in Costa Rica (71), Grand Cayman (18), United States (13), Mexico (11), Bahamas (4), Bermuda (3), Virgin Islands (1) and Venezuela (1). They were found distributed mainly in the southern coast. From the seven remaining tags, the original tag site is unknown. Considering the stage of the life cycle of the individuals recaptured in Cuba (both from the national tagging program and international ones), it can be said that the Cuban platform gathers green turtles in feeding and growing stages, green turtles that nest and feed in the Cuban archipelago and turtles that feed in Cuba and nest in other regions. This is confirmed by recaptures of turtles tagged in Cuba as subadults and found later in Florida, adult individuals tagged in beaches Isla de la Juventud and reported 4.6 years later in Punta de Ganado, Cuba, and adult turtles tagged in Cuba, reported nesting later in Costa Rica. It is also confirmed by green turtles found in Cuba tagged in other regions: 71 individuals (60%) were nesting females from Costa Rica and the rest (40%) were juveniles and subadults from other countries. It is known that green turtles tagged in Tortuguero, Costa Rica, migrate mainly to Cayos Miskitos, Nicaragua, which is their principal feeding area, and to other minor sites such as the Cuban platform. Considering that these turtles migrate to feeding grounds after the reproductive season and do not return to Tortuguero for two, three or four years (Carr *et al.*, 1978), it seems that some of them stay for that time feeding in the Cuban platform. This is demonstrated by 60% of the individuals tagged in Tortuguero were recaptured in Cuba in months out of the reproductive season, and that 25% were found in reproductive months but in Cuban feeding grounds.

It is very likely that these animals were not ready to nest in that year. The remaining 15% of the recaptures were found in months that coincide with the start of the reproduction, and in areas far from the feeding sites, therefore it is likely that they were heading towards the reproductive areas. With respect to the rest of the recaptures recorded in Cuba, the ones from Grand Cayman, released being one year old (Wood and Wood, 1993), were recaptured in juvenile stages between 30 and 40 cm in length. These animals probably headed to the Cuban platform in order to feed and grow to sizes close to sexual maturity, since individuals coming from that area were found as large as 70 cm. Since in Cuba exist areas with optimal conditions for feeding and nesting for the green turtle, such as Canarreos Archipelago and Cayería Doce Leguas, it is possible that overlap occurs with those populations coming from other regions to feed and nest. According to Carr (1980) feeding and nesting may be possible in an area with optimal conditions (water temperature above 15°C) and therefore there may be no ecological obligation for this species to abandon the area. It seems that some individuals stay in Cuban waters, which contribute to overlapping. Results obtained by Meylan *et al.* (1990) with genetic studies also confirm overlapping of populations in different areas of the Caribbean. In relation to DNA results, the only nesting population in Cuba characterized by a genetic marker was Playa Antonio, Peninsula de Guanahacabibes (Espinosa *et al.*, 1999). While comparing three haplotypes obtained with those reported by Encalada *et al.* (1996), it was found that two of them were new for the species. These haplotypes are Cuba I [different from haplotypes I, II and XVIII from Encalada *et al.* (1996) in the addition of 6 bp in position 540. Cuba II: Identical to haplotypes I, II and XVIII for the sequences fragment]; Cuba III (different from haplotypes I, II and XVIII by a transition of C for T in position 321). This haplotype corresponds to the hypothetical haplotype Hyp I suggested by Encalada *et al.* (1996) in their parsimony analysis. Table 2 shows the frequencies for these haplotypes and compares to those obtained by Encalada for regions close to the Guanahacabibes Peninsula, in which tag-recapture studies indicate interchange. The table shows that the haplotype Cuba II is the same one found in Costa Rica, Florida and Mexico, nevertheless, the haplotype with highest frequency was Cuba I, which could be originated from the former one or vice versa, since the difference is one mutational step. The haplotype Cuba III is also a new haplotype, that also satisfies the conditions of the hypothetical one suggested by Encalada *et al.* (1996), and completes the scheme for the Caribbean region. The values for haplotypic and nucleotide diversity for the Cuban population are 0.65 and 0.0011 respectively, values that are in between those referred by Encalada *et al.* (1996) for the nesting colonies in Florida (0.56) and Mexico (0.82). This result could indicate that the Cuban colony is a product of a "mixture" from the immigration of animals from diverse sources, due to the geographical position of the island. The analysis of the results suggests that at the Cuban waters, an

interchange exists of individuals from different populations from Central America and the Great Caribbean, both adult and subadults. Some individuals may feed at the platform and later migrate to nest to other areas, others migrate to the platform to feed in other locations and others come to nest to the Cuban platform, maybe by chance, and then establish and give place to a new colony. An example can be found in the situation of Peninsula de Guanahacabibes. Therefore, studies should be coordinated with the countries that share such populations.

CONCLUSIONS

In the Cuban platform there is an interchange or overlapping of green turtles from different populations from Central America and the Great Caribbean, both from adult individuals and subadults; some of them feed in the platform and later migrate to nest to other areas, others migrate to the platform to feed in other places and others come to nest to Cuban beaches. There is a high degree of endemism in the haplotypes found. The nesting population at Peninsula de Guanahacabibes (or in other areas of the Cuban platform) plays an important role in the understanding of the phylogenetic relationships between different populations of the Western Caribbean, therefore it should be important to characterize the genetics of other nesting areas in the Cuban platform.

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Table 1. Place of origin of the tags and life stages of the green turtles tagged in other regions and recaptured in Cuba.

Origin	Life stages	Researchers
Tortuguero, Costa Rica	71- nesting females	A. Carr, K. Bjorndal and J. Ottenwalder
Florida, E. U.	13- juveniles released from captivity and subadults	J.Ottenwalder, K. Bjorndal and C. Lagueux
Grand Cayman	18- juveniles released from captivity	J. Wood
Yucatan, Mexico	11- juveniles and subadults	R. Márquez
Inaguas, Bahamas	4- subadults	J. Ottenwalder and K. Bjorndal
Bermuda	3- unknown	A. Meyland
Aves Island, Venezuela	1- unknown	C. Lagueux
Virgin Islands	1- nesting female	J. Ottenwalder
Unknown	7- unknown	

Table 2. Distribution of the haplotypes found in nests of the areas connected to the cuban population (Mexico, Costa Rica and Florida) according to capture and recapture data (Moncada, 1998). The haplotypes marked with supraindex ^a and ^b include haplotypes (I, II, XVIII) and (I, V, XV, XVI, XVII) respectively from Encalada *et al.* (1996). The frequency data from Mexico, Costa Rica and Florida are also from Encalada *et al.* (1996), adjusted for the region flanked by primers TCR-5 and TCR-6.

Haplotypes	Populations			
	Cuba	Florida	Mexico	Costa Rica
Cuba I	8(0.53)			
Cuba II ^a	4(0.27)	23(0.96)	15(0.75)	15(1.00)
Cuba III	3(0.20)			
II ^b		1(0.04)		
V ^b			1(0.05)	
XV ^b			1(0.05)	
XVI ^b			1(0.05)	
XVII ^b			2(0.10)	

Sea Turtle Populations of the Chagos Archipelago, British Indian Ocean Territory

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INTRODUCTION

The Chagos Archipelago, located approximately midway between Africa and Indonesia and 1000 km east of Seychelles, is one of the most isolated island groups in the world. Chagos comprises five islanded atolls and a number

of submerged banks in an area of about 60,000 km² (Fig. 1). The islands are a British Territory with an unusual history of human settlement that began in 1780. During most of the past two centuries they were intensely exploited for production of coconuts. Undoubtedly human impact on the turtle populations was intense due to consumption of meat,

export of tortoise shell (Frazier, 1977), and the impact of feral animals such as dogs, cats, pigs and rats on the turtle rookeries (Mortimer and Day, 1999). In 1970-71, the British Government evacuated all the local people to Mauritius in order to establish an Anglo-American military base on Diego Garcia. Today, only Diego Garcia is inhabited. Prior to 1996, the most comprehensive study of Chagos turtles was made in 1970 during a five-day visit by Frazier (1977). R. Dutton (1980) also made some valuable observations over several weeks in 1978-79. During six weeks in 1996, JAM was able to visit all five atolls as a member of a multi-disciplinary international yacht-based scientific expedition. She surveyed the turtle nesting populations and habitats on 49 of the 67 islands (Mortimer and Day, 1999), collected genetic samples (Mortimer and Broderick, 1999), and plasma samples to evaluate sex steroid concentrations (Mortimer and Crain, 1999). JAM and MD returned to Diego Garcia in 1999.

RESULTS AND DISCUSSION

Nesting Populations

Both green turtles (*Chelonia mydas*) and hawksbills (*Eretmochelys imbricata*) nest on all five atolls. During the 1995-96 season, we estimated that roughly 300-700 hawksbills and 400-800 green turtles nested in Chagos (Mortimer and Day, 1999). The relative proportion and numbers of each species varied from atoll to atoll. While hawksbills were relatively more abundant at Peros Banhos and Diego Garcia, green turtles nested in greatest numbers at Egmont Islands, Chagos Bank and Diego Garcia (Mortimer and Day, 1999). Particularly significant green turtle rookeries were discovered at Danger and Sea Cow islands on the Chagos Bank. Growth Rates and Migrations of Foraging Hawksbills The military base occupies only the north west quadrant of Diego Garcia; most of the rest of the atoll is managed as a Nature Reserve. At the far south end of the inner lagoon is a tidal creek called 'Turtle Cove' (Fig. 1) which provides foraging habitat to significant numbers of immature hawksbill turtles (Mortimer and Day, 1999). On rising and falling tides, water flows in and out of Turtle Cove carrying bony fish, rays, sharks, and hawksbills along with a few juvenile green turtles. Larger sea turtles are found near the mouth of the creek and smaller ones move into its shallower reaches. A mark and recapture study of the foraging hawksbills at Turtle Cove was initiated by JAM in February 1996, and continued in collaboration with MD in February 1999. All turtles were captured by hand at low tide. During both the 1996 and the 1999 sampling periods, 41 immature hawksbills were captured, tagged, weighed, measured, and sampled for DNA and plasma. The size distribution of the turtles ranged from 32 to 71 cm straight-line carapace length (SLCL). Of the 41 hawksbills captured in 1996, 27 (66%) were recaptured exactly three years later in 1999. The rate of recapture was highest among the largest animals. When first encountered in 1996, the 27 hawksbills

recaptured in 1999 had carapace lengths between 36 and 69 cm (SLCL). Three years later, in 1999, they had grown by an average of 1.4 cm/year. Increases in carapace length were highest in the smallest size classes. Average annual growth rates for individual turtles ranged from 0.3 to 2.7 cm/year. These are similar to growth rates reported for hawksbills on the southern Great Barrier Reef of Australia (Chaloupka and Limpus, 1997).

Genetic Analyses of the Hawksbill Populations

Patterns of mitochondrial DNA variation were used to determine genetic relationships between hawksbill populations in the Chagos Archipelago and those in three adjacent localities: the Republic of Seychelles, the Arabian Peninsula, and western Australia (Mortimer and Broderick, 1999). Damien Broderick (DB) conducted the mtDNA analyses in the laboratory of Craig Moritz at the University of Queensland, Australia. Genetic samples from nesting hawksbills were collected in: Chagos (n = 9, by JAM); Arabian Peninsula (n = 14, by Jeff Miller); Seychelles (n = 73, by JAM); and western Australia (n = 31, Broderick *et al.*, 1994). Foraging hawksbill populations were sampled by JAM in Chagos (n = 50) and in Seychelles (n = 191). The analyses revealed that nesting hawksbills of Seychelles and Chagos have high frequency mtDNA variants not recorded elsewhere in the world, and also that slight frequency shifts separate the two populations. The foraging populations of Seychelles and Chagos, however, did not differ significantly from each other. Rookeries in Seychelles appear to be a major source of juveniles for both the Seychelles and Chagos foraging populations. Notably hawksbills from western Australian rookeries were not represented in either foraging population. The possibility that Arabian Peninsular or other yet unsampled stocks in the region make significant contributions to these foraging populations cannot be ruled out (Mortimer and Broderick, 1999; Broderick, Doctoral Thesis, In preparation). To better understand hawksbill migrations in the region, more genetic samples need to be collected and analyzed from hawksbill rookeries in Chagos, Madagascar, Mayotte, and along the east African coast from Tanzania to Eritrea. Awareness Campaigns for and Collaboration with Base Personnel During their 1999 visit, JAM and MD formed a 'Turtle Conservation Team' (TCT) led by the NSF Environmental Office and consisting of volunteers from base personnel. The TCT continues to collect data on seasonal nesting patterns at index beaches at Diego Garcia. Interpretive signboards explaining the significance of the turtles and other wildlife in Turtle Cove are being produced. Incoming base personnel receive briefings on the importance of turtles on arrival at Diego Garcia.

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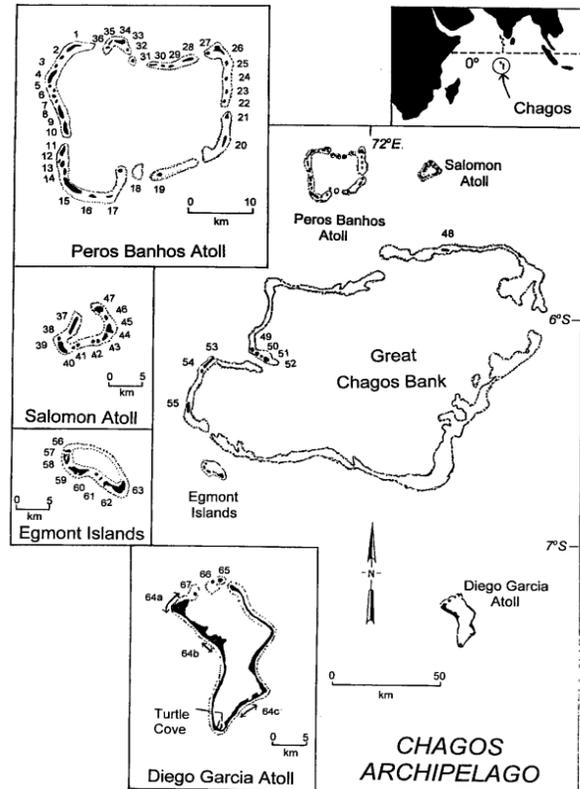
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Fig. 1. Map of Chagos Archipelago.



Studies of Marine Turtle Fibropapillomatosis in Mexico: An International Collaboration of Research and Training

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The international agreement of Mexus Pacifico has been for several years a vehicle for cooperation between the U.S. and Mexico Pacific coasts to manage and conserve fisheries stocks that cross international boundaries. Sea turtles are under the jurisdiction of National Marine Fisheries Service in U.S. and Instituto Nacional de la Pesca (INP) in Mexico. The INP's Centro Mexicano de la Tortuga (CMT) requested the support for cooperative work regarding methodology, training of scientists and research tools available to initiate the study of fibropapillomatosis (MTFP) in nesting olive ridley and other turtle populations. La Escobilla beach is located in the central region of the State of Oaxaca, Mexico. It is considered the most important nesting sanctuary of olive ridley turtles in Mexico and one of the three most important nesting beaches presenting the largest 'arribadas' in the world.

Fibropapillomatosis is a neoplastic disease that primarily affects green turtles in epidemic proportions. Although several infectious agents (herpesvirus, retrovirus and papillomavirus) have been associated with the condition, the etiologic agent has not been isolated or characterized. Causes of disease or natural mortality are mostly unknown for olive ridley turtles. The first report of fleshy tumors on the head, neck and front flippers of nesting olive ridley females occurred in Costa Rica in 1982. During the 'arribada' of October 1987, a nesting female was photographed demonstrating grossly multiple cutaneous tumors with the largest measuring 30 mm in diameter. Since that time, and based on field observations, both the prevalence and the size of skin tumors in individual animals have increased in Costa Rica and Mexico.

Surveys performed by personnel of CMT demonstrated an average MTFP prevalence of 3% by gross examination of many thousands of nesting females. A total of 88 biopsies of 48 nesting turtles were histopathologically analyzed. From these, 45% were classified as fibropapillomas, 47% as normal skin and 6% were focal areas of dermatitis. Sixteen (40%) of the tumors presented a cell-mediated immune response similar to regression. These results are comparable to the histopathology previously reported for MTFP of

olive ridleys in Costa Rica in which 42 of 50 biopsies collected were diagnosed as MTFP and eight were classified as chronic active dermatitis and not tumors. Twenty of 42 fibropapillomas were in stages of regression and nine of the remaining 22 tumors had histological changes that suggested early degeneration within the tumor (Aguirre *et al.*, 1999).

For the past three years this collaboration has permitted scientists in Mexico to submit their specimens for histopathologic evaluation. Tumors have been analyzed from other species including white turtles, Kemp's ridley turtles, and leatherback turtles. The first confirmed case of MTFP was reported in leatherbacks (see Sarti *et al.* This volume).

This international collaboration has permitted training of Mexican biologists and veterinarians. Visits on site and to NMFS Honolulu Laboratory have permitted close collaboration and extensive training in necropsy techniques, sample collection and handling, and processing. Likewise, several training courses have been given on site to train field personnel in biology, management, diseases and conservation of sea turtles. Mexus Pacifico has also been effective in developing field research of MTFP. Seasonal sampling of nesting females and males captured while snorkeling, have provided a detailed data base which includes hematology information, natural history data, and documentation of MTFP. Future efforts will emphasize pathology training of Mexican veterinarians and the development of a national data base and tissue bank for sea turtles in the country.

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Immunology of Green Turtle Fibropapillomatosis in Hawaii

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Fibropapillomatosis is a neoplastic disease with global distribution that poses significant threat to marine turtles like greens, loggerheads and olive ridleys. In endemic areas, prevalence of FP in green turtles in Hawaii can reach up to 80%. Previous work in Hawaii revealed hematologic changes in green turtles afflicted with FP that were suggestive of immunosuppression. A trial with captive green turtles in Hawaii evaluated tools to assess immune

response in this species and found that both cell mediated and humoral immune response can be measured. Cell mediated immune response of free-ranging green turtles with and without FP was measured on Oahu and Hawaii. Cell proliferation assays (CPA) indicate that turtles moderately to severely afflicted with FP are immunosuppressed; however, immunosuppression does not appear to be a prerequisite for manifestation of FP in green turtles.

Epizootiology of Green Turtle Fibropapillomatosis on the Florida Atlantic Coast

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Since 1982, the juvenile green turtles of the Indian River Lagoon (IRL), Indian River County, Florida, have exhibited a high prevalence of fibropapillomatosis. Between January 1998 and October 1999, we captured 289 green turtles in the IRL and 255 green turtles over worm rock reefs, near shore in the Atlantic at the same latitude. The prevalence of green turtle fibropapillomatosis (GTFP) in the IRL and near shore reef populations are 63% and 14.5%.

Subjective FP severity scores were given to all green turtles (score 0, non-diseased; score 1, mildly afflicted; score 2, moderately afflicted; score 3, severely afflicted). The frequencies of GTFP severity scores 0, 1, 2, and 3, are 35%, 33%, 23%, and 9% respectively in the IRL population. Among GTFP turtles, 29% showed regression

of FP tumors (over 88% of turtles showing regression are score 1; none of them is score 3). The mean carapace lengths of IRL green turtles by severity score are: score 0 = 50.4 cm, score 1 = 40.9 cm, score 2 = 40.3 cm, Score 3 = 40.3 cm, and regressed = 44.6 cm. One of our significant findings is that as the carapace length increases the number of diseased turtle's decrease. This relationship between size and severity of GTFP is the opposite seen in Indonesian and Hawaiian green turtles.

Health indices such as packed cell volume, hemoglobin concentration, and total protein values were examined as indicators of general health of individuals. All of the index values decrease significantly as the severity of GTFP increases; the diseased turtles are chronically anemic.

Helminth Parasites of the Loggerhead in Florida

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Fourteen loggerheads (*Caretta caretta*) that had died prior to or during rehabilitation efforts were necropsied at the University of Florida, College of Veterinary Medicine during 1998 and 1999. These were turtles which stranded in Florida and their carapace lengths varied from 49 to 103 cm in length. One species of aspidogastrid fluke, 19 species of digenetic flukes, four species of nematode and one species of trypanorhynch tapeworm (larva) were recovered from these turtles. The majority of the helminths were recovered from the gastrointestinal tract, but two species of blood flukes were found in the blood vessels or heart and one other fluke was from the urinary bladder. The average

number of helminths recovered from a loggerhead was 2581(69-9475). The 19 digenetic flukes ranged from 1/14 to 12/14 turtles infected with each species. The intensities of infection for these species ranged from two to 1405 flukes/infected turtle. The four nematode species were recovered from six to nine turtles. Only 3/14 harbored the aspidogastrid fluke (*Lophotaspis vallie*) and the mean intensity of infection was 42 flukes/infected turtle. *Orchidasma amphiorchis* was the most common helminth detected and it was the most numerous as well. The larger the turtle the more diverse the helminth fauna.

Habitat Characterization of the Feeding Grounds of Juvenile Hawksbill Turtles in Rio Lagartos, Yucatan, Mexico

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Coasts of the Río Lagartos Biosphere Reserve are feeding grounds of an important population of juvenile hawksbill turtles. In order to characterize the benthic habitat of these turtles, we carried out three video transects of five minutes in 12 georegistered sites in which we had observed or captured juvenile hawksbill turtles. In the laboratory, we analyzed visually 20 frames of each video transect covering a 2.5 m² area. In each frame, we identified to the finest possible level the observed organisms and we registered their percent of cover with the random points method. Using resulting data, we calculated the ecological indexes of each site and we carried out a multivariate

statistical analysis. In a general view, we observed that juvenile hawksbill turtles grow in five habitats: *Coordilleras*, characterized by great amount of rocky substrate and scabby sponges, as well as macroalgae and gorgonias; *Pastizales*, where the sea grasses are the dominants elements and the general diversity is low; *Pedreríos*; *Ramales*, where we registered high covering of gorgonias, macroalgae and rocks; and *Múcaros*, where the dominants elements were the sponges. The first one is the preferential habitat of the juvenile hawksbill turtles, these results agreed with other studies.

Evaluation of Green Turtle Habitat, Population Size and Distribution Using Remote Sensing and GIS Techniques

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INTRODUCTION

The Bermuda platform includes a group of more than 100 closely linked islands covering about 50 km² on the southeastern rim of a seamount in the western North Atlantic. The remainder of the seamount is several hundred square kilometers of coral reefs and shallow lagoons. Although green turtles no longer nest in Bermuda, they use the island's seagrass meadows as feeding grounds. These green turtles are immature and arrive from nesting beaches in Florida, Suriname, Costa Rica, Aves Island and possibly Ascension Island. Studies indicate that Bermuda lacks very small size classes as well as sexually mature adults. This supports the hypothesis that Bermuda is a developmental habitat for green turtles (Meylan, Meylan and Gray, 1999; Meylan and Meylan, 1999; Meylan *et al.*, 1994).

The size of Bermuda's resident green turtle population has not been previously estimated. Because of the steady turnover in population, traditional mark and recapture methods are difficult to use, and the adoption of new methods for population estimates became necessary. This study explores the use of GIS and remote sensing as tools for producing an estimate of population size and carrying capacity.

In order to assess a given biological resource, it is essential to estimate its habitat area (Bour *et al.*, 1986). To

accomplish this, a quantitative relationship must be established between the density of the target species and habitat type. An estimate of abundance is then made by multiplying the density of a species in a sampled area of habitat by the total area of that habitat. This technique is used for estimating green turtle population size in Bermuda.

It might seem that it would be difficult to estimate the density of a species, members of which are excellent swimmers and have highly migratory life cycles. However, the Bermuda turtles have been found through tag and recapture studies to remain faithful to given feeding areas. The green turtle is herbivorous once past its oceanic (post-hatchling) stage, and throughout most parts of its range it feeds mainly on seagrass pastures. Where seagrasses are lacking, algae form the bulk of the diet. Green turtles in Bermuda also frequently maintain grazing plots similar to those documented in the Caribbean by Bjorndal (1980) and others.

Specifically, the present study aimed to answer the following questions.

1. Can remote sensing and GIS technology be used to help estimate the numbers of green turtles resident on the Bermuda Platform?

2. Can the carrying capacity of Bermuda's seagrass beds be estimated? Can more turtles be supported than are currently present in the area, or has the carrying capacity already been reached?

METHODS

A combination of SPOT data and high-resolution aerial photography were used to produce a map of the benthic habitats of the Bermuda platform. A June 1987 SPOT satellite image of Bermuda was obtained from the Florida Department of Environmental Protection's Marine Research Institute through a collaborative agreement, and was augmented with a set of aerial photographs from 1988 and 1991. Aerial video from 1995 was also used during the groundtruthing process. A digitized bathymetric chart and coastline files were obtained from the Florida Marine Research Institute and used for georeferencing.

The image was stratified into approximate depth and turbidity regions prior to classification. Because depth related zonation in Bermuda's marine areas is well documented, bathymetric variation was emphasized during the classification process. To this end, two depth-related pseudochannels were created and used for classification along with the XS1 and XS2 bands in the rapidly deepening rim reef and central lagoon areas. These were the 1st principal component of the XS1 and XS2 bands, and the XS1 band radiances logarithmically transformed into an index of water depth according to an equation described by Stoffle and Halmo (1991). A texture pseudochannel was also created and used to complement spectral classification in the shallower inshore and nearshore areas. Final classification was performed using a combination of supervised (Maximum Likelihood) and unsupervised techniques. After classification, the stratified regions were mosaicked back together to produce the completed map. GIS analysis was used to edit the classes produced by image classification. The map was assessed for accuracy by using a stratified random sampling strategy with a total of 222 points, the habitat type of which was checked in the field.

Through monthly sampling with nets, data on turtle density have been gathered by the Bermuda Turtle Project. The sites are shallow (less than 20 ft) seagrass beds or areas of sand interspersed with seagrasses and/or algae. At the start of sampling, the capture team scouts the location by watching for turtles surfacing to breathe from a small boat. Once one or several turtles are sighted, the capture boat towing a net boat containing 2000 ft of 4 in mesh net, circles the area laying out the net in a circle around the location where turtles were sighted. Snorkellers swim the perimeter of the net to catch the turtles once they became entangled. The turtles are loaded on the boat for measuring, weighing, and tagging. Blood samples are taken for hormone assays and genetic analysis, and most turtles are released as soon as the measurements and tagging are completed. A portable Global Positioning System (GPS) is used to record the capture and release positions. Data on water temperature and depth are also collected for most of the locations (Meylan and Meylan, 1992).

In order to provide a direct link between the numbers of turtles and the benthic characteristics of that area, data on turtle numbers and habitat type were obtained simulta-

neously. Furthermore, the quantification of habitat characteristics had to take place inside of the turtle net, so that it could be ensured that the captured turtles were feeding on the seagrasses documented in the benthic studies. A diver, swimming a predetermined pattern consisting of randomly selected combinations of compass headings and kick cycles, photographed a total of 10 to 15 0.5 m² quadrats at each site. Concurrently, notes about the species of seagrasses and algae present, the length of the shoots, epiphytic coverage and the presence of turtle grazing marks and scars, were made for each quadrat. Turbidity (secchi disk) was recorded at each site. The method allowed for rapid sampling within the limited time period available during turtle capture operations. The photographs were later analyzed for percent cover of seagrasses and macroalgae.

Next, the extent of suitable habitat area was calculated from the map produced from SPOT satellite data. Only the habitats covered in seagrass and/or algae were considered in the calculations. An estimate of turtle numbers was then calculated by multiplying the mean number of turtles per sample unit in each of the habitat classes by the total area of that class. The area covered by the turtle net, approximately three hectares, was used as the sample unit in the calculations. The maximum number of turtles present was also calculated in the same manner using the maximum catches in each habitat category. The maximum number of turtles gives an upper limit to the turtle density estimates. In order to estimate the size of error introduced during the turtle capture operations, standard error was calculated for the numbers of turtles captured in each of the habitat categories during the total study period. The standard deviations were weighted according to the size of the sample in each category. These sample errors were then used to estimate the 95% confidence limits for the abundance estimates.

Carrying capacity was calculated using Bjorndal's (1985) estimate of 138 adult green turtles per hectare of seagrass area, or one turtle per 72 m². Bjorndal's estimate was calculated based on the physiology of adult green turtles and nutrient value of seagrasses in the Bahamas. For the Bermuda carrying capacity estimates, all available area covered by vegetation was considered in the calculation, including those areas, where algae, not seagrass is dominant. The carrying capacity of some seagrass categories was adjusted according to their estimated percent of the maximum possible carrying capacity.

RESULTS AND DISCUSSION

The benthic habitat map was assessed for a total accuracy of 79.9%. The classification of seagrasses was problematic because seagrass percent cover in Bermuda fluctuates considerably on a seasonal and an annual basis. Because of this, the use of a classification system based on density was not possible. Instead, a new classification

system was devised and based on the seagrass area's location. Four main areas of seagrass classes were selected: the rim, the lagoonal, the nearshore, and the inshore seagrasses. The nearshore and inshore classes were further separated into two subcategories of "nearshore seagrass" and "nearshore seagrass and algae". Similarly, inshore seagrasses were separated into "inshore seagrass and algae" and "inshore algae". The map can be seen in Figure 1.

The estimated number of turtles present using average densities in the calculations is 1880, and 7539 if maximum densities are used. The total 95% confidence interval is ± 61 turtles. However, it should be noted that the confidence limits only relate to the error caused by turtle capture operations, but not the portion of error caused by mapping inaccuracies. The total combined error is likely to be considerably higher.

Green turtle distribution in Bermuda appears to be function of a combination of benthic habitat type (biotic) and abiotic factors. Seagrass type and quality is a significant factor in turtle distribution, but other factors are also involved. More research is necessary to identify these factors and their significance in determining turtle distribution, as not enough data is available to do this presently. There is also a need to apply multivariate statistical analysis to discern the relative importance of various biotic and abiotic environmental factors on green turtle distribution.

The combined use of remote sensing, GIS and field work presents a new method for estimating green turtle abundance. Although the results from this study are only a rough estimate of the number of green turtles in residence in Bermuda, they indicate that the method was successful and can form a basis for further research. Future studies will document the extent of seasonal fluctuations and monitor the percentage of macroalgae in seagrass meadows, especially in the inshore waters, where an increase in macroalgal coverage may be an indicator of eutrophication. Although the current study found that turtles were present in numbers well below their carrying capacity, this carrying capacity may be reduced with fluctuations in seagrass coverage and with increasing eutrophication in inshore waters. Future research will aim towards monitoring the health, distribution and fluctuation in the density and composition of Bermuda's seagrass meadows, and use this data to better model the distribution and dynamics of the area's green turtle population.

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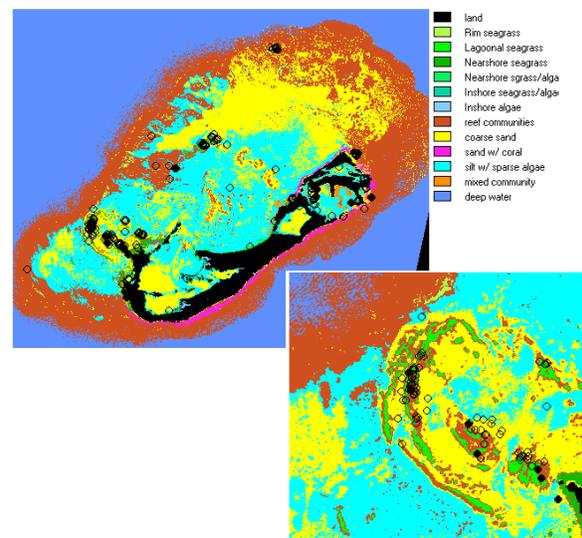
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Fig. 1. Simplified Bermuda marine habitat map with all seagrass categories included. Turtle capture locations are overlaid. Inset shows a closeup of the western seagrass flats.



Feeding Grounds of Adult Female Loggerhead Turtles, *Caretta caretta*, in the Western North Pacific Ocean Estimated by Carbon and Nitrogen Stable Isotope Analyses of Egg-yolks

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INTRODUCTION

Adult female loggerhead turtles (*Caretta caretta*) nesting in Japanese Archipelago have been supposed to overwinter in the East China Sea, which is a vast continental shelf in the western North Pacific Ocean (Kamezaki, *et al.*, 1997; Sakamoto *et al.*, 1997). However, more tagged females have recently been recaptured in the coastal waters of Japan during the post-nesting season (Bando, 1997; Hatase, unpublished) and thus their feeding ground in the season is not yet clear. In this study, carbon and nitrogen stable isotope ratios ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) of the egg-yolk were compared between two distant nesting grounds in Japan considering the body size of nesting females, in order to examine the feeding grounds after nesting.

In general, $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ in animals increase at a constant enrichment factor according to the trophic level in marine ecosystem (Hobson and Welch, 1992) and thus the isotope signatures of higher consumers, such as turtles, reflect the values of the primary producers through their feeding on intermediate consumers. Hence, the isotopic temporal and spatial variations of the primary producers give rise to similar variations in the turtle's signatures. We examined the signatures in the egg-yolk which would provide the information on the feeding of adult female turtles in winter, which was when their vitellogenesis was suggested to occur mainly (Rostal *et al.*, 1998).

METHODS

A total of 44 eggs (one egg per individual) were collected from Minabe (33°46'N, 135°18'E) in 1998-1999 and 105 eggs from Yakushima (30°24'N, 130°26'E) in 1999. Also, oviposited females were identified by tagging and their straight carapace lengths (SCL) were measured. Eggs were kept at -20°C. Yolk was taken and dried at 60°C, then lipids were removed with a chloroform-methanol (2:1) solution. Lipid-removed yolk was ground to a fine powder. Approximately 0.5-1.0 mg of powdered sample was used for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ measurements. Isotopic ratios were determined using a Finnigan MAT Delta S mass spectrometer interfaced with a Carlo Erba elemental

analyzer. The analytical precision was within 0.2‰ for both isotopes.

RESULTS

There were significant positive correlations between $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ in Minabe except for the turtles not less than 900 mm in SCL (Fig. 1a, Table 1). In Yakushima, on the other hand, similar significant positive correlations were found in the smaller turtles not more than 850 mm in SCL, while a clear relationship was not observed in the larger turtles over 850 mm in SCL (Fig. 1b, Table 1). Both the averaged $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ values increased with SCL in both nesting grounds except for the turtles not less than 900 mm that had nested in Yakushima.

DISCUSSION

The clear-cut positive correlations between $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ may reflect the nearshore-offshore local variations of their feeding grounds. Nearshore-feeding animals have relatively higher $\delta^{13}\text{C}$ values than offshore-feeders (e.g., Burton and Koch, 1999), which is probably caused by differences in the isotopic composition of the primary producers at the base of the food web. Since both isotopic values increased in larger turtles in both areas, it was also suggested that there was a size-related difference in their habitat areas. The differences of the results between the two nesting grounds may be related to the distance between each nesting ground and the East China Sea which has been regarded as the main feeding ground, since Minabe is about 600 km far away from Yakushima, which is close to the East China Sea. Hereafter, the isotopic characteristics must be examined in the East China Sea, and other estimated feeding grounds.

ACKNOWLEDGMENTS

We thank many volunteers for helping to collect eggs at night on beaches in Minabe and Yakushima. We also thank

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Fig. 1. The $\delta^{13}\text{C}$ - $\delta^{15}\text{N}$ maps for adult female loggerhead turtles, *Caretta caretta*, nested at (a) Minabe and (b) Yakushima. Individuals are shown as four symbols which are divided by straight carapace length; (X) < 800 mm, (O) 800-850 mm, (♦) 850-900 mm and (■) \geq 900 mm.

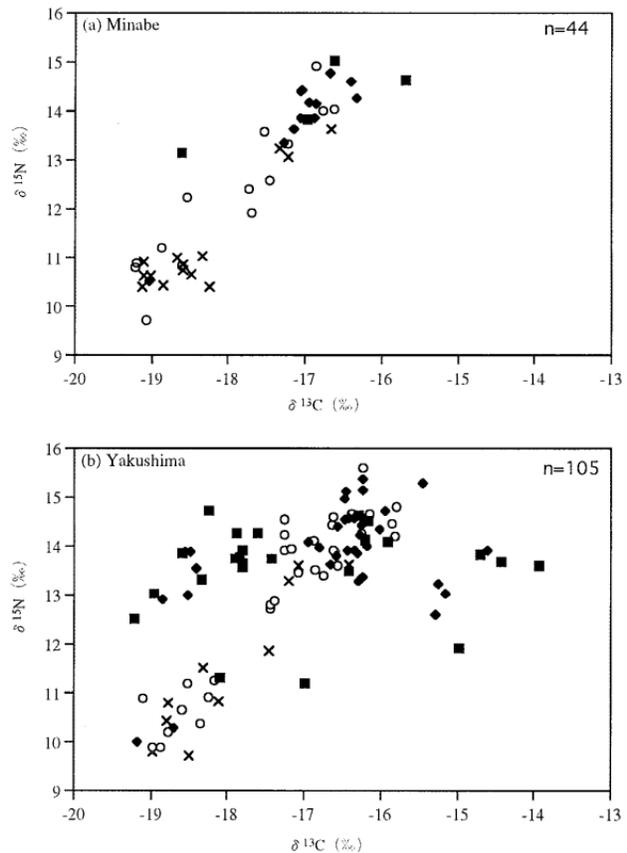


Table 1. Stable isotope ratios of adult female loggerhead turtles, *Caretta caretta*, grouped by straight carapace lengths (SCL). Values are given as the means \pm SD. Spearman's rank correlation coefficients (r) and probability levels (p) between $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ are also shown (ns = not significant).

SCL (mm)	Minabe					Yakushima				
	N	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	r	p	N	$\delta^{13}\text{C}$ (‰)	$\delta^{15}\text{N}$ (‰)	r	p
< 800	14	-18.4 \pm 0.8	-11.3 \pm 1.1	0.64	<0.05	11	-17.8 \pm 1.6	-11.8 \pm 1.0	0.94	<0.005
800-850	14	-18.0 \pm 0.9	-12.3 \pm 1.5	0.93	<0.001	34	-17.2 \pm 1.0	-13.1 \pm 1.7	0.86	<0.0001
850-900	12	-17.1 \pm 0.7	-13.8 \pm 1.1	0.76	<0.01	36	-16.7 \pm 1.1	-13.9 \pm 1.1	0.30	ns
900 \leq	4	-17.0 \pm 1.2	-14.2 \pm 0.8	0.80	ns	24	-17.1 \pm 1.5	-13.5 \pm 0.9	0.15	ns
Total	44	-17.8 \pm 1.0	-12.6 \pm 1.6	0.90	<0.0001	105	-17.0 \pm 1.2	-13.3 \pm 1.5	0.60	<0.0001

Home Sweet Home: Aspects of Green Turtle and Hawksbill Presence in Their Feeding, Resting and Cleaning Areas off Honokowai, West Maui, Hawaii (1989-1999)

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INTRODUCTION

By means of SCUBA, we have watched, photographed, and videotaped turtles at Honokowai, Maui, Hawaii since 1989. Using the images we've collected, we want to introduce you to the Hawaiian green turtles or 'honu' living there, show you what their home is like, and provide some ecological background

ONSHORE ASPECTS

Appropriately, George Balazs *et al.* (1987) wrote the first description of Honokowai in sea turtle literature. As they described, with the exception of a small park at the south end, this part of the coast is lined with sea walls built by resort condominiums. Note that concrete storm sewers mark both ends of our dive site. For years, these discharged runoff from pineapple and sugar cane fields directly into the ocean. Sediment catch basins were not added until 1995. Also, to the south and within 600 m of the shore, a sewage treatment plant pumps over 11 million liters per day of effluent containing high loads of phosphates and nitrates into injection wells (W. Wiltse, personal communication). Although no one has shown a direct connection to these onshore aspects, it is interesting that over the years, West Maui has gotten considerable attention because of repeated seaweed blooms. Studies commissioned in the mid-90's by the West Maui Watershed Management Project confirmed that the Honokowai ocean is high in nutrients, and several anthropogenic culprits were implicated, including both of those just mentioned.

RECENT ECOLOGICAL HISTORY

Since 1989, Honokowai has had a series of *Cladophora* sericea algae blooms - five that we've documented, with the worst in 1991. The area is also dominated by two new arrivals-exotic seaweeds. One, *Acanthophora spicifera*, was reported growing at Honokowai by Balazs *et al.* (1987) as early as 1985. We have documented that the other import, *Hypnea musciformis*, had already established itself by 1989. We have also recorded videotape showing young honu feeding on both species.

Honokowai's environment has also been degraded by run-off events, the most serious in July 1993, when red mud from the West Maui Mountains turned the coastal waters red. In some areas, silt collected in layers 10-15 cm deep.

It is within this setting that we have been observing fibropapilloma disease, or FP. Distressingly, FP has

infested Honokowai throughout our observation period, and almost certainly longer than that. Fifty-nine percent (N = 268) of the turtles that we have sighted at Honokowai in the last decade had FP. If we count turtles seen in at least two different summers, the rate rises to 74% (N = 91). If we stretch residency to four years, the FP prevalence increases to 81% (N = 31).

UNDERWATER ASPECTS

Nearshore Honokowai consists of several well-defined sections of underwater terrain, providing permanent habitat for honu in all size classes. Inshore water is up to 150 m from shore and 8 m deep. Seaweeds cover a large part of the bottom and provide forage for juvenile turtles. A number of these algae, *A. spicifera* and *Spyridia filamentosa* in particular, have been identified by Landsberg *et al.* (1999) as being high in okadaic acid-producing dinoflagellates called *Prorocentrum*. This is of interest because okadaic acid is a known tumour promoter in lab mice.

The Cavern is an example of turtle habitat inshore. Two ledges face each other 5-6 m apart, both capable of accommodating a juvenile turtle. Polzbarney, a 35 cm new arrival in 1995, spent the first year tucked under a coral head, then occupied The Cavern in 1996. In 1999, Polzbarney was still living in The Cavern, had grown to 50 cm, and was in his third year of FP.

The reefs are 150 m from shore and beyond and are up to 20 m deep. At the 10 m depth, a 50 m wide stretch of sand separates the inshore habitat from the beginnings of the reefs, which typically run perpendicular to shore. It is around and on these reefs that we see most of the turtles.

THE TURTLE HOUSE

Around Hawaii, sea turtles congregate at areas called 'Turtle Houses.' In the early 90's Honokowai had just one, which we called the Turtle House. At first, this meant the entire vicinity, but we later evolved names for the distinct sub-areas. One sub-area is called The Rock. Some young honu, such as Hoahale, have used the ledges underneath The Rock for rest and shelter. For most turtles, however, The Rock is simply an outstanding way to satisfy a carapace itch. Next to The Rock was a small reef of mixed corals. Turtles often rested there, so we named this the Rest Site. This area has since been reduced to mostly coral rubble-our Destruction poster (This volume) shows how-and by 1999 we seldom saw turtles resting there. Further seaward,

across a 25 m sand channel, is the mound of corals that forms the Turtle House proper. Here, we have always observed a considerable amount of cleaning activity. Originally, this area also offered several opportunities for a turtle to scratch, but some have now collapsed.

In 1995, we began sighting more turtles. Some honu began spending time on a large reef that we called Reef 2. It is at the south end of our dive site, and is primarily a resting site. Reef 2 is made up of mostly finger corals, with narrow channels and depressions that the honu like to settle into. This became the second major congregation area at Honokowai. There is not much cleaning at Reef 2, but it does have some scratching posts. The most prominent of them is a coral structure we call East House, which has recently collapsed.

In 1998, shore observations revealed shells surfacing to the north for the first time. Therefore, in 1999 we visited the new turtle-congregating area, which we'd already named North House. The most prominent feature in the area turned out to be a large coral head standing alone in the sand. We immediately named this Mt. Balazs. A few meters away, a crest of coral rose up 2-3 m. Atop this crest, we saw over a dozen turtles of various sizes, many already known to us. They were doing what turtles do in such a promising area: mostly lying around. Like the Turtle House, North House is a cleaning station, where turtles pose to attract cleaner fishes. Also like the Turtle House, North House offers opportunities to scratch. Like Reef 2, North House offers numerous resting spots. North House has become the third major Honokowai congregation area.

PERSISTENCE

What do turtles do at Honokowai? Well, the most notable thing they do is stay there. One example is Kaula, known since 1989. Kaula matured into a male during our observation time and still calls Reef 2 home. Tiamat, known since 1991, is another example of a long-term resident. We sighted her every summer until 1997, when she made her first migration to the French Frigate Shoals. In the summers of 1998 and 1999, we saw her daily at Honokowai. We expect her to migrate during Summer 2000.

On an average day, we sight over two dozen different honu at Honokowai. On lucky days, a Hawaiian hawkbill shows up. Since 1989, Honokowai has attracted a lot of turtles, with most of the increase happening since 1995. With these honu comes change.

ENVIRONMENTAL CHANGES

This is the Turtle House in 1989. Note the healthy corals, suggesting that honu were not yet established in large numbers. Certainly our pictures show that the coral destruction at Honokowai is recent, occurring in the last decade. This is the same area just three years later. Note the

coral head has been fractured. Finally, here it is in 1999. Clearly, honu are hard on corals. Although honu destroy a lot of coral through scratching and foraging, most damage results from the simple act of resting. Honu, year after year, are faithful not just to the same reef, as we show in our poster on fixity (Bennett *et al.*, This volume), but also to the same precise resting spots. This inevitably means the demise of corals. Finger corals snap easily and litter individual rest sites. Such sites are easy to spot even without a turtle present. We call these Turtle Tramples for obvious reasons.

EFFECTS ON FISH

It's likely that the most significant effect involves fish cleaning activity. We've always observed shell cleaners like goldring surgeonfish (*Ctenochaetus strigosus*) and skin pickers like Hawaiian spotted pufferfish (*Canthigaster jactator*) working on turtles. Saddleback wrasses (*Thalassoma duperrey*) target only tumoured turtles, something we've noted since 1990. We've also documented species that have learned cleaning behaviour. For example, between 1994 and 1995 both milletseed butterflies (*Chaetodon miliaris*) and long-nosed butterflies (*Forcipiger flavissimus*) took up cleaning tumoured turtles. In 1999, for the first time we observed yellow tangs (*Zebrasoma flavescens*) cleaning turtles. Fish also use honu for shelter, as cover from which to surprise prey, and will show up when a turtle is actively scratching or foraging for sponges. By disturbing the corals, the turtle is unintentionally making food accessible. The incidental destruction of corals also has a detrimental effect on reef fish and other animals, however, since habitat is being lost.

EFFECTS ON OTHER TURTLE SPECIES

Certainly one of the most fascinating events at Honokowai in the last decade was the 1998 appearance of a young hawkbill (*Eretmochelys imbricata*). We sighted Keoki again in 1999 and also that year, we began seeing another larger hawkbill-Ake. This is remarkable because Hawaiian hawkbills are extremely rare and Honokowai managed to attract two! We now believe it is possible, perhaps even likely, that the presence of honu are an attraction for hawkbills-an advantage. Every day, the honu change the nature of the reefs of Honokowai. This uprooting and trampling of corals gives the hawkbills access to previously unreachable sponges.

Still, hawkbills can write their own meal ticket. They dig distinctive holes anywhere they sense sponges might be hidden-leaving some coral fingers snapped cleanly in two! These holes are the hawkbill's 'calling cards' along Honokowai's reefs.

Observations confirm that the hawkbills are cleaned by many of the same fish species as the honu, share honu

resting sites, and sometimes even eat the same type of seaweed, *H. musciformis*, as shown here. On rare occasions, they even rest next to honu. There seems little doubt they're exposed to the same FP environment. Needless to say, we're monitoring these hawksbills closely.

SUMMARY

To summarize, we know that turtles of all size classes have settled at Honokowai and stayed for years, some at least a decade, despite high nutrient loads and sporadic runoff events. Since 1989, Honokowai has seen an encouraging increase in the number of turtles. During our observation time, these animals have spread out, occupying two new congregation areas. Judging by the effects we have seen them have on the corals, recovery and colonization have been recent-in the last decade-and in spite of a high prevalence of fibropapilloma. We believe there's a strong possibility that a youngster settling into Honokowai will mature there, migrate to the French Frigate Shoals and back during its reproductive years, age, and ultimately die at Honokowai. We're confident that one day the remarkable bond of the honu to their underwater home will be recorded in decades, not just years.

The Honokowai honu are a true 'ohana'-Hawaiian for a group that has shared experience-with individuals that live

together and interact over decades. Given the number of years that sea turtles live at the same site, it is therefore important to remember to keep the ocean clean!

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Environmental Pressures on Sea Turtle Nesting Habitats in the Gulf of Kachchh (Kutch) India

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INTRODUCTION

Besides Gahirmatha on eastern coast of Orissa in India, a number of nesting habitats in the western coast namely, the Gulf of Kachchh, are the "lesser known nesting habitats" which needs attention. This paper attempts to focus the importance of these nesting habitats and associated environmental issues.

Gujarat State, India has a 1600 km coastline with rich biodiversity of more than 900 species. The Gulf of Kachchh has a protected area (PA) called Kachchh Marine National Park. The PA encompasses 457 km² including 42 islands.

The Gulf is a recognized habitat for at least two major populations of sea turtles which are (1) green sea turtle (*Chelonia mydas*) and (2) olive ridley (*Lepidochelys olivacea*) (Bhaskar, 1982, Daniel, 1983; Nareshwar, 1997). Besides there are unconfirmed reports of leatherbacks (*Dermochelys coriacea*) and the hawksbill (*Eretmochelys imbricata*).

METHODS

The study site is located just outside the PA on the island of Beyt Dwarka. The site is a facility where Nature Education Camps and training programme are conducted by Centre for Environment Education (CEE) and Sundarvan specifically with reference to marine environment.

The period between 1996 to 2000, in the months of January, 1999, 2000; February, 1998; September, 1999; October, 1996, 1999; and November, 1996, 1997 and 1998, nesting habitats were monitored. Beach surveys were conducted at Beyt Dwarka during the night hours of high tide. Day surveys were also conducted. Fisher folks, personnel of Gujarat Maritime Board and Coast Guard were interviewed. Off shore surveys were also carried out. Islands such as Baidar, Chusna and Manmardi were visited. Baidar, Nora and Chank are confirmed nesting grounds. These islands are devoid of human presence. Visual documentation of environmental issues in relation to nesting habitats was made possible.

RESULTS AND DISCUSSION

The outcome of surveys conducted during this period indicate:

1. Wanton poaching of sea turtles or eggs by communities is not a practice. Though turtle eggs are occasionally removed to feed cart horses.

2. Fisherfolks admitted to incidental capture, and

drowning of sea turtles. When found alive they were rescued and let free. Trawlers operate without TEDS. Off shore drift nets contribute to turtle and common dolphin (*Delphinus delphis*) mortalities.

3. Pollution is a threat to nesting beaches. Marine debris such as thermocol, plastics, plastic laminated cardboards, discarded nylon nets, tin cans, rubber and glass were some of the constituents. Tankers and trawlers being cleaned up at midsea contributed to oil pollution. Slick was seen washed up onto prime nesting beaches. Dwarka and Beyt being a Hindu pilgrimage site, a numbers of hotels and guesthouses have proliferated to make situation grave. A number of industries have come up and more are ready to move in. Near one such industry Tata Chemicals cloudy "liquor" or bittern was seen discoloring the water.

4. Natural impact on sea turtle nesting beaches include cyclones and storms. This has contributed to erosion of nesting beaches. More than 90% of eggs fall prey to jackals (*Canis lupus*) and wild boar (*Sus scrofa*). Jackal count was done and guesstimates of 300 plus jackals inhabit Beyt Dwarka. The situation is similar on the mainland nesting beaches. Predatory pressures on other islands, such as Baidar, Chusna, Nora and Chank is minimal.

5. Some of the nesting beaches are being changed permanently due to extensive sand mining. Sand is excavated and carted away for construction purpose.

6. Gujarat Forest Department at Jamnagar has undertaken hatchery rearing. In 1999 the Gujarat Agricultural University, Fisheries Research Centre at Okha took up an experimental hatchery. In both cases it was observed a scientific approach was lacking.

The findings of surveys between 1996-1997 was utilised during the Biodiversity Conservation Prioritisation Project (BCPP) India Endangered Species Project, Conservation Assessment and Management Plan (CAMP) Workshop (1997) to up date Red Data List on Indian Reptiles as per IUCN norms. Four species of sea turtles are listed as-Threatened and one species-Lower Risk-(Near Threatened).

If hatchery rearing needs to be promoted, then location of hatcheries is crucial. A shore based structure should be advocated. Local building materials such as euphorbea or thorn fencing would suffice. This approach could be in-situ simulation, accounting for TDS factor.

It is suggested here that during breeding season all drift nets near nesting beaches should be banned to minimize sea turtle mortalities. Sand mining on Beyt and nesting beaches on mainland should be discouraged. Since sand is an important building material, the concept of sand depot should be promoted. This needs to be worked out with local authorities and town planners. A number of annual rivers could provide with a substitute. This may generate

opportunities for local employment.

Sea turtle conservation training programmes for forest department personnel, GMB and coast guard could be initiated. Local public awareness campaign is a must. During Nature Education Camps between December to March, "Turtle Walks" were initiated with a view to patrol and protect the nesting beaches. Beach clean ups were organised through camp participants.

Recently in December 1999 there happened to be a major oil spill. Approximately 15,000 tons of crude oil spilt into the Gulf of Kachchh. There were reports of sea turtles and dolphins being affected. Similarly oil slick may have also damaged the fragile coral ecosystem. The overall impact of this spill has yet to be assessed.

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The Nesting Frequencies of Marine Turtles in Rekawa, Southern Sri Lanka

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Five of the world's seven species of marine turtles come ashore to nest in Sri Lanka. Those are the green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), loggerhead turtle (*Caretta caretta*), hawksbill turtle (*Eretmochelys imbricata*) and the olive ridley turtle (*Lepidochelys olivacea*). Despite government legislative protection, marine turtles are still being exploited in Sri Lanka for their eggs and their meat. As a result of this and threats to habitats, all marine turtles are considered under threat and the hawksbill turtle is critically endangered in Sri Lanka (Hewavisenthi, 1993).

The Turtle Conservation Project (TCP) is a Sri Lankan NGO, established in 1993, with the aim of devising and

facilitating the implementation of sustainable marine turtle conservation strategies through education, protection, research and community participation. Rekawa beach, on the southern coast, is Sri Lanka's most important marine turtle nesting rookery, but was under serious threat from 100% turtle egg collection since the 1970's by local people. In 1996 the TCP established a pioneering community based *in situ* marine turtle nest protection and research program in Rekawa. This program was designed to employ former turtle egg poachers as turtle 'Nest Protectors'. The main aims of the program were: (1) to protect all nests using the *in situ* method and allow for the immediate natural release of all hatchlings to the sea on

emergence; (2) to provide new data on the biology of the nesting marine turtle populations of Sri Lanka; and (3) to provide an alternative sustainable income for the turtle egg collectors in Rekawa.

So far TCP researches have tagged 600 turtles including all five species. Out of 600 nesting females, 541 were green turtles, 28 were olive ridleys, 23 were leatherbacks, three were hawksbills, and five were loggerheads. Two thousand six hundred and sixty nests were laid on Rekawa beach during the period September 1996 to September 1999. There were 2572 green turtle nests (96.7%), 39 leatherback nests (1.47%), 36 olive ridley nests (1.35%), seven loggerhead nests (0.26%) and six hawksbill nests (0.22%).

INTRODUCTION

TCP surveys revealed that Rekawa is the location of one of the most important green turtle rookeries in Sri Lanka (TCP internal reports-unpublished). Leatherback turtles, loggerhead turtles, hawksbill and olive ridley turtles also nest at Rekawa. All of these species are listed as either endangered or vulnerable by the World Conservation Union (IUCN).

For more than 20 years up until 1996, local people from the impoverished Rekawa village had collected all the turtle eggs laid on Rekawa beach for sale or local consumption. This resulted in zero recruitment into the local marine turtle population. Egg collectors from Rekawa interviewed during TCP surveys have said that in the 1970's it was not uncommon to take eggs from as many as 40 nests per night. But today the number of the nests per night rarely exceeds 10. These egg collectors are either dependent or semi-dependent on the sale of marine turtle eggs for income generation. Some nesting female turtles are also occasionally killed for their flesh, which is also sold at local markets (TCP internal reports 1994/95-unpublished).

Marine turtles are believed to reach sexual maturity at about 30 years of age (Mrosovsky, 1983); research has also found that female turtle's return to nest at their natal beach. Therefore, as there'd been no recruitment into the Rekawa populations for more than 20 years-due to egg collection, there would only be a further 10 year period when first-time nesting turtles would arrive at Rekawa (i.e., up to the year 2006). After this time there would be no first time nesters and the nesting population would begin to dwindle due to mortality from natural and human factors (e.g. fishing by-catch, pollution). If egg collection had continued there would have been no further recruitment into the nesting population. The TCP therefore believed that if no action was taken to prevent egg collection, the nesting population of marine turtles at Rekawa would have been so over-exploited as to have been unable to recover, leading to the extinction of this population within 20 years (Richardson, 1996).

REKAWA: THE PROJECT SITE

The TCP selected Rekawa, a small village near Tangalle, in the district of Hambantota in southern Sri Lanka, for the implementation of the TCP's *in situ* marine turtle nest protection and research program. Rekawa is located on the border of the intermediate and dry climatic zones of Sri Lanka, and borders a large saline lagoon surrounded by extensive mangrove forests. There are no electricity or telephone lines in the village and the majority of households do not have running water.

The village is divided into two divisions, Rekawa East and Rekawa West, and the numbers of families in these divisions are 121 and 144 respectively (Foerderer, 1996, in press). Income generating activities for the families in the Rekawa area include agriculture (47%), lagoon fishing (10%), sea fishing (18%), coral mining (9%) and others (17%) such as masonry, carpentry, government services and labor (Banda *et al.*, 1994).

The community of Rekawa village has suffered several setbacks in the last decade. During the late 1980's and early 1990s, Rekawa was the location of political violence, which bereaved many families of their skilled men-folk. An irrigation system designed by the government to improve the quality of the agricultural land surrounding nearby Tangalle, drained Rekawa of its groundwater. The groundwater was eventually replenished by saline water from the sea and Rekawa lagoon, which rendered the land unsuitable for agriculture unless there are heavy rains. These events have resulted in low incomes for most of the families in Rekawa with approximately 57% of the families dependent to some degree on government welfare (Foerderer, 1996).

REKAWA'S NATURAL RESOURCES

Because Rekawa is located on the border of two climatic zones there is a high local biodiversity. As well as the mangrove forests, the local vegetation consists of scrub jungles, medicinal plants, fruit trees and a wide variety of wildlife including 150 resident and migratory birds, 29 species of mammals, 23 species of reptiles, many arthropods and diverse aquatic life (Kapurusinghe, 1995).

PROJECT OBJECTIVES

The objectives of the TCP Rekawa community *in situ* marine turtle conservation and research project can be listed as follows: (1) to protect *in situ*, all marine turtle nests located within the project boundaries and ensure that all resulting hatchling turtles reach the sea immediately after emerging from the nest; (2) to incubate the eggs collected from as many nests as possible laid on adjacent beaches outside the project boundaries in a small, scientifically managed hatchery and immediately release

the resulting hatchlings; (3) to collect biological data from the nesting female populations of marine turtles of each species present at the Rekawa turtle rookery. Research topics will include determining number of nests per season (individual and population totals), size of nesting female populations, growth rates of individuals, longevity of individuals beyond tagging, mean breeding frequency, migratory paths and geographical range, nest incubation periods, nest temperatures, and hatching success rates (*in situ* and hatchery comparative studies); (4) to involve local stakeholders in the planning and implementation of the *in situ* nest protection and research program; (5) to provide an alternative and sustainable income to those Rekawa community members currently financially dependent on marine turtle egg gathering by employing them in a system of non-consumptive and sustainable utilisation of local nesting marine turtle populations; (6) to set up a 'Turtle Watch' program for paying tourists to help contribute to the future sustainability of the project; (7) to provide a field study and training site for interested parties, such as university students, government department research officers, and NGO members, to learn about marine turtle conservation and research methodology.

METHODS

Involvement of Former Egg Collectors

A series of meetings were held with the egg collectors. During these meetings the regular egg collectors were identified by TCP. Those individuals were requested to stop collecting eggs once the program began. As an alternative they would be provided with the opportunity to take up employment as assistants to the Research Officers (ROs) (see "Research Methodology") of the research program and as *in situ* protectors of marine turtle nests. The transformation of the local egg collectors to 'Nest Protectors' provided the research team with an invaluable local understanding of turtle behavior in Rekawa.

Twenty four egg collectors were organized into a formally recognized group of 'Nest Protectors' (NPs). Discussions were held on the methodology of the *in situ* nest protection and research program and appropriate alterations made. The TCP also carried out basic training in *in situ* nest protection methods and data collection skills. The project began on 2 September 1996.

Research Methodology

Data sheets were designed to collect biometric data from each turtle and from each nest laid. Key data collection involved an initial mapping of the beach; the weighing, measuring and tagging of nesting female turtles; monitoring nesting behavior; and collecting data on incubation periods, hatchling biometrics, and hatching success rates. Each hind flipper of each turtle was tagged with a Dalton plastic tag, using first a leather punch to make a hole in the flipper and then an applicator for affixing the

tags. Flexible measuring tapes were used to turtle curved carapace length and width.

The 2 km stretch of beach within the project boundaries were patrolled 24 hours a day by the NPs in order to prevent poaching of marine turtle eggs. At least two ROs and six NPs were present on the beach from 19:00 hours to 3:00 hours every night. The ROs organized rotation patrols for themselves and the NP's, originating from a central position on the beach. Therefore, each half of the 2 km stretch of beach was patrolled every half hour at night by 2 personnel. The purpose of the patrols was to locate landed turtles and protect nests already laid.

Once a track has been located by a patrol unit of NPs, one of the personnel carefully ascends the track and ascertains the stage of the nesting procedure of the turtle. They then issue a recognized torch signal to the central position to indicate to the rest of the patrolling team that a turtle has been located. A RO based at the central position then returns a recognition torch signal and then makes his way to the nesting site with the necessary research equipment. Meanwhile the NPs observe the turtle's behavior, recording the time at the beginning of each stage of the nesting process. On arrival at the site, the RO manages the patrol unit in the collection of biometric data.

The RO and NPs on daytime duty measure the exact location of the previous night's nests and place a 'nest screen' over the nest. The nest screen is a 1 m square piece of steel cable mesh, the mesh size is small enough to prevent animal predators from excavating the nest, yet large enough to enable emerging hatchlings to escape.

ROs and NPs occasionally patrol the beach outside of the project boundaries. Any recently laid nests found in these areas are relocated and incubated within TCP boundaries, to prevent poaching. Similarly any nests that the TCP staff decides may be threatened within TCP boundaries for various reasons (eg. some nests are laid in areas subject to high tides), are relocated to a safe place. All the data collected by ROs was fed into a database (Microsoft Excel) on a regular basis.

Five full-time ROs were trained in data collection, research methods and nest protection, and were responsible for the coordination and supervision of the beach research and conservation. The posts were occupied as follows: one TCP Senior Research Officer and program co-ordinator; one TCP Research Officer; one Post-graduate student, registered with the Department of Zoology at the University of Peradeniya; one Officer from the Department of Wildlife Conservation; one National Aquatics Resources Agency (NARA) officer; and one Post-graduate student registered with the Department of Zoology at the University of Ruhuna.

DISCUSSION

Setting up and operating the participatory *in situ* nest protection and research program at Rekawa was an

enormous challenge for the TCP. It was Sri Lanka's first genuine marine turtle conservation and research program and one of only a few marine turtle conservation projects in the world operating as either *in situ*, or community participatory.

The program has not been without its problems and the TCP has had to continually review the program and address problems as they arise, working in cooperation with the NPs. It has been a learning process in both *in situ* turtle conservation, and community participation in conservation and development. The TCP staff is now confident in being able to deal with any future difficulties.

During the research period TCP staff observed dogs, crows, water and land monitors, ants and ghost crabs attacking and consuming hatchlings. Ghost crabs are the main night-time predator, while the remainder are daytime predators. One of the most destructive predators on Rekawa beach was a species of red ant attacking a small number of nests, killing and consuming hatchlings still in the sand after hatching.

The hatching success rate has improved through the project's duration as the TCP has adopted better methods in nest protection and nest relocation. Nests and their emergent hatchlings have been successfully protected from predators and environmental threats and it is believed that the nest success rate is significantly higher than it would be in the wild. The TCP expected considerable thefts on nests considering the radical change over from egg collection to egg protection as villagers were depending on eggs for over twenty years. The TCP managed to catch seven nest thieves who were reported to the police and given severe reprimands. Disappointingly, five of these people were 'Nest Protectors' working for the TCP and were subsequently sacked in the early stages of the project, a decision taken by the NPs and TCP management.

The predominance of the green turtle species was expected. We were however pleasantly surprised by the three hawksbill turtles that nested, as these have not been seen nesting in Rekawa for five years! The research has also been extremely successful with ROs and NPs working well as a team to produce a comprehensive and detailed data base on nesting turtles and nests hatched. This information will be extremely important in ensuring an improved understanding of the biology and behavior of Sri Lanka's marine turtles and hence provide for more effective future marine turtle conservation strategies. The research information collected by the TCP will also be an important contribution to the world data base on marine turtles to help produce more effectual regional strategies to protect this long distance migratory species.

The Rekawa project has also been very successful as a site for *in-situ* training for marine turtle research and conservation methodology: (1) NARA and the DWLC now have a trained officer in *in situ* marine turtle conservation; (2) ROs are currently undertaking their MSc dissertations based on the *in situ* conservation program, with positive implications for future marine turtle research in the

Zoology departments of their respective universities; (3) two hatchery managers have been trained in *in situ* methodology and good hatchery management procedure. It is hoped that hatchery management practice will become more scientific and conservation orientated as a result; and that hatchery managers and interested conservationists may be inspired to set up similar *in situ* programs; (4) marine turtle conservationists from around the world have also visited the project.

The project has provided a valuable source of education and promotion of marine turtle conservation and the principle of conservation as a whole, with visits from local people, Sri Lankans, foreign tourists and schools. A group of students from an International school in Colombo stayed in Rekawa for a week and undertook scientific research on beach geography and chemistry to evaluate impacts on nest success rates.

The project has provided a valuable alternative source of income for community members previously dependent on the destructive exploitation of marine turtles and their eggs at Rekawa. NPs now receive higher and more stable earnings than as egg collectors, thus aiding local development. Local people can now see there is an alternative to destructive exploitation of natural resources. Some NPs have seen hatchlings for the first time and now say they would not collect or eat turtle eggs again.

CONCLUSIONS

According to the results the authors would like to conclude that: (1) all five species nesting in Sri Lanka nest at the Rekawa marine turtle rookery; (2) the most common nesting marine turtle species in Rekawa is the green turtle (*Chelonia mydas*); (3) the 2 km stretch of beach at Rekawa can be considered the most important green turtle nesting rookery in Sri Lanka, according to the available data; (4) the least common nesting species at Rekawa is the hawksbill turtle (*Eretmochelys imbricata*); (5) the nesting female population in Rekawa is so far estimated to be 600 and it includes all five species found in Sri Lanka; (6) on average more than 800 nests per year are laid by the nesting turtles in Rekawa; (7) almost a 100,000 eggs are laid annually by the nesting turtles in Rekawa (8) dogs, crows, water and land monitors, ants, and ghost crabs are the main land predators for eggs and hatchlings on Rekawa beach; and (9) a viable alternative has been provided to the previous marine turtle egg collectors of Rekawa who were unsustainably exploiting the local marine turtle population.

RECOMMENDATIONS

Marine turtles have over 180 million years of evolutionary history. Despite increasing intensity in international marine turtle research, researchers still know very little about marine turtle biology. Therefore, the best

method to conserve marine turtles would be by adopting the *in situ* conservation method, which allows turtles to continue to interact with their natural environment and reproduce naturally as they would in the wild. Where *in situ* conservation is not possible or economically unfeasible, then *ex situ* conservation can play an important role in marine turtle conservation, as long as it is carefully managed according to the best scientific protocol available.

Considering the TCP's experience during the Rekawa marine turtle nest protection and research program, the authors would like to make the following recommendations: (1) the Rekawa *in situ* marine turtle conservation and research program should be continued for at least another ten years to ensure a reasonable recovery of the exploited marine turtle population in Rekawa; (2) the strength of the research and management including the administration should be increased by receiving more support from both government and non-government agencies including foreign donor and research agencies; (3) aspects of marine turtle research in the program should be expanded and improved by increasing the areas of research, incorporating more modern research techniques and increasing research staff training; (4) The community should be continuously involved with the program development and participate fully in program activities and benefits, as they do now; and (5) further activities for self-sustainability need to be developed and implemented.

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Ten Years of Marine Turtle Conservation in the Mediterranean (1989-1999)

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INTRODUCTION

From the seven species of marine turtles that occur in the world, three are frequently found in the Mediterranean: the loggerhead (*Caretta caretta*) and green turtle (*Chelonia mydas*) that have nesting beaches and the visiting leatherback (*Dermochelys coriacea*). MEDASSET, the Mediterranean Association to Save Sea Turtles, was set

up in 1988 to protect the remaining populations of marine turtles in the Mediterranean.

Since 1989, ten areas have been assessed from Sardinia to the N.E. Aegean Sea and from the Ionian Sea to the shores of Egypt and Libya, covering 7,300 km. Financial support came from various sources, including the EC and international intergovernmental and non-governmental organizations. After ten years of conservation work, it is

seen that the main problems are the non-implementation of legislation protecting marine turtles, tourism development and fisheries interactions. Public awareness campaigns, environmental education programs and lobbying of involved parties are thus vital to keep this subject in the limelight to instigate positive action by the appropriate authorities.

METHODS

In the period 1990-1999, MEDASSET has surveyed coastal areas with previously unknown or unconfirmed levels of marine turtle nesting. This is to target areas that are in need of specific protection with regard to marine turtles, whether it is for nesting or offshore populations (Fig. 1).

Nesting surveys have been carried out in Sardinia (Whitmore *et al.*, 1991), N. Aegean Greek waters (Kasperek, 1991), Syria (Kasperek & Baumgart, 1991), Libya (Laurent *et al.*, 1995, 1999) and Egypt (Kasperek, 1993). Surveys were also carried out for *Trionyx triunguis* in Turkey in 1998 and 1999 (Kasperek, 1999) to determine the status of this highly endangered species, which uses a complex of marine, brackish and riverine habitats. During each survey a detailed inventory of all the beaches is made (including descriptions of fauna, flora and geomorphology) and on the level of development. Where required, interviews with the locals and fishermen were also carried out. Recommendations for protective legislation and for implementation of existing legislation and protective measures were made to the states involved where important ecosystems of turtle nesting sites were found. Follow-up efforts for the implementation of the above and conservation efforts were instigated.

Conservation assessments have been carried out to determine the factors affecting turtle nesting, such as tourism and coastal development. The impact of tourism and other development on loggerhead nesting was investigated in S.W. Peloponese, Greece (Whitmore, 1989). In 1999, a study of the ecology and the impact of tourism on the sand dunes bordering the main nesting beach of Kefalonia Island, Greece (Roche, 1999) and a follow-up assessment of the status of three key green turtle nesting beaches in Turkey (Demirayak, 1999) were made. MEDASSET has supported satellite-tracking programs (1997-1999) in collaboration with the Stazione Zoologica-“Anton Dohrn” (Naples, Italy) and with Glasgow University and Swansea University (UK) in Cyprus. Also supported was a long-term study from 1989-1995 on incidental captures in the Ionian Sea, Greek waters, in collaboration with captains of eight vessels, investigating the impact of the swordfish long line fishery on marine turtles (Panou *et al.*, 1999).

The organisation is also an Observer at the Council of Europe Convention of European Wildlife and Natural Habitats (Bern Convention) and the Convention for the Protection of the Mediterranean Sea against Pollution and

its Related Protocols (Barcelona Convention) Meetings. Since 1988, it has presented yearly updates and technical reports with recommendations to various governments, exerting pressure for change, mainly regarding five Mediterranean nesting areas: Zakynthos and Kefalonia in Greece, Patara and Dalyan in Turkey and Akamas in Cyprus.

Public awareness and environmental education projects have made a huge impact, ranging from media coverage, tourist surveys to talks at schools. The “Euro-Turtle” Website, created with Exeter University and King’s College, is an educational and research database for the conservation of Mediterranean marine turtles. The website has received 42,000 visitors in 1998-1999 and won an award as one of the six best environmental education websites in Europe.

RESULTS AND DISCUSSION

The surveys carried out were important in determining which areas in the Mediterranean are host to the most significant nesting populations and require most conservation efforts. The surveys revealed that loggerhead nesting to different degrees occurs in Egypt, Libya and Syria, while offshore populations were confirmed for the North Aegean and Sardinian waters. Follow-up surveys are recommended to determine more accurately the size of these nesting populations, particularly for Libya. The Libyan coastline is still relatively undeveloped and a management plan with legislation is recommended for this area. Whether nesting of the green turtle occurs in Syria has still to be ascertained. Levels of loggerhead nesting in these areas were not as high as those found in Greece and Turkey. The surveys also confirm that nesting levels of green turtles are very low in the Mediterranean and seem to be limited to Turkey and Cyprus. Considering the highly endangered status of the green turtle, priority should be given to its protection. In 1998-1999, new populations of *Trionyx triunguis* were found in Turkey (Kasperek, 1999). MEDASSET has been instrumental in creating a legal framework for the protection of marine turtles in the Mediterranean. One of the main projects is in Zakynthos, which hosts one of the largest nesting populations of loggerheads in the Mediterranean. The uphill struggle of ensuring the enforcement of these laws has been an ongoing priority since 1983 (before MEDASSET was officially founded). An official complaint by MEDASSET to the European Commission in 1994 resulted in a European Court of Justice case in 1999. This was instrumental in hastening the signing of the Presidential Decree in December 1999, that declared the National Marine Park of Zakynthos after 17 years of campaigning.

Up until now most conservation efforts concerned with marine turtles have focused on the protection of nesting beaches. Difficulties in implementing conservation measures have been faced, in particular where there are conflicting interests with coastal and tourist development.

In relatively undeveloped areas, collaboration with the local authorities in creating a sustainable management plan will hopefully prevent such clashes. Although it is difficult to study the marine turtle at sea, such studies provide invaluable information on population size and distribution, feeding grounds, overwintering areas and migratory routes. The satellite tracking programmes carried out provided information on the movements of female turtles after nesting (including green turtles) and that of a juvenile rehabilitated turtle. Knowledge on the main threats facing the turtles in the sea is rather limited. A main threat is posed by interaction with fisheries, which includes incidental captures in drift nets, trawls and long lines. Drift nets have now largely been prohibited by EC regulations, (drift netting with more than 2.5 km nets was banned by EC regulation 345/92) but has not been fully enforced. In the study on incidental captures (1989-1999) in the Ionian Sea (Panou *et al.*, 1999), 157 loggerheads (mainly juveniles) were caught in 142 out of a total of 758 swordfish long line fishing trips (18.1%); an average of 7.7 turtles per year and vessel. The collaboration of the fishermen in the project yielded significant results-all turtles caught by incidental capture were released alive. A decline in the frequency of incidental captures over the total period of investigation was observed. There was also sensitization of the local public throughout the study area. Incidental captures may also result in unintentional or deliberate harm to turtles by fishermen or the exploitation of turtles, including consumption of eggs (as seen in Syria), the sale of sea turtles and their parts and consumption of their meat and blood, as was observed in Egypt. Also an important ongoing campaign in collaboration with the Ministry of Environment in Egypt was started in 1999 to reduce the exploitation of turtles in the fish markets of Alexandria.

In recent years, there have been increasing efforts to bring the non-implementation of the legislation protecting turtles to the attention of the various governments involved by intergovernmental, environmental and scientific institutions. It has to be ensured that the legislation covers all fishery interactions as well as the protection of nesting areas, foraging and wintering grounds. Measures have to be taken to ensure that the existing legislation, which protects marine turtles, is enforced at a local level. Within this respect, authorities should be designated and penalties introduced to ensure protection of the turtles. There has to be responsibility for the management of the fishery industry. Non-governmental organizations have an important role in turtle conservation. They continue to lobby governments and other involved authorities to ensure that the conservation of marine turtles remains a priority. The education and public awareness programs run by NGOs also ensure that the plight of the marine turtle is kept in high profile. These are not only targeted towards certain groups (landowners, fishermen, legislators and tourists) but to a broad segment of society. This will helpfully promote the understanding that protecting marine turtles is part of an overall aim to maintain the biodiversity on this planet.

CONCLUSIONS

MEDASSET sees various areas as requiring immediate attention. In spite of conservation measures, recommendations and protective legislation, there has been little progress for the effective protection of sea turtles. Governments and other authorities involved should be set clear targets for necessary conservation actions in the Mediterranean. These should be given priority over research expenditure with the latter reserved only for applied conservation projects. All conservation matters concerning the highly endangered *Chelonia mydas* to be given the absolute priority. All pragmatic opportunities should be recognized and pursued in ensuring the conservation of nesting beaches and offshore feeding areas on the northern shores of Cyprus, particularly for *Chelonia mydas*. A follow-up assessment of the Libyan coast to investigate further potential nesting areas and to implement a management plan. Legislation to control fisheries interactions. Consideration given to resolving the plight of *Trionyx triunguis*.

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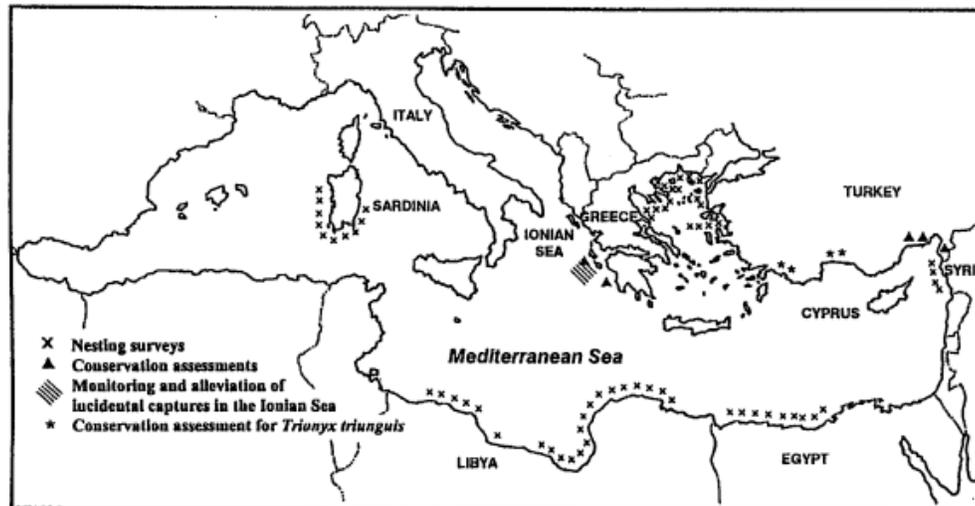
We would like to thank warmly all the individuals and organizations that have been involved with us in marine turtle conservation over the years, many of whom are listed below.

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Fig. 1. MEDASSET research activities 1989-1999.



Habitat Utilization of Hawksbill Sea Turtles at Buck Island Reef National Monument: the Zoanthid Question

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The National Park Service has conducted research on the nesting biology of the hawksbill sea turtle (*Eretmochelys imbricata*) at Buck Island Reef National Monument (BIRNM), St. Croix, Virgin Islands since 1988. In 1994 the program was expanded to include study of the juvenile hawksbill sea turtles resident and foraging in the coral reef habitat surrounding the Monument. Little is known about the residence time, foraging behavior, and habitat utilization of hawksbill sea turtles in their developmental habitat. At BIRNM over 80 individual juvenile hawksbill turtles have been tagged and recaptures are beginning to provide information on residency, growth, and habitat utilization. Research elsewhere has suggested that hawksbill turtles eat sponge after leaving the pelagic phase of their life cycle. In 1996 and 1998 two esophageal lavage studies were done. The results showed that juvenile hawksbill turtles at BIRNM were foraging primarily on *Zoanthus sociatus* (zoanthid) and red algae. This prompted another study to investigate the distribution of zoanthid around BIRNM. This information coupled with survey and sighting observations of juvenile hawksbills in the park is beginning to provide a picture of concentrated activity for this endangered species around BIRNM.

INTRODUCTION

Hawksbill sea turtles are listed as endangered in U.S. waters under the Endangered Species Act of 1973. It is listed as endangered by the International Union for the Conservation of Nature and Natural Resources (IUCN) and listed in Appendix 1 of CITES (The Convention on International Trade in Endangered Species of Wild Fauna and Flora). These turtles are small to medium in size and are found in tropical and subtropical seas of the Atlantic, Pacific and Indian Oceans.

Since 1988, the National Park Service has been studying the biology of nesting Hawksbill sea turtles at Buck Island Reef National Monument USVI Buck Island sits 1.5 mi off the northeast coast of St. Croix. It is 6000 ft long and two miles wide and is 340 ft high. The island is not volcanic in origin. Its sedimentary rocks were uplifted due to tectonic pressures. The park encompasses about 880 acres with 704 acres of it is water and coral reef and 176 acres is land. The island is surrounded by a bank barrier reef that is comprised of mostly dead *Acropora palamata*. This island is home to nesting brown pelicans, least terns, as well as nesting leatherbacks and green turtles. The island is a

popular tourist destination.

In 1994, the hawksbill nesting study was expanded to include a foraging study on juvenile hawksbills found in the reefs around Buck Island. In 1997 a habitat utilization study was initiated by a cooperative agreement between National Park Service and the Virginia Institute of Marine Science. The on-going objectives of these two studies were to assess the distribution of juvenile hawksbills in the park, determine habitat utilization and range, to identify food sources, to investigate the benthic habitat in the monument, to investigate size age class distribution, and determine genetic lineage.

Studies done on hawksbills in the past have described them as omnivorous scavengers (Ingle and Smith, 1949; Witzell, 1983). However, more recent studies in the Caribbean have described hawksbills as preferring a diet of sponges (Meylan, 1988; Bjorndal, 1997). At Buck Island coral reef monitoring has been ongoing since the late 80's and the results have shown that there is little to no sponge present in the monument (Bythell *et al.*, 1989 and 1993). This prompted a study in the monument to find out what the juveniles were feeding on. In the summer of 1996 an esophageal lavage study was done on 24 juvenile and one adult male hawksbill at Buck Island. The dominant food item found in these lavages was *Zoanthus sociatus*, a small anemone-like organism found in dense mats at Buck Island (Colin, 1978; Mayor, 1996). Another lavage study was done in the winter of 1998 with 17 juvenile hawksbills and the results were similar, suggesting that zoanthid was the dominant food of the juveniles hawksbills lavaged (Allen, 1998).

OBJECTIVES

In the spring of 1999, a zoanthid distribution study was initiated at Buck Island. Our objectives were to quantify zoanthid where it was found. The second objective was to relate the sightings of hawksbills with zoanthid abundance.

METHODS

The park was divided into 18 blocks at roughly 0.25 km² labeled A through R. Each block was surveyed for turtles in the summer of 1998 and the winter of 1999 with the use of snorkel swims and/or snorkel tows. Benthic cover was recorded during the surveys and it revealed that the

concentrations of zoanthid was found in the eastern side of the park. As a result, Blocks F through O were focused on for the zoanthid study. In each block, three, one square meter quadrats were done in each habitat zone to record the percent cover of zoanthid. The habitat zones sampled were Shoreline, Lagoon, Backreef, Reefcrest, and Forereef. The sampling was done along a transect line in each block extending from the shore to the Forereef.

RESULTS

The sea turtle distribution surveys showed the main concentration of juvenile hawksbills were in northeastern section of the park in blocks J through N. The highest percent cover of zoanthid was 35% and found in blocks K through N. The sea turtle sightings were log transformed to normalize it. The first graph compares the mean percent cover of *Zoanthus sociatus* by block with the combined juvenile hawksbill sightings from the foraging study and the habitat utilization study. R-squared of 50.2% and a P-value of less than 0.0491. The second comparison was between the turtles sighted for habitat utilization study and the mean percent cover of *Zoanthus sociatus* by block. ($R^2 = 68.9\%$; $P < 0.0107$).

DISCUSSION

The research done in other areas of the Caribbean suggest that hawksbills pursue a diet of spongivory (Meylan, 1988). The results from the two lavage studies showed that the juvenile hawksbills at Buck Island are focusing their feeding on *Zoanthus sociatus*. The survey data shows these animals are distributed in the northeastern section and their distribution is related to zoanthid cover. Observations of these turtles during the surveys at Buck Island have shown that they feed directly on zoanthids. One adult male was even observed feeding on zoanthids.

Last year I presented some of the preliminary results of the tracking work done at Buck Island for juvenile hawksbill habitat utilization study. The system had both a radio and a sonic component and was designed by Lotek engineering. The radio tags weighed 100 gm and were specially designed with a flexible double spring antenna to withstand the rigors of juvenile hawksbills in a coral reef. The sonic tags were small and weighed 16.6 gm. The radio tags were placed on the second vertebral scute and the sonic tags were placed along the number nine and ten marginal scute. There was a manual component to allow tracking of turtles in the field and a data logging station that logged the radio signals from transmitted turtles as they surfaced to breath. The data logging system was comprised of an array of six Yagi antennas and a Lotek SRX data logger located on top of Buck Island. The antennas were on a 30-ft tower and set up to provide full coverage of the entire monument. A total of four juvenile hawksbills were tracked with this system. The

preliminary results showed that these animals utilized areas around the park boundaries. All of the activity spaces were in areas of zoanthid concentration. There were no concentrations of sponge in the areas utilized. Three of the animals tracked were observed feeding on zoanthids.

In conclusion, there is a strong correlation between zoanthid abundance and juvenile hawksbill distribution. Juvenile hawksbills tracked utilized areas of heavy zoanthid abundance. Observations in the field suggest the juvenile hawksbills focus their feeding on zoanthid.

A possible explanation for this type of feeding regime by juvenile hawksbills is that the turtles' foraging is habitat dependant. The turtles are opportunistically feeding on zoanthid because it is mostly available. Although other studies suggest spongivory as their feeding regime, sponges are not common at Buck Island.

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Diet Selection by Immature Hawksbill Turtles at Two Sites in Southwestern Dominican Republic

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INTRODUCTION

Several studies of the diet of hawksbill turtles in the Caribbean have established that they feed almost exclusively on sponges (Meylan, 1988; Vicente, 1993; Anderes and Uchida, 1994; van Dam and Diez, 1996). Furthermore, these studies have shown that despite the fact that over three hundred species of sponges occur in the region, hawksbills select only a few, which vary somewhat among localities. However, very little is known about the abundance of the food item species in the hawksbill's environment.

To determine if hawksbills feed selectively, we designed a study in which we quantified the abundance of food items in their diet as well as in their habitat. Our objectives were: 1) to determine if hawksbills feed selectively, that is, if they are actively seeking food items that may be rare in their environment; and 2) to predict the effects of diet selectivity on the reef ecosystem.

METHODS

Our study area is located in southwestern Dominican Republic (17°55'N, 71°40'W). Within it, we selected two sites where, from previous studies (León and Diez, 1999), we knew juvenile hawksbills were frequently found: Bahía de las Aguilas and Cabo Rojo. Both sites were comprised of continuous shallow, hard bottom communities with depths from two to 20 m. Even though these two sites are only approximately four km apart, we knew from previous mark-recapture studies that the turtles didn't move outside either of them (León and Diez, 1999).

To sample the hawksbill diet components, we performed esophageal lavages with a technique adapted from Balazs (1980). We captured the turtles by hand following the protocol developed by Diez and van Dam (1994). The individuals sampled ranged in size from 18 to 50 cm (straight carapace length). Next, we measured the abundance of the food items the turtles were feeding on. For this, we conducted a series of random, 10 m long transects at the two study sites, which consisted in placing sequentially a 1 m² quadrat on the substratum along the transect line. Within each meter-squared quadrat, we estimated the area occupied each food species, using a smaller, grided quadrat. To quantify selectivity we used Manly-Chesson's selectivity index (Manly *et al.*, 1972, Chesson, 1978) which denotes a selection probability for each item, if they were all equally available in their environment. Therefore, negative or no selectivity are

represented at values near zero, and high selectivity at values near one.

RESULTS AND DISCUSSION

From the lavages, we found that the turtles were feeding on a total of six benthic species: the sponges *Chondrilla nucula*, *Geodia neptuni*, *Myriastra kallitetilla*, *Spirastrella coccinea*, *Thetya crypta*, and the corallimorpharian *Ricordea florida*. The lavages from Bahía de las Aguilas yielded five prey species, dominated by *Chondrilla* (58% of volume) followed by *Ricordea* (32%). In Cabo Rojo, only four prey species were found, but the same pair of species predominated in the lavage samples. However, in this site *Ricordea* had the highest proportion of the total volume (81%) followed by *Chondrilla* (14%). The remaining species represented less than 5% of the total volume.

When we compared the lavage results with the area coverage of the species at each site, we determined that *Chondrilla* doesn't seem to be actively selected for ($B = 0.07$ and 0.08 at Bahía de las Aguilas and Cabo Rojo, respectively). *Ricordea* had intermediate values of selectivity (0.30 and 0.12) which indicates some selection, especially at Bahía ($B = 0.30$) where it was less frequent in the environment than *Chondrilla*. However, the sponges *Myriastra* and *Spirastrella*, seemed to be highly selected for (B values ranging from 0.24 to 0.79), appearing in a relatively high abundance in the lavages even though they were rare in the environment.

The fact that the predominance in the diet of either *Chondrilla* (at Cabo Rojo) or *Ricordea* (at Bahía de las Aguilas) could be explained by their abundance in the environment alone, suggests that hawksbills may be somewhat flexible in choosing the main component of their diet (even across such nearby sites). Certain species, however, seemed to be actively selected for (e.i., *Myriastra* and *Spirastrella*), indicating perhaps that they represent critical resources to the turtles.

Our results also indicate a possible crucial ecological role for these turtles. Recently, Hill (1998) suggested that fish spongivory releases corals from competition with sponges in the Caribbean. The predominant diet species at the two study sites are aggressive competitors for space with hard corals. It has been documented in other studies in the Caribbean that *Chondrilla* frequently overgrows several species of hard corals, causing death to the colonies (Suchanek *et al.*, 1983; Vicente, 1987), and can also recover quickly from lesions (Vicente, 1987; Swearingen and

Pawlik, 1998). Less information is available on Ricordea, however, Vicente (1987) documented that it can also be an aggressive competitor for space. Therefore, it seems likely that hawksbills, through an indirect effect, play a critical role in maintaining reef health and structuring reef communities, a role that has been lost perhaps in areas where hawksbills have been decimated.

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Teaching Old Turtles New Tricks: Capture and Consumption of Novel Prey by Kemp's Ridley Turtles

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Among the activities involved in foraging, the processes of finding and identifying food and capturing and consuming that food are fundamental (Mellgren, 1998). Sea turtles tend to be somewhat specialized in their feeding preferences, possibly having innate food preferences leading to such specializations in their diet, although as hatchlings they are opportunistic feeders. The role that experience with different types of food plays in the preferences of adult sea turtles has not been examined. Dietary preferences in hatchling loggerhead turtles can be influenced by as little as two weeks of continuous experience with one prey type, but the experience-based preference is also flexible and responsive to new prey experiences (Grassman and Owen, 1982). Headstarted

Kemp's ridley sea turtles fed pelleted food from the time of hatching showed no hesitation at approximately 9-10 months of age to feed on natural food when presented with live items such as shrimps, crab, and fish (Klima and McVey, 1995). Similarly, the stomach contents of pellet-raised headstarted ridleys showed some differences from that of wild-raised turtles but there were also some similarities, suggesting that the headstarted turtles were adapting to a wild diet (Shaver, 1991).

In this experiment we tested adult Kemp's ridley turtles (approximately 12 years of age) that had been raised from the time of hatching on pelleted food for their reaction to live shrimps and crabs. We also included tests with the familiar pelleted food for comparison with the live items.

METHODS

Ten Kemp's ridley turtles (*Lepidochelys kempii*) were maintained individually in tanks measuring approximately 1.63 m in diameter. The turtles were born in captivity at the Cayman Turtle Farm and brought to Xcaret, Mexico in April 1999. (Marquez *et al.*, This volume). Water was taken directly from the Caribbean Sea and the tanks were cleaned daily. Normal feeding of pelleted turtle food was done once a day at approximately 1430 hours local time. The feeding tests were conducted approximately 1-4 hours prior to the normal feeding time. There were three types of feeding tests in which food was presented to each turtle: (1) two shrimps (*Penneus vannamey*), approximately 7.5-10 cm in length; (2) a single crab (*Graspsus graspsus*), approximately 5.0-8.0 cm in body width; and (3) two regular food pellets, approximately 1.8 cm in diameter. The time taken for the turtle to approach and strike at the particular food and the time taken to actually consume the food were measured. Only one type of feeding test was given on a single day, and each turtle experienced a different order of testing. At least two tests with each type of food were given to all turtles.

RESULTS AND DISCUSSION

On the test trial, all turtles ate the familiar pelleted food relatively quickly (mean = 5.2 minutes) even though the pellets had been delivered at an earlier time of day. Their reactions to the two shrimps and single crab were much more variable and unrelated to how quickly they ate the pelleted food. Four of the turtles did not eat or attempt to eat the shrimps. In fact, we left the two shrimps in the turtles' tank for over 48 hours to see if they would eventually eat or attempt to eat them, but no eating occurred. Of the six remaining turtles, three of them ate the shrimps on the first test in 0.2, 3.5, and 37.5 minutes. The other three turtles did not eat the shrimps in two hours of direct observation. The shrimps remained in the tank and sometime in the subsequent 20 hours, they were consumed. For these three turtles, when fresh shrimps were subsequently introduced for a second test, the turtles consumed them in 1, 2, and 6.2 minutes.

When the crab was presented for the first test trial, seven of the 10 turtles attacked and ate it and latencies ranged between 0.2 and 8.0 minutes. Of the three that did not attack or eat within two hours of observation, two of the turtles did consume the crab sometime during the following 20 hours. When tested a second time with a live crab, these latter two turtles consumed the crab in 0.2 and 3.3 minutes. The one remaining turtle failed to attack the crab, and anthropomorphically speaking, appeared not to have noticed the crab in its tank.

When a turtle was quick to eat a shrimp, it was quick to eat the crab, and when it was slow to eat a shrimp, it was slow to eat the crab. For the three turtles that ate shrimps on the

first test, all three consumed the crab in less than one minute of the first test. Of the three turtles that ate the shrimps sometime after the initial two hour test, they consumed the crab in 8.0, 6.2, and 1.2 minutes. Of the four turtles that never ate the shrimp, one never ate the crab; two turtles consumed the crab in the 20-hour period after the two-hour test. However, one turtle that failed to consume shrimps did attack and eat the crab on the first test in a very rapid fashion (0.3 minutes).

Generally, when a turtle attempted to consume the shrimps, there were several unsuccessful attacks before a shrimp was captured. Lively crabs could also elude the turtle for a period, and some crabs had their legs removed from inaccurate attacks until their bodies were finally consumed.

In conclusion, Kemp's ridley turtles raised on pelleted food from the time of hatching to adulthood will feed on live food that might be encountered in their natural habitat but some will do so with difficulty. (Large between-individual differences were apparent.) The difficulties the turtles experienced appear to reflect both recognizing the prey as food and the ability to capture the prey once identified. As Caillouet, Fontaine, Williams and Klima (1995) have suggested for younger, headstarted Kemp's ridleys, any plan to release turtles raised in captivity should be preceded by a month or more of experience in a semi-natural situation. The improvement in the time to capture the prey on the second test compared to the first supports the idea that the adult turtles' foraging capacity can improve from having experience with prey.

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Calcium Requirement and Growth in the Hatchling Loggerhead Sea Turtle *Caretta caretta*

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This study investigates the calcium requirement of the hatchling loggerhead sea turtle *Caretta caretta*. Calcium is important in the diet of growing animals due to its many functions. Calcium (Ca) is important in skeletal formation, neuromuscular function, heart contraction, blood clotting, membrane permeability, the activation of enzymes (Fowler, 1986), and buffering of blood during diving in sea turtles (Lutz and Musick, 1996).

The majority of the body's calcium is stored in the bones, but calcium is also present in plasma. The main organs and tissues involved in calcium homeostasis include the intestine, parathyroid and thyroid glands, and bone. Calcium homeostasis is maintained by three hormones. These include parathyroid hormone (PTH), calcitonin (TCT) and the biologically active form of vitamin D. The balance of these three hormones serves to maintain serum calcium levels in the body. Phosphorous (P) also has a strong relationship with calcium. Body calcium and phosphorous are in a ratio of 2:1. An excess of P drives the formation of an insoluble calcium phosphate, tying up the body's calcium in insoluble and inaccessible form.

Calcium deficiency may result in an animal experiencing metabolic bone disease. Metabolic bone disease is a generic term encompassing nutritional deficiencies related to the interactions of calcium, vitamin D, and an improper Ca:P ratio (Fowler, 1986). The disease in turtles may result in malformed bones, decreased bone density, softening of bones, weakness, anorexia, retarded growth, and misshapen, soft, pliable shells (Fowler, 1986). Fractured limbs are also common, and if conditions are prolonged or severe enough death may occur (Bolvin, 1990). The seriousness of hypocalcemia is directly related to the numerous roles of calcium in the body.

This study provides a first assessment of the calcium requirement for hatchling sea turtles. Most previous studies have focused on the herbivorous diet of the green turtle *Chelonia mydas* (Bjorndal, 1979; 1980, 1982; Thayer *et al.*, 1985) and the amino acid requirements of green turtles (Wood, 1974; 1977a; 1977b). Calcium requirements have only been described for the red eared slider (*Trachemys* spp.). A study by Kass *et al.* (1982) determined the requirement of the slider to be 2.0% dietary Ca on a dry basis.

This dietary information is important to educational, conservation, and rehabilitation programs that raise and rehabilitate sea turtles in captivity. It is important for those programs to feed the animals a properly formulated diet to

ensure that the skeletons of young turtles grow properly. Since the goals are often to release such animals, it is important they be structurally and biochemically normal and able to function normally upon release. Presumably, larger animals with greater bone density and properly formed shells will be healthier and better equipped to resist predation and have greater survivorship than smaller turtles with below average bone density.

This study was experimental in design and addressed the following questions:

- What is the range of bone densities found in wild caught hatchling and post-hatchling loggerheads?
- Do hatchling loggerheads grow faster and have better bone and shell formation on a commercially balanced diet, or the commonly fed diet of shrimp?
- Do hatchlings on diets with higher levels of calcium grow faster and/or have better bone and shell formation than those on diets with lower levels of calcium?
- Are signs of hypocalcemia evident in turtles on any of the test diets?
- What is the calcium requirement of the loggerhead hatchling?

METHODS

Recently hatched loggerhead sea turtles (n = 180, 15 nests) from local Florida beaches were divided among six diets. Each treatment group was housed at the FAU laboratory facilities in cleaned and disinfected 75 l glass aquaria with 10 turtles per aquarium. Each aquarium was filled 10 cm high with salt water and changed daily. The room was lit 12 hours/day with full spectrum UVA-UVB lighting. The temperature was approximately 26°C.

The test diets consisted of commercially formulated and balanced trout chow diets containing 1%, 2%, 3%, or 4% Ca and 1.65% P. Since the Ca requirement of loggerheads was hypothesized to be higher than that of the slider (2%) because sea turtles grow faster than freshwater turtles, 3 and 4% Ca were chosen. To identify a lower limit to the calcium requirement and to check for hypocalcemia, 1 and 2% were also tested. Commercially available AquaMax 500 pelleted trout chow (2% Ca) as well as bait shrimp *Pennais* spp. were also tested. All diets were analyzed to confirm Ca and P content. The previously unfed turtles were fed three to five hours/day starting on day four, every day for four weeks.

Measurements of body size were taken initially on day one of the feeding trials and again at the end. Measurements were taken to determine initial bone density before the turtles began feeding and again at the end of the experiment. A standard Aluminum reference scale was used in each x-ray to calibrate for bone density.

RESULTS AND DISCUSSION

The nutrient content of bait shrimp was found to be high in protein (~88% crude protein) and low in calcium (0.7% Ca). This calcium level is lower than in any of the experimental diets. Shrimp was also found to have 1.27% P which means that feeding turtles a diet of shrimp provides a diet which contains an inverted Ca:P ratio (0.55:1).

The average crude protein for the fabricated diets was approximately 46% with P held constant at 1.65% and Ca:P ratios ranging from 2.4:1 at 4% down to 0.6:1 at 1%. These diets ranged from what were presumed to be good Ca:P ratios to what we would expect to induce hypocalcemia.

The results for growth trials showed a significant difference in all growth measurements of turtles fed shrimp versus those fed all other diets. Turtles fed shrimp grew larger.

A significant correlation was found between the calcium content of the turtles and the measured bone density in AL equivalents. This indicates that the method we were using was a reliable method for assessing body Ca content.

Average bone density for wild caught turtles was 1.75 Al equivalents and no significant differences were found between the wild caught post-hatchling bone densities and the final bone densities for captive raised turtles. No visible signs of hypocalcemia were present in any of the x-rays, and no significant change was found in the bone densities of turtles on any of the diets over the four-week period. An analysis of the bodies of dead hatchlings found % Ca ranged from 1.06-1.82% on a dry matter basis, with an average of 1.52% Ca.

Growth in turtles fed diets as high as 4% calcium did not differ significantly from those fed only 1% Ca. These results support the hypothesis that mineral content is not the limiting factor for growth. The greater growth of shrimp-fed turtles (who were consuming <1% Ca) also supports this. These results also suggest that other factors were defining growth rates, with the most likely factor being protein. Shrimp contained almost twice as much protein as the test diets. Turtles on test diets could not make up for this difference in protein content by consuming more of the feed, in this case because of the higher fiber content of the commercial feeds. Fiber serves to make the turtles full, and the same volume of food is less digestible. Overall, a diet of shrimp provided for better growth than the test diets.

No signs of hypocalcemia were evident. Bone and shell formation appeared normal, and growth in turtles on test

diets with lower Ca levels and Ca:P ratios had bone densities similar to those fed higher levels of Ca and more normal Ca:P ratios. Hence, it appears that loggerhead turtles are capable of thriving in spite of inverted or atypical ratios. Also, no signs of deficiency were observed, therefore, no lower limit for Ca or insufficient Ca:P ratio were identified in this study.

The hatchlings thrived on ratios of Ca:P which differ greatly from the 1.5:1 to 2:1 ratios considered normal for reptiles. Loggerhead hatchlings are capable of tolerating levels of Ca and Ca:P ratios lower than other reptiles. If reptiles such as iguanas and fresh water turtles were fed such ratios they would exhibit signs of hypocalcemia. Higher levels of Ca are not necessarily more beneficial to the hatchling turtles. This is supported by the similarity in bone densities between captive and wild caught turtles, and the lack of difference among experimental turtles.

No significant change was found between initial and final bone densities of any turtles on any diets. The lack of change may have resulted from a reorganization of Ca within the shell and bones (suggested by the radiographic results). Overall density appears greater in the initial x-rays, while overall density remains the same, and specific areas of greater and other areas of lesser mineral concentration are visible in the final x-rays (after four weeks of growth). The absence of detectable change also suggests a maintenance of an overall, average bone density during growth by the turtle. Instead of simultaneously adding bone and building density the turtles may simply be maintaining a certain density.

This study serves as the first step towards understanding the mineral requirements of the loggerhead sea turtle

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Skeletochronology in Juvenile Kemp's Ridleys: Validation, Settlement and Growth

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The analysis of humeri from known-age and wild Kemp's ridleys (*Lepidochelys kempii*) have allowed for calibration of the annular nature of the deposition of growth layers, identification of settlement time, and age and growth rate estimation. Morphometric measurements of the humerus were correlated to straight carapace length for 114 animals. The relations were linear with all $r^2 > 0.97$ indicating that bone growth is proportional to somatic growth. A comparison of the amount bone growth after the last growth layer with the stranding date for a 40 animal confirms the annual cyclic nature of growth mark deposition and provides indirect evidence of the annular deposition of growth marks. Skeletochronological analysis of humeri from two headstart Kemp's that spent at least three years in the wild concur with the actual ages of the individuals, providing direct evidence of the annual nature

of the growth layers in juvenile post-settlement Kemp's. Results from a skeletochronological analysis of 140 small Kemp's (<30 cm SCL) retrieved as stranded, previously unknown animals, reveal the consistent presence of a first layer (settlement line). This layer was hypothesized to mark settlement to the nearshore benthos, similar to what has previously been seen in loggerheads (Snover *et al.*, 1999). We analyzed the stable isotope ratios of carbon and nitrogen in 10 of these humeri, sampling both before and after the settlement line. Results indicate that a diet shift occurred between the two sampling sites, specifically there is a shift to feeding at higher trophic levels after the settlement line. To date 96 humeri from juvenile (<50 cm SCL) Kemp's have been analyzed for age and growth rate estimation.

Measuring the Success of Sea Turtle Hatcheries in Malaysia: Using Emergence Success, Sex Ratios and Hatchling Performance as Indicators

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Data obtained from legal egg harvests and tagging data collated by Federal and State fisheries agencies from Peninsula Malaysian beaches suggest that the green turtle populations are under immense pressure. Since 1960 the use of hatcheries to protect sea turtle clutches have been employed on several beaches along the Terengganu and Pahang coasts. The success of these hatcheries has in previous years only been measured using emergence success and sex ratios as the key indicators. During the 1999 nesting season data was collected from hatcheries on mainland beaches and Pulau Redang on sand temperatures, emergence success, nest parameters and hatchling performance. Data indicated that emergence success from natural *in situ* nests and hatchery nests were above 80% and on par with successful beaches worldwide. Sand

temperatures in the hatcheries were above 29° C and within the range of 90-100% female production. The incubation period of eggs was significantly longer at Pulau Redang than on the mainland beaches and the depth of nests to the bottom of the egg mass was deeper. Hatchling running speed was quicker at Pulau Redang than both of the mainland rookeries, however there was no difference in hatchling size and weight from the rookeries. Nor was there a correlation between hatchling size/weight and running speed. Hatchling performance appeared to be linked to the incubation environment. In order to establish and maintain a successful sea turtle hatchery, managers must look at the combined approach of these factors so as not only to produce quantity but quality.

Rationale for Evaluating the Design and Function of Monitoring Programs Undertaken in Association with the Nourishment of Florida's Marine Turtle Nesting Beaches

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INTRODUCTION

It is fundamentally accepted that beach nourishment impacts nesting and incubation habitat for marine turtles. Monitoring programs have become a common aspect of permit requirements for nourishment projects, largely because of the acknowledgment of these impacts on critical marine turtle habitat. These monitoring programs characteristically contain both biological and physical aspects to be quantified, with the ideal result being that nourishment causes no impact to these beaches. Realistically, however, nourishment impact does exist in one form or another. The real utility of the monitoring program is its ability to look at specific impacts seen in the biological data, and having the capability to trace the cause of these impacts back through the physical components, revealing where in the nourishment project adjustments need to be made. Recommendations can then be made as how to improve future nourishment projects in order to minimize their impact on important marine turtle habitat. A casual inspection of monitoring programs suggests shortcomings exist in current monitoring programs. These shortcomings result in a large economic investment, which gives way to the generation of large data sets, whereby no clear conclusions have yet been made specific to the impacts of beach nourishment on marine turtle nesting beaches. Because of the difficulty in determining what, if any, impacts are specifically made on marine turtle nesting

beaches, regulatory agencies cannot and have not made any major advancements in nourishment project protocol specific to these nesting beaches. Ultimately, as we are unable to assess specific impacts from nourishment projects, nourishment continues on these beaches, and will continue to do so without regard to the impacts on marine turtles. The long term cumulative effect of this is currently unknown, but must be determinately malign. This paper describes: 1) a preliminary evaluation of the marine turtle monitoring program undertaken at Sebastian Inlet, Florida, and 2) recommendations for program improvements.

METHODS

The monitoring program at Sebastian Inlet, Florida was initiated through permitting in 1989 by a regulatory mandate (which was dropped several years later), and has run continuously through all nesting seasons until the end of 1999. Sebastian Inlet is located along the east coast of Florida, in the center of the Archie Carr National Wildlife Refuge, and the beaches about this inlet are known for their high densities of marine turtle nesting (National Research Council, 1990). The program monitors physical and biological characteristics of nesting beaches at two high density nesting beaches. This paper will specifically examine the physical portion of the monitoring program as this component is a relatively new addition to nourishment monitoring programs undertaken in association with

marine turtle nesting. The north beach (which has never been nourished) is situated north of the inlet while the south beach (undergoes periodic nourishment in association with inlet maintenance) is located south of the inlet (Fig. 1). The project is designed to assess whether beach nourishment performed in association with inlet maintenance and compliance with the Beach Management Act of 1988 impacts these high density nesting beaches. Table 1 lists the parameters quantified in this program, whereupon each of these parameters were collected monthly at cross-shore locations consisting of the toe of dune, spring high water, and mid-backshore. Each parameter was measured at 30 cm and 60 cm to coincide with loggerhead nest depth. For a full explanation detailing methods of collection, please refer to Parkinson and Lucas (1999). In order to quantitatively evaluate the monitoring program, a 5-Way ANOVA was performed on data collected for each physical parameter with the factors consisting of year, month, beach, depth, and station location. Use of this test allowed simultaneous comparisons to be made within each data set, as well as testing the data for interaction between factors. Data was tested to ensure it met the necessary assumptions of the ANOVA, and if it did not, transformation of the data occurred. If the data still did not meet the assumptions of the ANOVA, the Scheirer-Ray-Hare extension of the ANOVA was employed (Sokal and Rohlf, 1995). If significance was found to occur, the Bonferroni multiple comparison was applied to determine where significant differences existed (Sokal and Rohlf, 1995).

RESULTS AND DISCUSSION

Results obtained from the statistical analyses are presented in Table 2. Individual factors were not statistically testable when interactions were present (n/a), so only trends will be discussed in these cases. Given the limited amount of space for this paper, only select examples will be discussed.

The monitoring program under review was found to exhibit inappropriate experimental design, redundant data collection, and a poor linkage between the physical and biological parameters being quantified. The first example to be discussed pertains to inappropriate experimental design. Data collection occurred equally at three cross-shore stations, however 95% of the overall nesting activity was found to occur in the upper two-thirds of the beach, with only 5% of nesting occurring proximal to the spring high water station. In light of this information, it has become apparent that we are creating a disproportionate representation of the nesting and incubation environment, biasing the data toward an area of the beach which is scantily nested. Therefore, the characterization we develop for this environment may be very different from that which is naturally occurring. Data collection at the spring high water station was also found to introduce a large amount of variability into the data set, and in fact was responsible for

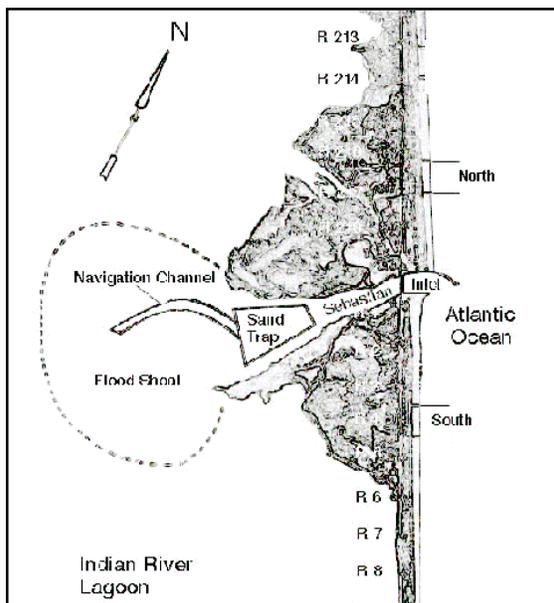
59% of the overall variability in the moisture content data set. Keep in mind that under ideal conditions, this station would contribute approximately 33% of overall variability. This large amount of variability makes statistical comparisons difficult as the spring station creates so much noise, detection of nourishment impacts become impaired. As moisture content was the only parameter seen to vary significantly with regard to cross-shore station location, and due to the small proportion of nesting occurring proximal to this station, the monitoring program would benefit from a re-evaluation of cross-shore station locations. The second example to be discussed deals with redundant data collection. Data collection for each of the physical parameters occurred monthly, however none of the parameters varied significantly on a monthly basis. Ambient beach temperature does follow monthly trends which perhaps would be statically significant without the presence of an interaction, however nourishment monitoring programs are designed to determine whether the placement of fill creates sub-optimal environments for marine turtles. Speaking strictly in terms of quantifying physical parameters, it would be feasible to sample beach temperature on a scale less rigorous than is currently in use, and still accurately determine whether or not significant changes have been made to the beach environment. When looking at biological implications however, it is unclear as to the frequency of sampling necessary to characterize impacts, more work clearly needs to be done in this area. Parameters such as grain size and shear resistance, however, which do not vary on a monthly basis, could be monitored less frequently. This would allow for a more cost-effective program, as well as improving overall efficiency and allowing researchers to focus their effort on areas currently lacking. The final example to be discussed deals with a poor linkage between the physical and biological parameters being quantified. Beach profile and the presence of scarps has been shown to impact female nest placement, as well as incubation of the nests (Ehrhart and Herren, 1997, Crain *et al.*, 1995). The presence of scarps can contribute to a larger number of abandoned nesting attempts, nesting in sub-optimal environments, and may prove to be lethal to incubating nests as a result of tidal inundation. While scarping occurs on most nourished beaches, it is rarely included in monitoring programs associated with beach nourishment. Perhaps monitoring parameters less frequently will allow for the addition of new parameters to facilitate our understanding of these nesting beaches. The evaluation undertaken at Sebastian Inlet, Florida suggests the current monitoring programs associated with beach nourishment should be re-evaluated in order to eliminate problems of inappropriate experimental design, redundant data collection, and to tighten the link between the physical and biological parameters being monitored. In performing this evaluation, it would allow for the development of a better understanding in how the physical and biological aspects of marine turtle nesting and incubation interact. Once we have

a better grasp on these interactions, we can confidently determine impacts of beach nourishment, and make recommendations as how to improve the selection, placement, and maintenance of fill material on these nesting beaches. This concept is beginning to develop among researchers, and in fact, during the symposium, a workshop was held in order to better define which physical parameters should be monitored in association with beach nourishment (the results of this workshop are available online at www.fit.edu/dmes/new-coastal/orlando2000.htm). Beach nourishment projects are not going to disappear, and in fact will be occurring more frequently and on larger scales as time progresses. We must better define what should be included in monitoring programs before we lose our chance to preserve this critical marine turtle nesting habitat.

ACKNOWLEDGMENTS

We would like to take this opportunity to thank Ron Johns, the park manager at SISRA, the UCF team who collected biological data, and the Sebastian Inlet Tax District for funding this research.

Fig. 1. Location map of study site at Sebastian Inlet, Sebastian, Florida.



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Table 1. Physical parameters monitored at Sebastian Inlet, Florida. All data were acquired at the toe of the dune, mid-backshore, and spring-high water at depths of 30 cm and 60 cm.

Physical attribute	Units	Technique	Sample frequency
Ambient beach temperature	°C	thermocouples	monthly; every 3 hr over a 24-hr period
Mean grain size	mm	nest sieves	monthly
Shear resistance	p.s.i.	cone penetrometer	monthly
Moisture content	dry wt. %	wet wt./dry wt.	monthly

Table 2. Results of statistical analyses performed on individual factors. Results are described as follows: ns = not significant, * = p<0.05, ** = p<0.01, and *** = p<0.001. Where significant interactions occurred between factors, those factors could not be specifically analyzed because of the interaction. In these cases, only trends will be qualitatively discussed.

Parameter	Factor					Significant interactions
	Year	Month	Beach	Depth	Station	
Ambient beach temperature	n/a	n/a	**	0	ns	Year/Month
Mean grain size	ns	ns	***	ns	ns	none
Shear resistance	ns	ns	***	***	ns	none
Moisture content	n/a	ns	n/a	ns	0	Year/Month*** Year/Month*

Going Beyond TEDs: Protected Swimways for Sea Turtles

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SUMMARY

Endangered and threatened sea turtles could benefit from a network of protected and linked swimways that would provide safe passage through migratory, nesting, developmental and foraging habitat around the world. International conservation groups are calling for 20% of the world's oceans to be protected in Marine Protected Areas (MPAs) to preserve fisheries and marine biodiversity (National Research Council, 1998). Creating 'international parks' that are free from human pressures-industrial fishing in particular-could help provide global protection for sea turtles. Such parks or reserves would benefit other marine life by offering undisturbed areas that will help maintain our wild oceans.

Turtle Excluder Devices have not proven to be a complete solution for protecting endangered sea turtles from shrimp fishing. Ten years after TEDs were implemented in the U.S., sea turtle mortality continues during shrimp fishing. Many shrimp fleets of the world still do not use TEDs. And U.S. TEDs laws are being eroded by global trade treaties. Longline fishing is clearly another threat to sea turtle populations. Other types of commercial fishing activities also cause sea turtle mortality.

Most of our important sea turtle nesting beaches now possess a high level of protection and monitoring, and trade in sea turtle products is illegal. Yet, sea turtles still remain vulnerable to extinction. New approaches that go beyond beach protection and fishing regulations are needed to protect sea turtles in their ocean habitat and assure their survival for the next thousand years and more. A global network of protected swimways-closed to commercial fishing-established through linked Marine Protected Areas could achieve this while providing benefits to fisheries, other marine life, coastal communities and future generations.

LAND-BASED PROTECTED AREAS

About four percent of U.S. land is protected in national parks such as Yosemite, Yellowstone and the Grand Canyon (Fujita, 1998). However, wildlife biologists have recognized that the national parks have, in many cases, created fragmented islands of habitat. As a result, a new call to protect larger connected areas of habitat for far-ranging mammals including grizzly bears, wolves and mountain lions is coming from groups such as The Wildlands Project. The group's Yellowstone-to-Yukon (Y2Y) initiative is the first effort to link large areas of protected habitat for large mammals.

Other coordinated efforts to link protected terrestrial habitat have been initiated by IUCN and WCPA through the Circumpolar Protected Area Network, the Western Hemisphere Shorebird Reserve Network and the Mountain Area Protected Network.

These land-based efforts provide models for what could be achieved in marine habitat. And the sea turtle could become the flagship species for establishing linked networks of marine protected areas.

WHAT IS A MARINE PROTECTED AREA?

A Marine Protected Area is defined by the International Union for the Conservation of Nature (IUCN) as "any area of intertidal or subtidal terrain together with overlying waters and associated flora and fauna, and historical and cultural features that have been reserved by law or other effective means to protect all or part of the enclosed environment."

The IUCN defines six different categories of MPAs, depending on level of protection (International Union for the Conservation of Nature, 1994). Currently, no standard MPA definition exists. Hundreds of MPAs have been established in many countries around the world using a variety of terms such as marine reserve, marine sanctuary, and ecological reserve (Marine Protected Area News, 2000). Some allow no human activity at all, while others restrict fishing only, and still others permit all activities except a very specific activity like oil exploration or dumping.

For example, the U.S. National Marine Sanctuary Program has established 12 marine sanctuaries. However, these sanctuaries provide a low-level of protection for marine life because all activities including commercial fishing are allowed. Only oil exploration is prohibited.

In contrast, the 16 marine reserves established in New Zealand during the past 35 years are all no-take zones (Ballantine, 1999). Swimming, boating and diving are allowed, but no fishing or other extractive activity.

Marine protected areas have been created in many ways by many different agencies.

At Channel Islands National Park in California, a coalition of stakeholders including government agencies, fishers, and environmentalists have collaborated on an effort to create a 25,000-acre no-take zone to protect abalone, sea otters and other marine life. The National Park Service took the lead in this effort.

In Florida, the Gulf of Mexico Fishery Council approved a no-take marine reserve to protect gag grouper, a long-lived sedentary fin-fish species. A large no-take

marine reserve is currently being proposed for the Dry Tortugas in the Florida Keys to protect a vibrant zone of marine habitat.

A de-facto marine reserve closed to longline fishing was established by court-order in a million square miles of ocean north of Hawaii due to illegal killing of endangered leatherback sea turtles by that fishery.

CALLS TO PROTECT OUR OCEANS

The concept of creating protected swimways for sea turtles in important migratory, foraging, developmental and nesting habitat arose in response to increasing calls from marine scientists to protect our wild oceans in marine protected areas. Today, less than one-half of one percent of the 4.4 million square miles of submerged lands under U.S. jurisdiction is protected. The IUCN and the U.S. National Research Council are calling for 20 percent of the world's oceans to be set aside in marine protected areas by the year 2020 due to threats to marine biodiversity-overfishing, habitat destruction, pollution, alien species and global atmospheric change (National Research Council, 1998).

The Marine Conservation Biology Institute and The Cousteau Society released a proposal in February 2000 pressing the Clinton Administration to set up a network of linked marine protected areas in the U.S. (Marine Conservation Biology Institute, 2000). The proposal asked for two percent of U.S. waters to be protected by 2005 and for 20 percent of each ecosystem type to be represented. Unlike Canada with its Ocean Protection Act, the U.S. currently has no policy to establish a network of marine protected areas.

To date, most efforts to create marine protected areas have been fishery focused on a case-by-case basis and viewed primarily as a tool to protect diminished fish stocks. To benefit sea turtles, the discussion must be enlarged to include endangered species and all marine biodiversity.

WHY SEA TURTLES NEED PROTECTED SWIMWAYS

Use of Turtle Excluder Devices in shrimp nets have not stopped large numbers of sea turtles from washing up dead and dying along coastline when shrimping is underway. Compliance with and enforcement of TEDs laws has been inconsistent. Despite stepped up enforcement efforts by federal and state officials during the past two years, sea turtle strandings have risen in many areas.

Repeated capture and escape of sea turtles through TEDs may be causing sea turtle mortality. And a recent report from National Marine Fishery Service provides evidence that legally approved TEDs opening sizes are too small for larger loggerhead and green sea turtles to escape (National Marine Fisheries Service, 1999). This points to the conclusion that TEDs have not turned out to be the total solution for allowing shrimp fishing to occur without

negatively affecting sea turtles.

The commercial longline fishery is also taking a toll on sea turtle populations, primarily the endangered Pacific leatherback. The coastal drift gillnet fishery in California is exceeding its allowable take of loggerheads. Other fisheries certainly take a toll on sea turtles as well.

For these reasons, sea turtle protection in fisheries must be enhanced by creating marine protected areas that are closed to commercial fishing. Strategically placed MPAs closed to commercial fishing would provide immediate relief from incidental sea turtle capture and mortality.

WHERE TO START?

Because the Kemp's ridley is the most endangered sea turtle in the world, establishing a Kemp's Ridley Marine Reserve along the South Texas coast could be the place to start.

At the species' primary nesting beach in Rancho Nuevo, Mexico, a three-tiered conservation strategy has achieved results in the form of slow recovery of a once abundant population. The strategy includes beach protection, TEDs and a marine reserve that is off limits to shrimp fishing during the sea turtle nesting and mating season, March to August.

The Kemp's ridley in the U.S. has beach protection and TEDs, but no marine reserve. As a result, more adult Kemp's ridleys die along the South Texas coast than anywhere in the world (Shaver, 1999). This is also the only regular nesting site for the Kemp's ridley in the United States.

The South Texas coast also provides important developmental habitat for juvenile green sea turtles. Loggerheads and hawksbills also occasionally nest here and leatherbacks are found stranded on these beaches every year.

Other key areas in the U.S. to create protected swimways off limits to shrimp fishing could include sections of the coast of Florida, Georgia, North Carolina and South Carolina where sea turtles regularly nest and forage. Existing marine reserves and sanctuaries could provide natural starting points for establishing sea turtle swimways and increasing fishing restrictions. Sea turtle biologists studying sea turtles in the U.S. and overseas are best equipped to determine where other sea turtle swimways should be established.

BENEFITS OF SEA TURTLE SWIMWAYS

Beyond protecting sea turtles in their ocean home, protected swimways could also provide protection for marine mammals, fin-fish species, other marine life, and the sea floor. Benefits could extend to coastal communities in the form of enhanced fisheries and eco-tourism, to

scientists for research and for future generations of people.

STRP encourages the sea turtle community to begin identifying locations for sea turtle swimways and become active in coalitions working to create marine protected areas. STRP is working to create a internet-based communications network for sea turtle conservationists striving to create marine reserves or swimways for sea turtles.

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Sea Turtle Depredation by Jaguars at Tortuguero National Park, Costa Rica

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Depredation of green turtles by jaguars in Tortuguero National Park has previously been reported. The scarce published and anecdotal information available indicate that depredation levels until recently have been low. In an effort to quantify jaguar depredation, the number of sea turtles killed by jaguars were recorded during regular track surveys along 30 km of nesting beach in Tortuguero National Park, 1997-1999. Jaguars killed both green turtles (*Chelonia mydas*) and leatherbacks (*Dermochelys coriacea*). Jaguars ate only the neck muscle and a part of the internal organs of the turtle; the carapace was always left intact. The number of jaguar-depredated green turtles increased from a minimum of four in 1997 to 25 in 1998 and 22 in 1999. Two leatherbacks killed by jaguars were encountered in 1999. Several factors may be involved in causing the increase in jaguars depredating nesting turtles. The jaguar population may have increased in recent years as a result of protective measures in Tortuguero National Park or by immigration of jaguars from deforested areas in the proximity of the park. The increase in depredation by jaguars might also be

attributable to a small number of jaguars developing the habit of depredating turtles, possibly in response to decreasing populations of other prey species. A more detailed study to quantify the number of jaguars and to determine their prey preference is needed to explain the apparent increase in sea turtle depredation.

ACKNOWLEDGMENTS

Area de Conservacion Tortuguero provided the permit for this research. Caribbean Conservation Corporation funded and organized the study. Chuck and Tom Carr, Eduardo Carrillo, Eduardo Chamorro, Kazuo Horikoshi, Cynthia Lagueux, Anne Meylan, Jeanne Mortimer and Larry Ogren provide useful jaguar information. My co-authors Eddy and Alonso Rankin conducted the majority of track surveys. Research assistants during the 1997-1999 turtle programs also helped with track counts.

Determination of the Percentage of Olive Ridley (*Lepidochelys olivacea*) In Situ Nests That Are Affected by Beetles at Escobilla Beach (Mexico)

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During the nesting season 1999-2000 it was possible to review olive ridley nests *in situ* at Escobilla Beach, to determine the percentage that were affected by the beetle *Omorgus suberosus fabricius*. This predator prefers the wet area on the beach, where it is more frequently found than in the dry area.

On the beach it was possible to find places with fewer beetles because the rivers clean the beach. During the first arrival we found 38.66% destroyed by the beetle. During the second arrival we found 26.06% destroyed. During the

third arrival we have results for three zones finding a total of 16.90% destroyed, but in some wet areas the percentage increase to 70%. In contrast, at the corral (the place where the nests are relocated) 89.95% were destroyed, even the shells were eaten by the beetle; just 2.83% hatched in this area. It is important to mention that in some nests 250 adult beetles were found. The results of the fourth arrival were better, only 7.62% had the predator and 87.98% hatched. The final results are given here.

Mortality Rates of Sea Turtle Species in the Bahía Magdalena Region

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INTRODUCTION

Coastal lagoons of the Baja California peninsula, Mexico, such as Bahía Magdalena provide important feeding and developmental grounds for sea turtles. Five different sea turtle species are known to occur in this region: the Eastern Pacific green turtle (*Chelonia mydas*), locally known as the black turtle (*Chelonia agassizii*), the

Pacific loggerhead (*Caretta caretta*), the olive ridley (*Lepidochelys olivacea*), the hawksbill (*Eretmochelys imbricata*) and the leatherback (*Dermochelys coriacea*).

Although sea turtle populations are affected by many sources of natural mortality, human-related causes of death are a continuous concern world-wide. While these factors may include drowning in fishing nets, boat collisions, and ingestion of plastics, consumption of turtle meat as a result

of incidental and deliberate catches of sea turtles may be contributing substantially to the decline of many sea turtle populations (Clifton *et al.*, 1982).

In 1972 the Mexican government began to strictly regulate the capture of sea turtles (Secretaria de Pesca, 1990). Although laws now exist that forbid the capture or consumption of turtles, they are often difficult to enforce. Along the Baja California Peninsula there are numerous natural resource-dependent communities. In many of these towns, such as those in the Bahía Magdalena region, the majority of the inhabitants are employed as fishermen who have limited economic alternatives. In towns such as these, sea turtles have been historically considered a delicacy to be served on special occasions (Felger and Moser, 1987). In addition to being a food source, sea turtles were used by coastal communities for various purposes including games, decorations, and gained traditional, even spiritual, importance (Felger and Moser, 1987). Despite the fact that it is illegal to deliberately catch a turtle anywhere in Mexico, it has proven to be very difficult to manage the use of this resource which is so engrained as part of this region's cultural heritage (Clifton *et al.*, 1982).

Our study was conducted to assess the threats to sea turtle populations in the region of Bahía Magdalena. The specific objectives were to identify which species are experiencing the highest mortality levels in this region; to determine the size classes that are most commonly vulnerable and to estimate the magnitude of mortality of sea turtles in this region.

METHODS

Bahía Magdalena is located on the Pacific coast of the Baja California Peninsula between 24°15' N and 25°20' N, and 111°30' W and 112°15' W. As a result of seasonal upwelling, it is a highly productive lagoon that is sheltered from Pacific waters by two barrier islands, Isla Magdalena and Isla Margarita.

A search for sea turtle carapaces was conducted throughout the Bahía Magdalena region from June to December 1999. This search included the towns and dumps of Puerto San Carlos, Puerto Magdalena, and Puerto Alcatraz. Also surveyed were the Pacific coastal beaches of the islands, Isla Magdalena and Isla Margarita. The species of each turtle carcass was identified and the location determined using a handheld Garmin 12 Global Positioning System (GPS).

The straight carapace length (SCL) of each turtle was recorded using calipers, taken from the anterior nuchal notch to the longest posterior point of the carapace. After each carcass was measured, the underside of the carapace was marked with neon spray paint to avoid duplicate counting. Initial surveys were conducted in June to identify and mark all turtle carapaces, and then these areas were resurveyed repeatedly throughout the six month period in order to estimate a rate of mortality based on the new turtles

found over time. The estimated mortality rate for the Bahía Magdalena region was the sum of the new carapaces found for each survey area divided by the amount of time that lapsed between surveys.

RESULTS AND DISCUSSION

Over the 6-month study period, carapaces of four out of the five species known to occur along the peninsula were found. A total of 514 turtle carapaces were measured. Two species, the green and loggerhead turtles, experienced the highest apparent mortality. Green turtle carapaces were the most frequently observed ($n = 267$, 52%), with loggerhead carcasses/carapaces ranking second ($n = 180$, 35%). Olive ridley ($n = 12$, 2%) and hawksbill ($n = 6$, 1%) carapaces made up a much smaller percentage of the totals (Table 1). The species identity of approximately 10% of the carapaces found could not be determined.

The mean SCL of loggerhead turtles was 58.5 cm (sd = 11.1, range = 26.6-83.4), all of which were smaller than the average size of adults reported on nesting grounds (87 cm) (Miller, 1996). The green turtle average SCL was 59.8 (sd = 13.7, range = 35.6-94.2) which is smaller than the mean lengths reported for this species in the Gulf of California (W.J. Nichols, personal communication). Over 87% of the green turtles found in the Bahía Magdalena region were smaller than the average size of adults reported on nesting grounds (77 cm) (Figueroa *et al.*, 1992).

The majority (78%) of the turtle carapaces found were observed in the towns and dump sites of the region. Turtle carapaces from the town of Puerto Magdalena made up 46% of all findings and in Puerto San Carlos, 28% of the carapaces were observed. The community of Puerto Alcatraz contributed to the turtle mortality to a much lesser extent (3%). Only 22% of the carapaces found were located in the non-populated areas of the region. During the surveys of June and July, only 12 turtles were found on uninhabited beaches and only four of the turtles showed signs of not having been consumed (freshly dead whole carcass).

However, some regions were located in such isolation that they were difficult to access and could not be surveyed more than once. For instance, during the fall surveys (September to November), 92 of the 255 new turtles found were located along the northern beaches of Isla Magdalena. This region contained approximately 1.5 turtles/km but was surveyed only in September. Since these areas were not previously or repeatedly surveyed, they could not be included in the mortality rate estimates.

Also surveyed for the first and only time was the western beach of Isla Margarita and the town of Puerto Alcatraz. Only 17 turtles were found in this town and only one carcass was found along the 20 km beach of this island. This contrasts greatly with the high numbers of turtles found on the surveyed beaches of Isla Magdalena. Two hypotheses exist to explain this inconsistency: the directions of ocean currents or reduced fishing off the

coast of Isla Margarita. Two of the surveyed beaches of Isla Magdalena where the highest number of stranded turtles were found face NW, while the beach on Isla Margarita faces WSW. Furthermore, fishermen report higher fishing effort in waters offshore Isla Magdalena, in Bahía Santa Maria, than waters off Isla Margarita.

The minimum sea turtle mortality rate for the Bahía Magdalena region was estimated to be 47 turtles per month, or 564 turtles per year. Turtle carapaces were 3.5 times more numerous in the towns and dump sites of the region than on the uninhabited beaches. There were 2.5 times as many green turtles as loggerheads found in the towns, however, a stranded turtle found on one of the Pacific beaches was 6 times more likely to be a loggerhead than a green turtle (Table 1).

The overall goal of this study was to provide a general gauge as to the magnitude of sea turtle mortality in this region. Although this minimum estimate for Bahía Magdalena may contain inaccuracies, this estimate is most likely very conservative. Most loggerhead turtle mortality in this region impacts juvenile animals that have not yet reached reproductive maturity. This is likely a reflection of the population at large, rather than selective mortality (Nichols *et al.*, 2000). Mortality of green turtles seems to be primarily related to domestic consumption and impacts both juvenile and adult animals. It is difficult to discern whether consumed animals were incidentally or purposefully captured. However, local informants suggest that it is a combination of both and an incomplete understanding of the Mexican laws prohibiting turtle use. Sea turtles originating on beaches as far away as Japan and southern Mexico contribute to the populations found in the waters of the Baja California Peninsula. Continuation of this rate of mortality, particularly if Bahía Magdalena is representative of the entire region, will drastically impede and confound long term recovery efforts and research taking place on sea turtle nesting beaches.

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Table 1. The location of sea turtle carapaces/strandings during surveys conducted in the Bahía Magdalena, BCS, Mexico, region during the summer and fall, 1999.

Species	Communities			Beaches			Total
	Pto. Magdalena	Pto. San Carlos	Pto. Alcatraz	Isla Magdalena	Isla Margarita	Unidentified	
<i>Chelonia mydas</i>	119	123	12	11	0	2	267
<i>Caretta caretta</i>	80	18	3	78	1	0	180
<i>Eretmochelys imbricata</i>	4	1	0	0	0	1	6
<i>Lepidochelys olivacea</i>	5	2	0	5	0	0	12
Unidentified	30	1	2	12	0	4	49
Total	238	145	17	106	1	7	514

Turtle Mortality in Fisheries off the Coast of Peru

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INTRODUCTION

The capture of leatherback turtles (*Dermochelys coriacea*) and green turtles (*Chelonia mydas agassizii*) less than 80 cm long, has been prohibited in Peru since 1976. In 1995, the Peruvian government enacted a new decree (No. 25977) prohibiting the capture, trade and consumption of marine turtles [green turtle, leatherback turtle, olive ridley turtle (*Lepidochelys olivacea*) and hawksbill turtle (*Eretmochelys imbricata*)]. However, these measures were poorly or not at all enforced in many ports of the Peruvian coast, and sea turtles were openly caught for human consumption in Pisco (13°45'S, 76°13'W), Chincha (13°30'S, 76°11'W), Pucusana (12°30'S, 76°45'W), Callao (12°02'S, 77°05'W) and Chimbote (09°05'S, 78°36'W), among other fishing towns, until recently (Hays, Brown, and Brown, 1982; Aranda and Chandler, 1989; Van Bresseem *et al.*, 1998; Alfaro-Shigueto *et al.*, 1999; and Van Waerebeek *et al.*, 1999).

During their long-term monitoring of the mortality of small cetaceans in fisheries off Peru, members of the Peruvian Centre for Cetacean Research (CEPEC) regularly observed and recorded captures of marine turtles in several ports. Here we present data on turtle mortality in fisheries in 1993 and 1994 in Cerro Azul (13°00'S, 76°30'W) and Chimbote, as well as a compilation of the data on the capture of leatherback turtles along the Peruvian coast for the period 1984-1999.

METHODS

CEPEC has been monitoring dolphin mortality in fisheries in several ports of the 2500 km long Peruvian coast since 1984. The ports visited, the survey periods and the methodology used are described in detail in Read *et al.* (1988) and Van Waerebeek *et al.* (1997). Data on the capture of marine turtles were collected opportunistically while monitoring cetacean mortality in fisheries, and entered into field books, cetacean specimen data sheets and diaries. They were also gathered during dedicated surveys geared toward turtles from 1999 onwards. Numbers of landings of turtles should be considered as minimum, as they were either collected opportunistically or because fishermen were sometimes hiding their catch as a consequence of the prohibition. Individuals were measured and sexed when feasible. Carapace and plastron measurements were taken in straight lines, following standard methods (Pritchard *et al.*, 1983). Skin samples were collected in 20% DMSO and 70% ethanol.

RESULTS

The green turtle, olive ridley turtle (both 83.2%) and leatherback turtle (16.18%) were the most commonly landed species at the fishmarkets of Cerro Azul and Chimbote in 1993 and 1994. In Cerro Azul, 23 turtles were observed in 128 days of monitoring from February to December 1993. The stratified estimate of total capture in 11 months was 77 ± 12 (ES) turtles. Fourteen individuals were landed in 84 days monitored in the period January-August 1994. The stratified estimate of the total capture in eight months was 45 ± 8 (ES) turtles. In Chimbote, 31 individuals were observed during 50 days of monitoring in the periods January-April 1993 and June-August 1993. The stratified estimate of the capture during these months was 133 ± 29 (ES) turtles (Table 1.). Turtles were commonly taken with 'animaleros' which set large mesh drift gillnets to take large species such as sharks and rays but also dolphins and these marine reptiles.

In the period 1985-1999, we observed at least 33 leatherback turtles, alive or dead, on beaches, in fishmarkets or in dumps in Pisco, Cerro Azul, Pucusana, Ancón (11°47'S, 77°11'W), Chancay (11°37'S, 77°16'W), Huacho (11°07'S, 77°37'W), Chimbote and Salaverry (8°14'S, 78°59'W). Several carcasses of leatherbacks found at Cerro Azul in April 1985, were considered as one specimen (Table 2.). Besides, in late 1984 the sunburnt carapaces and skeletal remains of at least two dozen, mostly leatherback turtles were encountered in Pucusana fish offal dumps. Most leatherbacks were captured in gillnets and landed with other species, mainly green turtles and small cetaceans. Eighteen of 28 leatherbacks (64%) landed alive or recently dead were observed during the austral spring and summer (21 September-21 March). Standard length (SL) of the carapaces was 111 to 165cm (N = 10). Of 10 animals measured, six had a SL over 130 cm, the size at which leatherbacks from the Pacific were quoted to reach sexual maturity. Two sexually mature females, one of these 156 cm long, carried eggs in their oviducts.

DISCUSSION

Updated information on the status of marine turtles along the Peruvian coast is scarce (Van Bresseem *et al.*, 1998; Van Waerebeek *et al.*, 1999; Alfaro-Shigueto *et al.*, 1999). Results from these and current studies show that turtles are still caught and utilized for human consumption, despite the 1995 decree prohibiting their capture, trade and consumption. The recent clandestine nature of this trade makes monitoring of captures and sampling difficult.

Nonetheless, through sustained effort, valuable data and biological samples can be obtained.

As most turtles are commercialized after being caught alive, and are almost never released, their captures are strictly directed and should therefore not be labelled 'by-catch'. Recent data showed that green turtles have been captured with longlines too and some reports indicated that this may also occur to leatherback turtles (Van Waerebeek *et al.*, 1999). Future work should address interactions with fisheries, such as longlines and industrial purse-seines for small schooling fish.

Interviews with fishermen and CEPEC's observations indicate that catches of leatherback turtles have been in decline for a protracted period. Though many green and olive ridley turtles appear to be still common along the Peruvian coast, the high level of capture may affect their long-term survival. CEPEC's environmental education program, directed to fisherman's children and port authorities, is intended to reduce the capture, trade and consumption of endangered marine fauna. The environmental education and research programs should be continued and expanded to other ports of the Peruvian coast.

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Table 1. Data on turtle mortalities in fisheries off the central and northern coast of Peru. OB, ES, and SE are the observed and estimated numbers and the standard errors (respectively), stratified per month, of green and olive ridley turtles landed at the ports of Cerro Azul.

Month	Chimbote, 1993			Cerro Azul, 1993			Cerro Azul, 1994					
	Days	OB	ES	SE	Days	OB	ES	SE	Days	OB	ES	SE
Jan	10	0	0	0	0	0	0	0	9	2	7	4
Feb	6	10	46	8	3	2	19	8	12	1	2	2
Mar	10	12	37	14	10	2	6	5	17	5	9	2
Apr	8	0	0	0	9	2	7	4	3	1	10	10
May	0	0	0	0	12	5	13	5	8	1	4	3
Jun	4	0	0	0	14	3	6	3	14	2	4	2
Jul	5	6	37	17	13	4	10	3	14	0	0	0
Aug	7	3	13	8	12	3	8	3	7	2	9	8
Sep	-	-	-	-	13	1	2	2	-	-	-	-
Oct	-	-	-	-	11	0	0	0	-	-	-	-
Nov	-	-	-	-	15	1	4	1	-	-	-	-
Dec	-	-	-	-	16	1	2	1	-	-	-	-
Total	50	31	133	29	128	23	77	12	84	14	45	8

Table 2. Data on the mortality of leatherback turtles (*Dermochelys coriacea*) in fisheries off the coast of Peru between 1985 and 1999. The ports are as follows: HU = Huacho, CA = Cerro Azul, PU = Pucusana, CB = Chimbote, AN = Ancon, SV = Salaverry, CC = Chancay, and PI = Pisco. Sex is coded as follows: F = female, M = male, and U = undetermined. CL and CW are carapace length and width, respectively, in cm.

Date	Port	Sex	CL	CW	Comments
3/18/85	HU	U	U	U	Skull found at dump.
4/1/85	CA	U	U	U	Several carcasses found at dump.
11/20/85	CA	U	U	U	With artisanal fishery.
12/8/85	PU	U	175	U	Authorities prohibit its slaughter in market.
7/9/86	CB	U	U	U	Freshly cut carapace seen at fishmarket.
7/10/86	CB	U	165	U	Alive, seen at the fishmarket.
5/26/87	PU	U	115	63	Length including head= 185cm.
2/18/89	PU	U	157	87	Landed at pier.
2/21/89	PU	U	U	U	Still alive.
3/2/89	PU	U	U	63	Released alive. Turtle on its back.
2/26/91	AN	U	U	U	Head cut off while alive.
2/27/91	AN	U	U	U	With common dolphins and porpoises.
3/7/91	AN	U	U	U	Landed with porpoises and turtles (probably green turtles).
3/12/91	AN	U	U	U	Landed with porpoises and common dolphins.
12/7/92	AN	F	129.5	U	Sold at fishmarket.
1/11/93	SV	U	U	U	Fresh head at dump.
1/11/93	SV	U	U	U	Fresh head at dump.
2/10/93	CC	M	146	83	Still alive.
2/13/93	CB	F	156	78	Alive. Carried eggs. Skin collected. Shot by port authorities.
3/15/93	CB	F	U	U	Carried eggs. Alive. Caught near Santa River.
4/1/93	CA	U	U	U	Alive at departure of observer, most likely killed.
6/3/93	CA	U	U	U	Alive. Landed with a green turtle.
7/19/93	CA	U	135	84	Dried remains found on the beach (Los Reyes).
7/31/93	CA	U	U	83.5	Dried remains found on the beach (Los Reyes).
8/24/93	CA	U	U	U	Caught alive.

Historical Data on the Mortality of Sea Turtles at Various Sites on the Equatorial Coast and Recent Observations in Regards to a Massive Mortality of *Lepidochelys olivacea* (Reptilia, Cheloniidae)

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There are four species of sea turtles registered in the marine waters of Ecuador: *Lepidochelys olivacea*, *Chelonia mydas*, *Eretmochelys imbricata* and *Dermochelys coriacea*. *L. olivacea* is migratory and there is no evidence of it nesting in Ecuador. With data obtained from the monitoring of marine vertebrates performed in 1994 by the Ecuador Foundation for the study of marine mammals (Fundación Ecuatoriana para el estudio de Mamíferos Marinos-FEMM) and the data registered recently in 1999 by the Natura Foundation (Fundación

Natura-FN), Management Program of Coastal Resources (Programa de Manejo de Recursos Costeros-PMRC), and the National Fisheries Institute (Instituto Nacional de la Pesca-INP), we give data of the presence of dead turtles in these beaches and recent observations in regards to a massive mortality of olive ridleys (*L. olivacea*). In 1994, according to FEMM, 66 dead turtles were registered (carcasses, decomposing specimens), in various locales in the province of Guayas.

Recently in July, August, and September of 1999, there

has been an unusual massive mortality of olive ridleys in various coastal points of the Equatorial coastline. According to FN and PMRC, 99% of the dead specimens correspond to the olivacea species. The average carapace length oscillated between 57.8 and 63 cm. The zones with the greatest concentration of dead turtles were the sectors between Villamil-El Pelado-Engabao beaches, and the Manabi province. The INP data indicate the presence of more than 700 turtles in the province of Guayas as well as in the province of Manabi. The increase in mortality, comparing to data from 1994 and 1999 is 82.31%. We also give the possible causes of this mortality as related to natural events (thermal stress due to cold temperatures caused by the Humboldt current and epidemics), and as related to interactions with fishing activities. The microbiological and pathological analysis indicate the presence of bacteria from the genera *Vibrio*, *Aeromonas*,

and *Pseudomonas* in the blood and some of the organs, as well as inflammatory reactions or abscesses at the descending level of the esophagus, the presence of erythema or reddish-violet coloration on the plastron, falling-off of corneal scutes in relation to bone plates (desecdesis), and the presence of enteroparasites in the feces (trematode eggs and coccidia cysts). Some specimens presented lesions due to fishing interaction. The number of dead turtles in the equatorial coastline is estimated in the thousands.

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Reproductive Ecology of Olive Ridleys in the Open Ocean in the Eastern Tropical Pacific

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INTRODUCTION

Although mating behaviors of marine turtles have been observed in captivity (Ulrich and Parkes, 1978; Parkes, 1981; Wood, 1988), the most common observations have come from the limited area directly offshore of the nesting beaches, where most mating has been thought to take place (Booth and Peters, 1972; Hughes and Richard, 1972; Balazs, 1980; Ehrhart, 1982; Alvarado and Figueroa, 1989). Almost nothing is known about the reproductive activities of turtles far at sea although mating pairs have been sighted on the open ocean, some as far as 1850 km from the nearest mainland (Pitman, 1990; Kopitsky *et al.*, 2000). To study the distribution and mating behavior of olive ridley turtles *Lepidochelys olivacea*, we conducted the first two years of a planned three-year study in the eastern tropical Pacific (ETP) in order to evaluate the biological significance of mating pairs hundreds of kilometers offshore.

METHODS

We conducted sea turtle research during Southwest Fisheries Science Center dolphin survey cruises from July to December 1998 and 1999. The study site extends from 25°N to 15°S, from the coast of the Americas to 155°W. When dolphin observers reported turtles, we deployed a small boat to capture turtles, while the survey vessel continued along the cruise track. At capture we recorded the turtles behavior (mating, basking, swimming, feeding, or other), time, location and any associations. Turtles were offloaded onto the main vessel while it continued underway. Turtles were weighed, measured, and tagged, a blood sample taken, and (as part of another study) females were ultrasounded to determine reproductive status. In order to monitor movements of mating turtles, we attached Telonics SDR-T10 satellite transmitters to the carapaces of selected individuals, a process taking approximately two hours. All turtles were released unharmed.

RESULTS

A total of 324 olive ridleys have been captured, including 142 males and 103 females (62 juveniles and 20 other individuals will eventually be sexed from blood samples). The SCLs ranged in size from 14.9 to 70.3 cm. At capture, 255 turtles were basking, 50 were involved in mating (including 12 intromittent pairs, and two females each with two males mounted on them), 19 were observed swimming, four were entangled in longline fishing gear, two were associated with a log, one was entangled in a nylon,

one was feeding, one was caught on a fishing hook, and one was dead. Mating pairs were observed from 120 to 851 km offshore of the Americas. One mounted female was observed with her tail tucked in and rear flippers clasped together, making her cloaca inaccessible; this was an apparent refusal to mate. Of the three mating females fitted with satellite transmitters, two were tracked to the vicinity of nesting beaches although actual nesting could not be confirmed. One of these was captured 198 km off the coast of Mexico and traveled 681 km straight-line distance to a nesting beach in Escobilla, Mexico in 20 days. The third satellite tagged female was captured on September 30, 1999, and was observed nesting in Ostional, Costa Rica December 1, 1999 (A. Chavez, personal communication).

CONCLUSION

Contrary to what is generally believed, olive ridleys are capable of mating in the pelagic zone, hundreds of kilometers from the nesting beaches. These matings appear to be the result of chance encounters at sea, which may result in fertilization. For example, the satellite-tagged female that traveled to Escobilla was mounted by an intromittent male when she was captured and she was dripping semen from her cloaca when we brought her onboard. The other two females also went to nesting beaches as well, suggesting these matings are normal. This pelagic mating behavior very likely facilitates gene flow between distant nesting populations, and may be one of the reasons for the lack of genetic differentiation that has been found between nesting populations in Costa Rica and Mexico (Duenas, 1998). These observations suggest that perhaps the traditional concept of an olive ridley 'mating area' (i.e., immediately offshore of the nesting beach) may need to be re-evaluated. Also, if oceanic mating provides a regular mechanism for gene flow this could have an impact on the management of olive ridley populations in the ETP and elsewhere.

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The Endocrinal Ecology of Green Turtle Mass Nesting on Raine Island in the Northern Great Barrier Reef

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Raine Island in Australia's Northern Great Barrier Reef constitutes one of the largest and highest density green turtle rookeries remaining in the world. During periods of high-density nesting, many thousands of green turtles may compete for limited nesting habitat. Although not intentionally aggressive, intraspecific disturbance during green turtle mass nesting can physically impede, delay or even cease the nesting behavior of females. As a result individual nesting success can be greatly reduced due to considerable levels of intraspecific disturbance in high-density nesting rookeries. In this study we investigated if there was any association between profiles of plasma steroids, catecholamines and reproductive behavior during

both high and low-density nesting on Raine Island. One aim was to examine if differences in plasma hormone profiles could illustrate any potential for behavioral tactics that may enable successful nesting of individual turtles during high-density nesting situations. In addition, another consequence of high-density mass nesting is that conspecific disturbance prevents individuals form successful oviposition even after several successive attempts. We examined if this unusual feature was physiologically stressful to green turtles on Raine Island. Finally, we discuss our hormonal results in the context of evolutionary and ecological strategies that underlie reproductive tactics maximizing reproductive success in female green turtles.

The Fertility of Leatherbacks Nesting at Playa Grande, Costa Rica, During the 1998-1999 Nesting Season

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Leatherback turtles, *Dermochelys coriacea*, are known to have low hatching success compared to other species of sea turtles (Whitmore and Dutton, 1985). Leatherbacks at Playa Grande, Costa Rica have had a hatching success near 50% for the past several years and 20% in the 1997/1998 nesting season. We tested the hypothesis that this low hatching success rate was due to low fertility rates. We determined the fertility rates of 15 female *Dermochelys coriacea* at Playa Grande, Costa Rica during the 1998/1999 nesting season by incubating 10 eggs

from at least three clutches of each female in incubators. We determined an egg to be fertile if a white spot formed on the shell or by dissecting those eggs that did not form a white spot and staging those embryos. The majority of the dissected eggs revealed embryos that died before or soon after ovipositioning. The majority (n = 13) of females had a mean fertility rate of 90% or greater. It appears that *Dermochelys coriacea* has a high fertility rate, and that the low hatching success of leatherbacks at Playa Grande is caused by early embryonic death.

Enzyme Linked Immunosorbent Assay (Elisa) for Sea Turtle Vitellogenin

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Vitellogenin (Vtg) is a large lipoglycophosphoprotein synthesized in the liver in response to the ovarian hormone estrogen, secreted during follicular maturation. Vtg travels in the circulation to the ovary where it is processed into yolk proteins that are incorporated in the growing oocytes. The quantification of Vtg levels is important for reproductive physiology studies as an indicator of reproductive maturity and activity. We developed an enzyme linked immunosorbent assay (ELISA) for sea turtle Vtg using a polyclonal antibody raised against Vtg of a freshwater turtle (*Trachemys scripta*) and a standard of Vtg

purified from Kemp's ridleys (*Lepidochelys kempii*) sea turtle blood. The assay had a sensitivity of 1.5 ng Vtg/ml blood. Vtg was detectable in blood samples as small as 1.0 ul. There was no immunological crossreactivity with blood samples from males. Using the assay, we observed increases in immunoreactive Vtg in captive Kemp's ridleys associated with ovarian development and estrogen treatment. The assay provides an excellent tool to better understand the dynamics of this important protein that is essential for the nutrition of developing embryos and survival of hatchlings.

Evidence for a Hormonal Tactic Maximizing Green Turtle Reproduction in Response to a Pervasive Ecological Stressor

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Adrenocortical modulation, or the ability to down regulate the acute stress response appears to be utilised in some vertebrates including marine turtles during reproduction. The ecological basis of this physiological strategy is that it is thought to maximize reproductive investment in the current breeding episode by preventing disturbances (inclement weather, predation, intraspecific conflict, etc.) from disrupting an individual's reproduction. It is suspected that this physiological strategy facilitates reproduction but at a potential cost to survival. In this study we examine the ability of nesting green turtles to maintain this physiological strategy even in the face of an extremely pervasive ecological stressor. In particular, we

examined the ability of breeding green turtles to maintain reduced adrenocortical responsiveness and normal reproductive physiology to an ecologically pervasive stressor of extreme change in body temperature encountered while nesting on Raine Island. Despite the sometime's lethal nature of this ecological stressor both reduced adrenocortical responsiveness and normal profiles of reproductive hormones were maintained in breeding females. These results are discussed in terms of how physiological strategies can aid the reproductive success of breeding green turtles but also under certain conditions induce survival costs during reproduction.

Marine Turtle Nesting on the Beaches of the North-Western, Western, and Southern Provinces of Sri Lanka

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INTRODUCTION

Sri Lanka is an island situated between 5°55' and 9°51'N, and 79°41' and 81°54'E, between the Tropic of Cancer and the Equator. It has a 1585 km long coastline. Sri Lanka is presently divided into 25 administrative districts of which 14 have maritime boundaries (Anon, 1990).

Out of the seven living species of sea turtles in the world, five are reported to nest along the coastal belt of Sri Lanka (*Caretta caretta*, *Chelonia mydas*, *Lepidochelys olivacea*, *Eretmochelys imbricata* and *Dermochelys coriacea*; Deraniyagala, 1952).

The main objectives of this study were to identify the sea turtle nesting grounds distributed within the study area; to estimate nesting frequency, nesting density and nesting diversity for each beach; and to prepare a nesting beach index.

METHODS

The study consisted of two main parts, a frame survey (from July 1996 to Desember 1997) and a comprehensive nesting beach survey (from January 1997 to December 1999). The coastal belt between Karathivu (in Puttalam District) and Yala (In Hambantota District) was surveyed. The study area extended over seven administrative districts (from north to south-Puttalam, Gampaha, Colombo, Kaluthara, Galle, Matara and Hambantota). The length of the study area was 479 km.

The frame survey was the initial attempt made to identify the existing sea turtle nesting beaches in each administrative district. A total of 35, 13, 14, 23, 51, 22 and 37 beaches of the respective districts were visited to collect the basic information. Bi-weekly field visits were made to the beaches where the nesting were frequented. The beaches where the annual number of nesting was over 50 were selected to establish a comprehensive beach survey programme. Data collectors were appointed for each beach after a short training on species identification and filling of data sheets.

Nesting frequency data at each site for the three years were pooled on a monthly basis to estimate the average monthly nesting frequencies. Average monthly nesting frequency of a particular month [AMNF_m] = (MNF_m for 1997+ MNF_m for 1998+ MNF_m for 1999)/3. Using the [AMNF_m] values, other parameters were estimated. The nesting rate at a particular beach = (AMNF_{Jan} + AMNF_{Feb} + AMNF_{Dec})/12; and the nesting density at a particular beach = (AMNF_{Jan} + AMNF_{Feb} + AMNF_{Dec})/L_B, where L_B = length of the beach.

RESULTS AND DISCUSSION

Frame survey

Due to the existing security reasons the beaches located in most northern part of the Puttalam district and the beaches in the national parks of the Hambantota district were not surveyed by the frame survey. Table 1 shows the basic information of the study area. The surveyed beaches were grouped into five categories according to the average number of nests per year (Table 2). Number of beaches in each category for each district are shown in Table 3. No good nesting beaches were found in the Puttalam, Gampaha, Colombo, Kalutara and Matara districts. All the rookeries are located in the Galle and Hambantota districts.

Comprehensive Beach Survey Programme

The sea turtle nesting beaches were graded by considering nesting rate or the average number of nestings per month (nests month⁻¹), nesting density or the average number of annual nesting per kilometer (nests year⁻¹km⁻¹), and nesting diversity or the number of species nested (Amarasooriya, 1999). The major findings of the survey are shown in the Table 4.

The surveyed beaches of the Galle district are located between the Bentota River mouth to Balapitiya Bridge as a series. Those of the Habantota district are rather scattered except Kahandamodara 1, 2, and 3. With respect to the nesting rates and the nesting densities all beaches studied could be graded into four major grades, as shown in Table 5. Using the third criteria (nesting diversity) the beaches in each grade could be divided into five sub-grades, as shown in the Table 6.

All the beaches covered by this study were nested by two or more species. Therefore, none could be included in the sub-grade e. Nevertheless, there are a few beaches in Kalutara, Matara and Hambantota districts which are nested only by one species (Amarasooriya and Dayaratne, 1997).

As far as the conservation of marine turtle's nesting habitat is concerned, the high priority should be given to the beaches of the upper grades as given in Table 7. For the beaches of grade 01 and 02, introduction and implementation of *in-situ* nest protection programmes are highly recommended. As the nesting rates, nesting densities and nesting diversity are very high in the beaches between Mapalana and Balapitiya Bridge in the Galle district and Rekawa Beach in the Hambantota district, these area should be declared as protected turtle nesting grounds.

ACKNOWLEDGMENTS

The author would like to express his thanks to the NARA for providing funds, transport and library facilities. The assistance of Mr. M.G.K. Gunawardana in the field throughout the study is gratefully acknowledged.

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Table 1. Length of coastal belt, number of beaches surveyed and percentage covered in each district.

District	Length of the coastal belt (km)	Number of beaches surveyed	% covered
Puttlam	126.5	35	80
Gampaha	35.4	13	100
Colombo	30.4	14	100
Kaluthara	35.4	24	100
Galle	76	47	100
Matara	46	22	100
Hambantota	129	37	65

Table 2. Categories of the beaches according to the reported number of nesting.

District	Length of the coastal belt (km)	Number of beaches surveyed	% covered
Puttlam	126.5	35	80
Gampaha	35.4	13	100
Colombo	30.4	14	100
Kaluthara	35.4	24	100
Galle	76	47	100
Matara	46	22	100
Hambantota	129	37	65

Table 3. Number of beaches in each category for the respective district.

District	Nil nesting	Rarely nested	Occasionally nested	Usually nested	Frequently nested
Puttlam	33	1	1	-	-
Gampaha	13	-	-	-	-
Colombo	8	2	3	1	-
Kaluthara	7	5	12	-	-
Galle	7	7	9	15	13
Matara	2	10	10	-	-
Hambantota	1	5	14	10	7

Table 4. Mean values of nesting frequencies, nesting densities and nesting diversity at the surveyed beaches for 1997, 1998 and 1999. The species names are abbreviated as follows: GT = green turtle, OR = olive ridley, HB = hawksbill, LB = leatherback, and LH = loggerhead.

Beach	Length (km)	Nesting rate (nests month ⁻¹)	Nesting density (nests year ⁻¹ km ⁻¹)	Nesting diversity (# of species)
Bentota	2.73	9	40	4 (GT, OL, HB, LB)
Warahena	2.4	4	17	3 (GT, OL, LB)
Induruwa	2.0	3	16	4 (GT, OL, HB, LB)
Kaikawala	1.0	9	96	3 (GT, OL, LB)
Habbakkala	1.32	9	73	2 (GT, OL)
Mapalana	0.5	6	103	4 (GT, OL, HB, LB)
Duwemodara	0.25	24	814	4 (GT, OL, HB, LB)
Kosgoda	1.0	30	322	3 (GT, OL, LB)
Bandarawatta	1.16	25	283	5 (GT, OL, HB, LB, LH)
Thibbattawa	1.0	17	193	2 (GT, OL)
Wathuregama	2.8	10	59	3 (GT, OL, LB)
Ahungalla	0.3	7	111	4 (GT, OL, HB, LB)
Balapitiya	1.75	14	103	5 (GT, OL, HB, LB, LH)
Galle District	18.21	167	171	5 (GT, OL, HB, LB, LH)
Rekawa	2	53	320	5 (GT, OL, HB, LB, LH)
Wellodaya	2.6	6	39	3 (GT, OL, LB)
Kahandamodara-1	1.5	15	125	3 (GT, OL, LB)
Kahandamodara-2	1	11	135	3 (GT, OL, LB)
Kahandamodara-3	1.5	18	175	3 (GT, OL, LB)
Welipatanwila	3.8	18	76	5 (GT, OL, HB, LB, LH)
Walawemodara	1.7	21	141	4 (GT, OL, HB, LB)
Bundala	3.6	9	43	5 (GT, OL, HB, LB, LH)
Hambantota District	17.7	151	132	5 (GT, OL, HB, LB, LH)

Table 5. Level of criteria used in grading of the nesting beaches.

Grade	Nesting rates	Nesting densities
01	>25	> 300
02	15 - 25	100 - 300
03	5 - 15	50 - 100
04	1 - 5	20 - 50

Table 6. Level of the third criteria used in sub-grading of the nesting beaches.

Sub-grade	Number of species nested
a	5
b	4
c	3
d	2
e	1

Table 7. The classification of the sea turtle nesting beaches in southern Sri Lanka.

Grade	Sub-grade	Beach	District	Grade	Sub-grade	Beach	District
01	a	Rekawa	Hambantota	03	a	Balapitiya	Galle
		Bandarawatta	Galle			Bundala	Hambantota
	b	Duwemodara	Galle		Welipatanwila	Hambantota	
	c	Kosgoda	Galle		b	Ahungalla	Galle
02	d	Nil		c	Kaikawala	Galle	
		a	Nil			Wathuregam	Galle
	b	Nil		Wellodaya	Hambantota		
	c	Kahandamodara 1	Hambantota	d	Habbakkala	Galle	
		Kahandamodara 2	Hambantota	04	a	Nil	
		Kahandamodara 3	Hambantota	b	Induruwa	Galle	
		Walawemodara	Hambantota	Bentota	Galle		
	d	Thibbattawa	Galle	c	Warahena	Galle	
			d	Nil			

The Occurrence of the Hawksbill Turtle (*Eretmochelys imbricata*) in West Africa

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Until recently, our knowledge of hawksbills along the Atlantic coast of Africa has been very limited (Fretey, 1998a). Sea turtle projects now underway in many countries in West and Central Africa have provided important information on this species in the region. Hawksbills are present in the waters of all countries from Mauritania to Congo Brazzaville. Hawksbills seem to be rare in the Canary Islands, Madeira and the Azores; their presence has not been confirmed in Morocco (H. R. Martins, personal comments; Hernández and Simó, 1981; Brongersma, 1982; Maigret, 1983; Fretey, 1998a). A hawksbill tagged in November 1994 by TAMAR in Brazil was recaptured in April 1999 in the Bay of Corisco, between Equatorial Guinea and Gabon (Bellini *et al.*, 2000). Another individual tagged in Brazil was killed in Senegal in 1990 (Marcovaldi and Filippini, 1991). Based on available information, there appear to be two geographical regions along the Atlantic coast of Africa where hawksbills occur and nest on a regular basis: 1) from Mauritania to west of the Ivory Coast, including Cape Verde; 2) the Gulf of Guinea. In the first region, there is occasional nesting in Mauritania, Senegal, Cape Verde, Liberia, and the Ivory Coast (Maigret, 1975, 1978; Brongersma, 1982; Fretey *et al.*, 1999; López-Jurado *et al.* 2000;). Some authors have described nesting by 100 to 200

females a year in the Bijagos Archipelago of Guinea-Bissau. However, a recent publication (Barbosa *et al.*, 1998) has questioned these numbers on the basis that *Eretmochelys* and *Lepidochelys* tracks may have been confused. There are only four hawksbill nests a year on the island of Adonga, in the Bijagos (C. Barbosa, personal communications). In the Gulf of Guinea, it has been difficult to verify nesting in Cameroon, Gabon, and the Congo. Only nesting sites at Bioko, São Tomé and Príncipe appear to be regularly frequented (Castroviejo *et al.*, 1994; Fretey, 1998b). Seventy nests were counted in the region in 1999 (J. F. Dontaine, personal communications). The corals that occur in Cameroon and São Tomé are not well known, but the presence of corals and juvenile hawksbills appears to be correlated. Lopez Jurado's team in Cape Verde often observes juveniles around Boavista. In the Ivory Coast, fishermen claim to frequently catch hawksbills between 30 and 40 cm (SCL) in length. Hawksbills are exploited for their meat in most African countries where they occur. Domestic trade in hawksbill shell is particularly well developed in São Tomé and has been for many decades. Forty artisans have been identified to be involved in turtle shell crafts. As in the Seychelles, a project to retrain these artisans is underway, along with the purchase and destruction of their stock. Many West African countries

still have inadequate national legislation for the protection of wildlife, and sea turtles are not protected. In some countries where hawksbills are legally protected, poaching is still prevalent.

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Marine Turtle Nesting in the Bocas del Toro Archipelago, Panama

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INTRODUCTION

Carr (1957) and Meylan (1982) reported that important nesting beaches existed on the Caribbean side of Panama, for four marine turtle species: green turtle (*Chelonia mydas*), loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*) and hawksbill (*Eretmochelys imbricata*). However, to what extent these beaches are utilized by each species is unknown.

In 1997, the Institute for Tropical Ecology and Conservation (ITEC) initiated a long-term study to ascertain the importance of turtle rookeries in this region of western Bocas del Toro Province. In conjunction with the Instituto Nacional de Recursos Naturales Renovables

(INRENARE-ANAM), ITEC has continued a marine turtle monitoring and tagging program in Bocas del Toro.

This report presents a comparison of nesting data collected during three consecutive years of study (Richard, 1998; Lahanas, 1999; Ordoñez, 2000), to determine to what extent each marine turtle species utilized regional beaches. The objectives of this program are to: 1) locate the more important nesting beaches in Bocas del Toro Province; 2) evaluate the causes of nest loss due to beach erosion, immersion, poaching and predation; 3) determine the extent of adult turtle mortality; and 4) understand aspect of female behavior in terms of migration, remigration, renesting, frequency of nesting, philopatry, nesting period, and effective population size.

METHODS

Bocas del Toro Province is situated at the western extreme of the country, between the 82°56'10" and 81°8' west longitude, and 8°30' and 9°40' north latitude. It is bordered by the Caribbean Sea to the north, Veragua Province to the east, Chiriquí Province to the south, and by the Costa Rica Republic to the west. Study sites include San-San Soropta Beaches near Changuinola City, First, Second, Third, and Long Beaches on Bastimentos, Zapatilla Cays beaches, Courtney and Bluff (1997 only) Beaches on Isla Colón, and Chiriquí Beach south of Valiente Peninsula. Other beaches within the Bocas del Toro Archipelago were also monitored periodically.

The ITEC Marine Turtle Monitoring Program extends from May and to August. Research volunteers conduct diurnal patrols on nesting beaches and count the number of tracks and record nesting and non-nesting emergences. During the first visit to the beach in a given season, a general census was done where both new and old nests were recorded. Subsequently, regularly-monitored beaches were examined at a three or five days interval depending on the proximity of the beach. Data recorded for each track encountered included data, species, beach location, nest type (nest or non-nest), nesting zone, and ultimate nest fate.

During nocturnal forays, beaches were patrolled from 8:00 p.m. to 5:00 a.m. looking for nesting female turtles. When encountered, females were first examined for the presence of tags or tag scars. New encounters were fitted with two sequentially numbered metal tags either on the hind flipper (leatherback) or front flippers (all other species). All turtles encountered were examined for mutilations, and measured for carapace length and width. Nest location, number of eggs deposited, diameters of 10 randomly chosen eggs, nesting zone, and general conditions were also reported.

RESULTS AND DISCUSSION

This research provided information on the external and regional distribution of sea turtles nesting areas in Bocas del Toro Province as well as the degree of poaching activity.

Figure 1 shows the results of the nesting and non-nesting emergences observed during the past three years of research conducted in the province of Bocas del Toro, Panama. In 1997 and 1998, six beaches were regularly monitored. In 1999, the study area was extended to 10 beaches distributed throughout the region. In all three years, leatherbacks nest most frequently in the region, followed by hawksbill nests. Green turtle and loggerhead nests are encountered less frequently but still represent an important component of the sea turtle nesting community.

All 10 beaches monitored in this study showed turtle nesting activity. Chiriquí Beach appears to be the most important as a leatherback rookery. A one-day survey of tracks and nests conducted on this 25 km beach yielded 735

leatherback tracks. Most of the crawls (85%) were observed primarily along the 8 km stretch south of the Cañaberal river mouth. The remaining 15% were distributed evenly along other areas of the beach.

Hawksbill nests were recorded on all area beaches, but the greatest nesting activity occurred on Zapatilla Cays. Figure 2 shows the turtle tracks distribution in the 1999 beaches (Ordoñez, 2000).

Along the Caribbean coast of western Bocas del Toro Province, some communities depend on sea turtles as a resource for food and medicines, and derive an income from the sale of turtle jewelry (tortoise shell), eggs and meat. These activities have threatened regional sea turtle populations (Meylan, 1993).

The poaching of eggs and adult females on their nesting beaches appears to represent a significant problem in the area. The eggs and meat of all four species are taken. The most significant adult mortality on beaches occurs on San San and Soropta beaches near the city of Changuinola where more than 60% of the observed nest were poached. Turtle eggs poached from area beaches are rarely consumed by poachers, which instead, sell them in Changuinola and Almirante.

Although rarely killed elsewhere (Pritchard 1979), adult leatherback females are regularly taken on San-san and Soropta beaches. The females are primarily killed for the shelled and oviducal eggs they contain. It is unclear whether the meat is utilized, but in some instances the blood may be used in ritualistic activities by the indigenous populations (ANAI 1996).

There were 25 dead turtles recorded in 1997, 31 in 1998, and 44 leatherback and one green turtle in 1999 (Richard, 1998; Lahanas, 1999; Ordoñez, 2000). Because the ITEC program begins relatively late in the leatherback nesting season, these numbers represent only part of the total number of females destroyed on these beaches.

In addition to the taking of nesting females, marine turtles of all species are also taken by spears from boats and by gill-type nest placed in the sea near the nesting and feeding areas near Isla Bastimentos and Isla. Wooden decoy turtles are often employed to attract turtles (presumably males) to nest or boats. The poaching of sea turtles and their eggs remains a serious problem in Bocas del Toro Province particularly in view of its wide-ranging effect. Many of the nesting leatherbacks encountered on beaches in Bocas del Toro were original tagged on the Costa Rican beaches of Gandoca and Tortuguero.

To what extent regional populations can hold up against the degree of poaching observed in western Bocas del Toro is unknown. Thus, it is important to continue conservation and research programs on Panamanian beaches to avoid the extirpation of these species in the area. There are several groups interested in the conservation and protection of the sea turtles in Bocas del Toro Province, it is therefore important then that these groups establish working relationships to reach the common goal of protecting regional marine turtle populations.

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The sea turtle work by ITEC has been possible due to the permits and assistance provided by Instituto Nacional de Recursos Renovables (INRENARE-ANAM). We would like to thank all of the volunteer Research Assistants who have participated in this program with enthusiasm, devotion and perseverance during the field work. We also thank INRENARE-ANAM personnel in the town of Bocas del Toro, Panama City and Changuinola for their continued support and for the use of boats and facilities for this project. Finally, we wish to thank the David and Lucille Packard Foundation for a scholarship awarded to Cristina Ordonez to attend the 20th International Sea Turtle Symposium, which made it possible to present this work.

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Fig. 1. Number of tracks registered in Bocas del Toro, Panama (1997-1999).

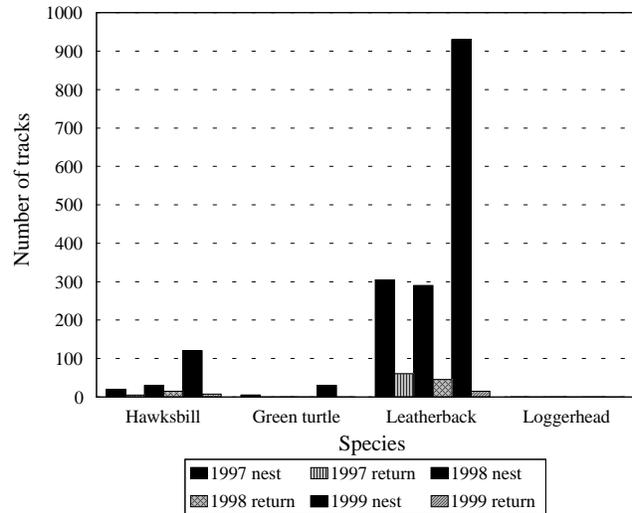
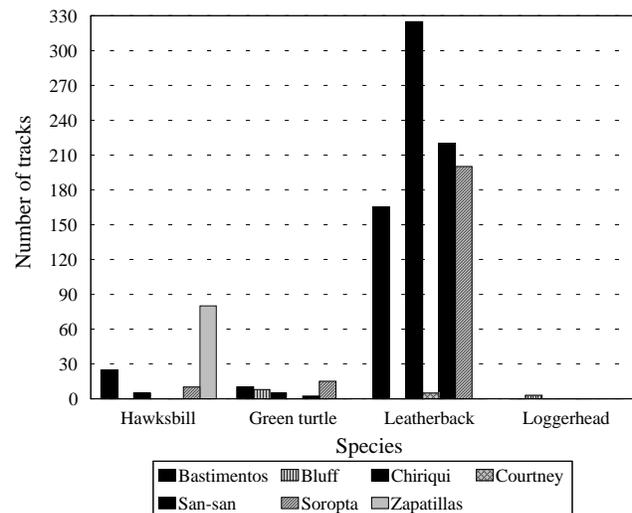


Fig. 2. Species distribution by beach.



Monitoring of Loggerhead Turtle (*Caretta caretta*) Nesting on the South Coast of the Isla De La Juventud, Cuba

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INTRODUCTION

In Cuba, the most important nesting areas for marine turtles are found on the south coast. This paper reports on monitoring of loggerhead turtle (*Caretta caretta*) nesting

on the southern coast of the Isla de la Juventud, from 1983 to 1996. Characteristics of nesting activity, including the period of nesting, inter-nesting interval and mean clutch size are presented.

MATERIALS AND METHODS

The survey area lies on the southern coast of the Isla de la Juventud. Specifically, the area surveyed is a 4 km long stretch within Playa Larga, a 26 km long beach. The survey area extends from Punta El Guanal to La Canoa. It is a beach of high energy (Pritchard *et al.*, 1983) in the first 1500 m from the western edge, and the remainder of it is of low energy. A reef barrier lies some 100 m off the beach. The major vegetation is salvia marina (*Tournefortia anaphalode*), cuabilla de playa (*Suriana maritima*) and boniato de playa (*Batis maritima*). The dominant fauna includes crabs, "jutías" and wild pigs, the latter being a major predator of marine turtle eggs.

The beach was walked at night, between 2100 hour and 0400 hour, between May and August, from 1983 to 1996 (Table 1). The period of time over which surveys were undertaken in a particular year varied from 19 to 103 days. From 1990 onwards, all females sighted nesting on the beach were tagged (monel steel tags), and biological data relating to the nest (e.g., time, location, distance from maximum tide line) were recorded, including the tide type and moon phase at the time. From 1983 to 1993, eggs were counted, and transferred to a protected area to avoid predation, following the methodology of (Márquez *et al.*, 1981). However, some nests were already partially predated by the time they were located. From 1994 to 1996 eggs were left in the nest.

RESULTS AND DISCUSSION

The nesting period for *C. caretta* at Playa Larga extends from the beginning of May to the end of August, with peak activity in June. These data correspond with those of Márquez (1990) for the species in the general region. Nesting activity was observed to occur mainly from two hours before and two hours after nightly high tide. The first nests in the season were laid on a full moon.

The numbers of nests located in each year are in Table 1. Looking at those years for which more than 20 days were expended in surveys, the number of nests located has increased significantly over time, but so had survey effort. When data were standardised to the mean number of nests located per day, this index was stable over time (linear regression, $r^2 = 0.24$, $p = 0.10$), although the trend is positive. The highest number of nests (174) was recorded in 1989. In the first 11 years of monitoring, eggs were relocated to a safe area to avoid predation by wild pigs, but over the last three years eggs were left *in situ*, as numbers of pigs had been greatly reduced. Hatching success in those last three years was more than 90%, and no predation was recorded.

The mean clutch size (mean of annual means) was 103.9 eggs over the entire survey period (1983-94) where data were available. However, mean clutch size increased significantly between 1983 and 1996 (linear regression, r^2

$= 0.58$, $p = 0.011$, $n = 10$), with the mean clutch size being 112.0 from 1993-96.

Ninety-two female *C. caretta* were tagged between 1990 and 1996 (Table 2). Of these, 22 (24%) were observed nesting on more than one occasion. The inter-nesting interval was calculated to be between 10 and 15 days, with an average of 11-12 days. Females ranged from 85 to 110 cm CCL, with an overall mean (mean of annual means) of 97.1 cm CCL (Table 2).

The monitoring at Playa Larga has revealed valuable long-term data on the pattern of nesting for *C. caretta*, as it has for *C. mydas* (Nodarse *et al.*, 2000). Notwithstanding the increasing survey effort over time, the data indicate that nesting has remained stable from 1983 to 1996. Mean clutch size has increased significantly within that period, but there are no data on female size before 1990 to confirm whether increasing clutch size is a result of increasing female size. However, this is one possible factor which could be responsible.

Management at Playa Larga includes beach patrols by frontier guards, and over the last few years active measures were taken to reduce the numbers of wild pigs, which were a major predator of the eggs. The monitoring program ensured that researchers were present on the beach during the peak nesting period, and no predation by humans was recorded. Since 1996, surveys have been undertaken, but data have not been recorded as systematically as they were previously, and effort has been reduced. This is largely because nest predation was essentially eliminated, and hatching success is generally high. Although management priorities have shifted to other fisheries in recent years, due to economic constraints, protection of the beach will be maintained, and a systematic (comparable) survey undertaken every few years.

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Table 1. Numbers of *C. caretta* nests and eggs recorded during surveys of a 4 km stretch of Playa Larga, on the southern coast of Isla de la Juventud, 1983-1996. Some nests (1.7%) were either partially or completely predated by the time of location. All nests were left in situ during the last three years.

Year	Survey period	Days	Number of nests	Number of eggs
1983	17/07 - 26/08	41	8	787
1984	11/06 - 10/09	92	23	2,253
1985	31/07 - 18/08	19	0	0
1986	07/07 - 05/09	61	12	4,077
1987	20/06 - 15/08	73	55	5,490
1988	22/06 - 15/08	62	125	11,855
1989	01/06 - 26/08	87	174	17,871
1990	05/06 - 20/08	71	88	8,786
1991	13/05 - 08/08	88	76	8,495
1992	15/05 - 23/08	100	97	11,044
1993	25/05 - 08/08	76	144	15,684
1994	13/05 - 14/08	94	99	10,922
1995	29/06 - 19/07	21	20	-
1996	18/05-27/08	103	109	-

Pritchard, P., P. Bacon, F. Berry, A. Carr, J. Fletmeyer, R. Gallagher, S. Hopkins, R. Lankford, R. Marquez, L. Ogren, W. Pringle Jr., H. reichart, and Y R. Witham 1983. Manual of sea turtle research and conservation techniques, Second Edition. K.A. Bjorndal, and G.H. Balazs (editors) Center For Environmental Education. Washington. D.C.

Table 2. Numbers and mean size (curved carapace length, CCL) of nesting female *C. caretta*

Year	No. of Females Tagged	Mean CCL (cm)
1990	4	956
1991	8	976
1992	23	990
1993	35	983
1994	7	927
1995	4	985
1996	11	978
All years	92	977

Nesting and Survival Threats for the Sea Turtles of St. Kitts, West Indies

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Three species of sea turtles, leatherbacks, hawksbills, and greens, nest on the island of St. Kitts in the Lesser Antilles. I monitored all beaches on that island for evidence of turtle nesting throughout 1999 (in progress as I write). I recorded 120 leatherback nesting events (crawls and pits) between late March and late July. From early July I have recorded 84 hawksbill nesting events. Green turtles nest infrequently on the island, and this coupled with the fact that I monitor their preferred beaches less often has led to me finding only three nests starting in early July.

For leatherbacks a major survival threat is nest poaching, and 30% of nest pits exhibited evidence of human tampering. I also discovered a freshly butchered adult female on a favored nesting beach. In eight excavated

hatched nests I noted high percentages (8-67%) of developed, but unhatched eggs. This could be a survival threat as well if it is the norm.

The predominant nest threat to hawksbills is predation by the introduced Indian mongoose, and 45% of nests have been raided. Another hazard to hawksbill nesting is vegetation clearing. Hawksbills most frequently nest under shrubs, so when these are removed nesting beaches may no longer be appealing to turtles.

With very little data I know that green turtle nests are sometimes poached. Additionally, one nest was discovered at a construction site of a new hotel and sea wall. These activities would be detrimental to turtle nesting wherever it occurs.

Aspects of the Emergence and Dispersal Physiology in Hatchling Green Sea Turtles from Heron Island, Australia

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Hatchling turtles typically take between three and five days to emerge from the nest environment. During this time they are subjected to a near anoxic environment and are surviving via nutritional input from the yolk sac. We collected hatchling green sea turtles from different stages of nest digging and post emergence and determined patterns in the hormones corticosterone (B), adrenaline (A) and nor-adrenaline (NA) as well as glucose and the energetic metabolite lactic acid. Samples were also collected and analyzed for circulating lipid levels. Data

suggest that corticosterone levels rise following emergence and peak at four hr post emergence from the nest and then begin to decline reaching near basal levels by 12 hours. Lactate levels show a peak during nest digging and swimming phases and serum glucose peaks at 0.5 hours following emergence from the nest. This data supports the notion that hatchling sea turtles have a reduced swimming frenzy and these hormone and energetic parameters appear to be correlated with nest digging and dispersal from the inshore habitats.

A Comparative Approach to Understanding Sea Turtle Hatchling Metabolism During Emergence

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INTRODUCTION

To get from the nest to the ocean, sea turtle hatchlings must accomplish an incredible feat. First, they must develop in underground nests, at the mercy of the physical environment of the surrounding sand. Upon hatching, hatchlings must dig to the sand surface and emerge from their nests. This nest emergence involves periods of high intensity digging up through the sand, and once at the sand surface, hatchlings may rest for minutes to hours. Finally, hatchlings must crawl to the water and swim approximately 24 hour offshore (Wyneken, 1996).

Because of periodic intense digging behavior, anaerobic metabolism may be necessary during emergence (Dial, 1987; Baldwin *et al.*, 1989). The sum of maximal energy produced aerobically and anaerobically is termed the metabolic scope. Reptiles generally have a limited metabolic scope, although they can utilize anaerobic metabolism for short periods of intense activity (Bennett, 1982). Lactic acid is the major anaerobic end product in reptiles and is a reasonable means for identifying anaerobic activity. Reptiles with large accumulations of lactic acid have diminished behavioral capacities and appear lethargic. Another cost of using anaerobic metabolism is the accumulation of an oxygen debt that must be repaid aerobically.

An Australian study by Baldwin *et al.* (1989) reported elevated levels of blood lactate in green and loggerhead sea turtle hatchlings digging up through the sand during nest emergence. This study suggested that green turtle hatchlings have higher blood lactate levels than loggerhead hatchlings, because green turtle nests are typically deeper than loggerhead nests. However, they did not account for species effects in this study.

Of the three species that regularly nest in Florida,

leatherback hatchlings emerge from nests that are typically the deepest. Green turtle nests are intermediate in depth and loggerhead nests are typically the most shallow of the three species. In addition to depth there are other physical factors (temperature, water and gas diffusion) that influence the nest environment, and may influence anaerobic metabolism in hatchlings.

These ideas of nest depth and other physical factors that may influence anaerobic metabolism in hatchlings during nest emergence, led to the questions addressed in this study: (1) Do blood lactate levels differ in *Caretta caretta* hatchlings among nest depths during similar activities? (2) Are blood lactate levels in emerging hatchlings related to nest O₂ and/or nest temperature? (3) Do hatchlings emerging immediately have higher blood lactate than those resting at the surface for longer periods?

METHODS

In order to factor out species effects on anaerobic activity, hatchlings from one species (the loggerhead turtle, *Caretta caretta*) were compared from nests in Juno Beach, FL (26°52'N, 80°02'W). Thirty-six loggerhead nests were relocated to three depths to determine if loggerhead hatchling blood lactate levels are related to nest depth. The loggerhead nests (n = 12 nests per treatment) were relocated to 65 cm, 85 cm and 100 cm depths. These depths correspond to typical nest depths of *C. caretta*, *C. mydas* and *D. coriacea*.

An oxygen/temperature probe combination was placed at the center of each clutch during relocation. Gas sampling tubes were made from 1/8" Tygon tubing (polyethylene). Samples were taken using 10 cc air-tight syringes and then injected into a blood-gas analyzer (PHM71 MK Blood and

Gas Analyzer, Cameron Instruments, calibrated with 99.9% pure nitrogen and room air). Because pore spacing may affect gas exchange within nests, bulk density (proportional to pore spacing) of the sand adjacent to the middle of the nest chamber was measured (Brady, 1990).

Nest temperatures were monitored throughout incubation using temperature probes constructed from a Physitemp BAT-12 probe kit (Spotila *et al.*, 1983). Temperature was monitored to account for nest temperature effects on gas diffusion rates and hatchling activity. Temperatures were measured between 1900 and 2200 hours, when hatchlings may begin emerging from nests. Gas and temperature measurements were taken once a week for the first three weeks of incubation, then every other day thereafter.

Blood samples of 50:1 were taken from an external jugular vein of each hatchling using disposable heparinized insulin syringes (after Bennett, 1986; Wibbels, 1998) and analyzed for lactate concentrations (Sigma Diagnostics Lactate Kit #735-10). Up to five hatchlings were sampled for each emergence activity. These activities were classified as: (i) resting at the bottom of the nest, (ii) actively digging up through the sand, or (iii) resting at the sand surface. Time spent at the surface was also measured. After blood samples were taken, hatchlings were released near the surf where they could crawl to the water.

I used ANOVA, Tukey-Kramer post-hoc tests, and correlation z-tests to determine if hatchlings digging from deeper nests have higher blood lactate levels and/or are relying on anaerobic metabolism to a greater extent than those from shallower nests. Percent data were converted to proportions and arcsine transformed for analysis.

RESULTS AND DISCUSSION

Blood lactate levels were low in resting hatchlings (Fig. 1). Lactate levels were significantly higher in digging hatchlings than resting hatchlings ($p < 0.001$). High levels of blood lactate in hatchlings that are actively digging up through the sand column indicate that intense digging requires hatchlings to supplement aerobic with anaerobic metabolism. Hatchlings digging from deeper nests had higher lactate levels than those digging from more shallow nests ($p < 0.025$), suggesting that an increased distance (and perhaps time) of digging requires hatchlings to rely on anaerobic metabolism to a greater extent when emerging from deep nests.

Nest oxygen concentrations throughout incubation showed the typical pattern for loggerhead nests (Ackerman, 1980). During the last third of incubation, nest oxygen concentrations decreased at a faster rate than the first two-thirds, as the embryos grew and consumed more oxygen. Oxygen concentrations in nests during incubation and on night of first emergence were not significantly different among treatment depths. However, hatchling lactate levels were negatively correlated with nest O_2 concentrations ($z =$

-3.054 , $p = 0.0023$). When oxygen concentrations were low, blood lactate levels tended to be high. There was an overall decrease in pore spacing with an increase in depth. The mean pore spacing values were significantly different among treatment depths ($p < 0.001$), however no correlation was found between pore spacing and hatchling blood lactate levels.

Mean nest temperature for each treatment depth was approximately $31^\circ\text{C} \pm 1$. These temperatures were not significantly different among depths. Also, blood lactate levels were not significantly correlated with temperature in this narrow range. This study suggests that anaerobic metabolism within temperature ranges found in relocated nests is thermally independent in sea turtle hatchlings during nest emergence. The ranges of temperatures observed in my relocated nests (as well as in other studies, e.g. Milton *et al.*, 1997) are relatively narrow (29.7 - 34.2°C), so the lack of correlation with temperature is not surprising.

Hatchlings of all treatments resting at the surface for periods longer than 20 minutes, had significantly lower lactate levels than those at the surface less than 20 minutes (65 cm depth: $p < 0.001$; 85cm depth: $p < 0.05$; 100 cm depth: $p < 0.001$). A period of about one hour was necessary for lactate levels to return to resting levels, which is similar to what Baldwin *et al.* (1989) found in loggerhead and green hatchlings. Hatchlings resting at the sand surface may be waiting for other cues such as social facilitation or temperature (Carr and Hirth, 1961; Mrosovsky, 1968), and not limited by their accumulation of lactate. Although it may benefit hatchlings to rest and reduce lactate levels before beginning their offshore migration, hatchlings resting at the sand surface may be at an increased risk of terrestrial predation.

CONCLUSIONS

Lactate levels differed among activities in loggerhead hatchlings. Anaerobic metabolism was correlated with nest depth and oxygen availability, but not temperature and pore spacing. Hatchlings resting at the surface for longer time periods had lower lactate levels than those that emerged immediately. Since hatchlings will leave the nest with elevated lactate levels, blood lactate accumulation is probably not a limiting factor in determining when a hatchling emerges from the nest. Other cues, such as temperature and social facilitation, appear to take precedence over repayment of the oxygen debt.

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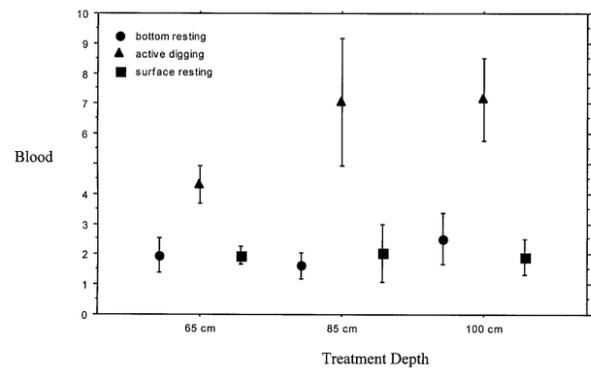
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Fig. 1. Blood lactate levels in hatchlings from relocated loggerhead nests. Values are means 95% confidence intervals.



Isolation and Proliferation of Peripheral Blood Mononuclear Cells from the Loggerhead Sea Turtle (*Caretta caretta*): Techniques and Applications

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INTRODUCTION

A healthy immune system is vital for the survival of all organisms, but little is known about the basic immune functions of the loggerhead sea turtle. Suppression of the immune system by environmental contaminants or disease could ultimately result in decreased survival of this threatened species. Therefore, there is currently great interest in the normal and impaired functions of the sea turtle immune system.

The purpose of this study was two-fold, 1) to determine appropriate methods to measure the response of the loggerhead immune system, and 2) to collect data on these basal immune responses. Specifically, we examined

various techniques for isolating peripheral blood mononuclear cells (PBMCs) from juvenile loggerheads and the proliferation of PBMCs in response to mitogens.

METHODS

PBMC Isolation

To determine an appropriate method for isolating PBMCs (lymphocytes and monocytes), blood was collected from five juvenile loggerheads (45-55 cm straight carapace length) from Core Sound, NC. Specific details of the method can be found in Harms *et al.* (2000). Briefly, blood was collected using three different anti-

coagulants (heparin, potassium EDTA, and sodium citrate). Blood was centrifuged at 400 x g for five minutes at 4°C, and the buffy coat (the thin layer of white blood cells that settle above the packed red blood cells) was removed and resuspended in RPMI 1640 media. The cell suspensions were underlaid with either a single layer of CellSep, a commercially-prepared arabinogalactan solution of 1.077 g/ml density commonly used for separation of mammalian lymphocytes, or a multiple step gradient of Percoll (40-60%), a colloidal PVP-coated silica solution. Following sequential centrifugation at 400 x g for 15 minutes and 800 x g for 15 minutes, cells at each interface of the gradients were removed, washed, and differential white blood cell counts were performed.

PBMC Culture and Mitogen Exposure

Blood from seven juvenile loggerheads (53-86 cm straight carapace length) from Core Sound, NC was collected with heparin between June and July of 1999. PBMCs were isolated using the above described methods with a two step Percoll gradient (45 and 55%). PBMCs were resuspended in RPMI 1640 media supplemented with 10% fetal bovine serum, 25 mM HEPES, 100 U/ml penicillin, 100 mg/ml streptomycin, and 0.25 mg/ml fungizone. PBMCs were cultured in 96 well plates at varying cell densities (0.125-1.0 x 10⁵ cells/well). Upon plating, varying concentrations of mitogens were added to each well in triplicate. Mitogens tested include phytohemagglutinin-P (PHA) and concanavalin A (ConA) which stimulate T cell proliferation, and lipopolysaccharide (LPS) from *E. coli* 0127:B8 which stimulates B cell proliferation. Cells were then incubated at 25-26°C with 5% CO₂.

PBMC Proliferation Assay

Cell proliferation was measured between days 1 and 12 of mitogen exposure using the Promega CellTiter 96 Non-Radioactive Cell Proliferation Assay. This colorimetric assay is a non-radioactive substitute for the commonly used ³H-thymidine assay. The dye solution, which was added to each well for varying amounts of time (0.5 to 4 hours), contains a yellow tetrazolium salt that is converted to a blue formazan product in proliferating cells. The reaction was stopped by solubilization of the cells and product conversion was measured at 540 nm according to the manufacturer's instructions. A stimulated response was determined as a statistically significant increase in cell proliferation following mitogen exposure using a one-way ANOVA followed by a Dunnett's multiple comparison test ($p < 0.05$).

RESULTS

The results of the different isolation techniques are detailed in Harms *et al.* (2000). Briefly, the highest yield of PBMCs was obtained by centrifuging heparinized blood

over a two-step (45:55%) Percoll gradient. The majority of PBMCs were collected at the 45:55% interface, while many thrombocytes and a population of low-density granulocytes were screened out at the medium: 45% Percoll interface, with red blood cells and most granulocytes accumulating in the pellet. CellSep, although a simpler technique, resulted in a more heterogeneous cell population. EDTA caused severe hemolysis, which made locating the buffy coat difficult. Sodium citrate resulted in red blood cell contamination in the PBMC isolation, thus heparin was recommended as an appropriate anti-coagulant for this technique.

The cell proliferation method was maximized using various cell densities and dye incubation times with PBMCs from a single turtle. The highest cell density (100,000 cells/well) and the longest dye incubation (four hours) resulted in the optimal absorbance values.

All of the mitogens tested stimulated loggerhead PBMC proliferation in a dose-dependent manner (see Fig. 1 for a representative sample of the turtles that were tested). PBMC proliferation responses varied between individual turtles in magnitude, mitogen concentration and mitogen exposure time (Fig. 1). Generally, peak responses were seen between day three and six of mitogen exposure. PHA stimulated the strongest and most consistent responses at concentrations between 1-50 mg/ml in all seven loggerhead PBMC cultures. Higher concentrations of ConA (5-50 mg/ml) and LPS (20-200 mg/ml) were required to induce proliferation and the magnitude of those responses were generally less than those stimulated by PHA. Additionally, not all cultures of PBMCs responded to ConA and LPS (80% of the turtles tested, $n = 5$).

DISCUSSION

Loggerhead PBMC proliferative responses are similar to those of other marine turtles. The loggerhead PBMCs responded to similar concentrations of mitogens and showed similar peak stimulation times as the green sea turtle (McKinney and Bentley, 1985). However, there are some important differences. The magnitude of proliferation response seen in the loggerhead was less than that of the green, and the loggerhead exhibited less individual variation than did the green sea turtle.

The methods developed and tested in this study provide much needed opportunities to measure baseline and altered immune function in this threatened species. The proliferation assay measures the ability of T and B lymphocytes to undergo polyclonal expansion. Significant reduction or absence of proliferation in these cells imply that effector functions are impaired resulting in depressed humoral and/or cell-mediated immune functions. Therefore, this assay can be used to study the immune response to seasonal changes, diseases (i.e., fibropapillomas), parasites (i.e., barnacles), and chemical contaminants.

The goals of our future research are to examine

seasonal differences in loggerhead PBMC responses and to compare responses to contaminant concentrations. The immune responses of most lower vertebrates, including sea turtles, fluctuate with seasons (McKinney and Bentley, 1985; Zapata *et al.*, 1992). Additionally, stress from environmental contaminants can suppress the immune system, thereby increasing susceptibility to disease. The proliferative responses of PBMCs from other marine organisms have been shown to be reduced by contaminants (De Swart *et al.*, 1994; Lahvis *et al.*, 1995). Results from this study are expected to determine whether the sea turtle immune system is vulnerable to contaminants.

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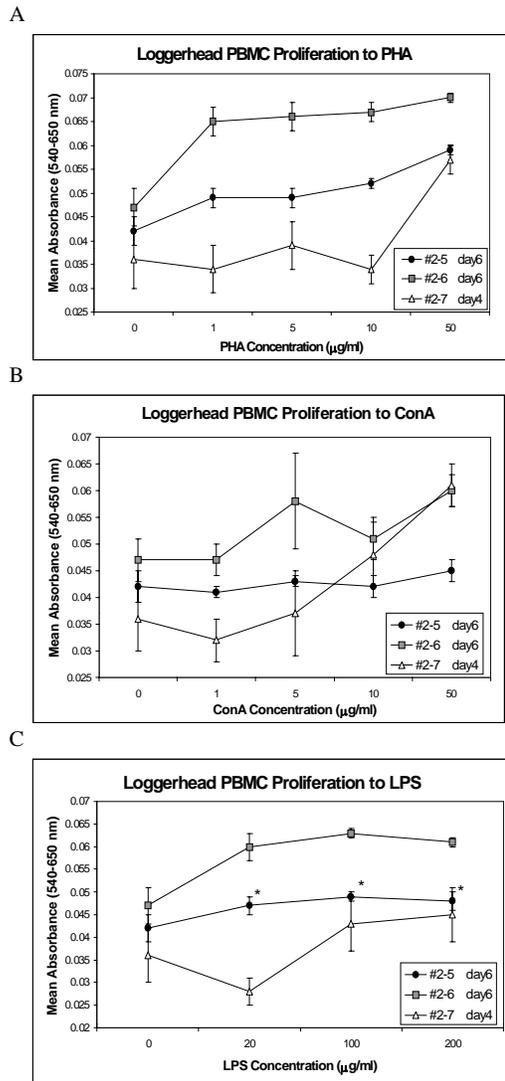
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Fig. 1. Loggerhead PBMC proliferation upon stimulation with mitogens: A = phytohemagglutinin (PHA), B = concanavalin A (ConA), C = lipopolysaccharide (LPS). Cell proliferation was measured via the Promega CellTiter 96 kit with 100,000 cells/well and a four hour dye incubation. Each line represents PBMC proliferation from a single turtle on the day of mitogen exposure that resulted in the maximum number of stimulated responses (listed in the figure legend). Data points represent means of triplicate wells and error bars indicate standard deviation. The asterisks indicate a statistically significant difference between the mean and the control mean.



Blood Flow in Sea Turtles: How Do They Regulate Heat Exchange with the Environment?

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We examined the blood flow in the flippers of two green turtles (*Chelonia mydas*) and four loggerhead turtles (*Caretta caretta*) using Doppler ultrasound (Multi Dopplex II, Huntleigh Diagnostics, UK). The turtles were kept in tanks of circulating, filtered seawater at 22.9° to 20.8°C. Blood flow at a given water temperature was recorded for each turtle before it was transferred into a second tank with an experimentally manipulated water temperature. Immediately after the transfer the blood flow was measured at the same point on the flipper to examine the effect of water temperature changes on blood flow. The procedure was repeated using experimental temperatures ranging from 17° to 32°C. Measurements were only made

when the turtles were in a relaxed state with their heads submerged. This was further verified by the low heart rate, which was calculated from the recorded Doppler waveforms. To evaluate the handling effect of the transfer, turtles were brought into another tank with the same temperature and blood flow was measured. There was no difference in blood flow before and after such transfers. Contrarily, all turtles showed an increased blood flow velocity when exposed to warmer water and a decreased blood flow velocity when brought into colder water. The data will be discussed for their importance to thermoregulation in sea turtles which are exposed to sudden temperature changes.

Looking at Turtles in Three Dimensions

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INTRODUCTION

Historically, the tools and techniques available to describe anatomy are gross dissection, various types of preservation and preparation, histology, and skeletonization. Dissection of carcasses has many advantages when fresh dead animals are available: the color and texture of organs can be described, tissues may be collected for histology, and the general layout of the organs can be seen. While a great deal of information is gained using these methods, truly fresh normal specimens are rare. Once opened, we lose some three-dimensional information as structures collapse. Often landmarks for structures become obscure, the dissections are destructive, decomposition alters organs and tissues rapidly, and we can not observe the organs functioning. Our goals in this study are to introduce the use of technologically advanced tools that enhance the accuracy of descriptive anatomy and diagnostics.

Our study involved the use of computed tomography (CT) and functional magnetic resonance imaging (MRI or FMRI) to describe the anatomy of normal unanesthetized turtles. We briefly describe the value of each alone or in combination with standard anatomical procedures for describing morphology.

METHODS

Each turtle sat in a plastic container while it was imaged using CT and FMRI. CT scans of the turtles were made using a GE model FX/I high-speed helical scanner to describe the skeletal system and lungs. MR images were taken with a GE Horizon LX with echo speed gradients. The unit was equipped with a cardiovascular package.

DISCUSSION

X-ray technology measured differences in absorption of ionizing radiation. CT is a three-dimensional radiographic (x-ray) procedure in which thousands of very fast projections are taken with an x-ray tube that spins around the subject. Exposures were minimal at 28 dG/cm². Computer software is used to reconstruct the images in three-dimensions. The advantages to using CT include that animal is alive (typically). One has a three-dimensional image of all or part of the animal that provides excellent detail of hard structures (bone) or airways (lung). CT images can be manipulated to provide three-dimensional landmarks.

Magnetic Resonance (MR) technology reflects the atomic makeup of the tissue. MRI uses no radioactivity.

Magnetic resonance measures the relaxation times of hydrogen protons, after they have been excited by radio waves. Since hydrogen is the most abundant element in the body, MR is able to create clear images of any tissue containing hydrogen. Protons in tissues or liquids temporarily respond in tissue-specific ways to generate an image. Images are reconstructed using computer software to create “serial sections” (two-dimensional) or three-dimensional images. The results of high-speed sampling are clear images of soft tissues such as fat, brain, eyes, salt gland, GI, kidney, or gonads. Gas and blood can be distinguished in some modalities and blood flow can be traced with a contrast medium (Gaditeridol) or without. Modern functional MRI allows real-time observation of some organ functions and/or organ condition.

Both CT and MRI can be used repeatedly on live animals and are particularly effective for describing anatomical changes with ontogeny or following disease progress.

The use of CT, MRI and traditional anatomical methods together allow for the most reliable anatomical

descriptions to date. The combination of tools enable use to provide normal anatomical landmarks for structures that typically collapse in dead specimens (such as arteries and veins and visceral circulation). The real-time capabilities of some systems also allow us to visualize organ function such as perfusion of organs (e.g., liver, kidneys, brain, or heart). Visceral changes can be observed in situ. There are numerous diagnostic capabilities with MRI. Just two examples would include analysis of head or spinal cord injuries and monitoring the location(s) and changes of gas pockets in floating.

ACKNOWLEDGMENTS

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The Status of Efforts to Protect Atlantic Sea Turtles in Benin (West Africa)

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Sea turtles are subjected to intensive capture along West African coasts and particularly in the Republic of Benin. Although the Republic of Benin has ratified the CMS, the phenomenon has been worsening in recent years. It is characterized by the systematic massacre of the turtles and the collection of their eggs and hatchlings. This destruction is due to the extreme poverty of the population, the lack of awareness and because regulations are not strictly enforced. Since 1998, genuine actions have been undertaken in this field, bringing about greater awareness of the different partners of the following question: How can we assume a sustainable management of the biological diversity in the Republic of Benin?

INTRODUCTION

Sea turtles are listed in Annex I of the Convention on Migratory Species or CMS to which the Republic of Benin has adhered with the decree n° 83 - 204 of 31 May 1983. Consequently they are fully protected by the law n° 87 - 014 of 21 September 1987 on nature protection and hunting in Benin.

For many years, sea turtles have been subject to illegal and intensive capture by fishermen and residents along the Atlantic coast of Benin. The main reason for this situation is the lack of information and awareness. Indeed populations ignore the endangered status of sea turtles.

Since 1998, research and educational work has been undertaken within the framework of an urgent plan for the protection of the Atlantic sea turtles of Benin. This program is being supported by the Wetlands management Program (Programme d'Aménagement des Zones Humides "PAZH") and the German Cooperation (GTZ) and deserves to be strengthened by further research in order to better protect these migratory species, a natural heritage of all humanity.

An international conference on the conservation of sea turtles along the Atlantic coast of Africa was held in May 1999 in Ivory Coast. It strengthened the development of a network of regional cooperation aimed at better understanding and protecting marine turtles. This conference was attended by representatives from Benin and has been a starting point for fruitful exchanges and the elaboration and application of management strategies for the Benin Program for the protection of sea turtles.

ZONE OF STUDY

Benin area has approximately 114,763 km² and is

situated along the Gulf of Guinea. It is bordered to the west by Togo, to the north by Burkina Faso and Niger and to the east by Nigeria. The population is estimated at 6 million with a growth rate of 3.5% per the year. The administrative capital is Porto-Novo (300,000 inhabitants), but the most important city is Cotonou, the economic capital with approximately 850,000 residents.

The Beninese coast, which is the subject of our study, is situated between 6° and 6°30 north latitude, and 1° and 2°44 east longitude. It has approximately 121 km of coast, between the Togolese border to the west and the Nigerian border to the east. Along all this coast it is sandy and low, covered by vast coconut plantations. It is interrupted in the west by the "Mouth of the King", the joint outlet of the Mono River and Aheme Lake, and by the channel of Cotonou in the east.

The north side of the coast is a series of interconnected lagoons and lakes: Lake Aheme, the lagoon of Ouidah, the Coastal Lagoon, the lagoon of Grand-Popo, the Ancient Lagoons, the lagoon of Cotonou, Lake Nokoué and the lagoon of Porto-Novo. Because of its sandy nature the Beninese coast is potentially suitable for nesting turtles throughout. Despite a low level of organic matter (0.5-1%) we can find a variety of coastal vegetation including coconut trees (*Coconuts nucifera*), filao (*Casuarina equisetifolia*) and occasional cactaceae (*Opuntia linguiformis*).

METHODS

Between July and December 1999, four teams of three or two persons were assigned to carry out field work in the following study areas: Zone Sèmè (covering from Kraké beach to PK10, 24 km); Zone Cotonou (from Ambassadors area to Togbin, 22.8 km); Zone Ouidah (from Agbéhonou beach to the limit of Agonsodji beach, 28.2 km); and Zone Grand-Popo (between Adjakaho beach and Hilla-Condji beach, 46 km).

The adopted methodology is based on the participatory approach, supported by the pamphlets and posters illustrating the different turtle species in the Atlantic, the different nesting stages and threats affecting the sea turtles on the coast of Benin. Field work includes the organization of educational efforts on sea turtles conservation with fishermen, local authorities, trawlers, operators, students and coastal villagers, as well as data collection on number of intentional and accidental captures, number of releases and nesting activity within each area.

RESULTS AND DISCUSSION

Awareness Building

In the chosen pilot zones (Togbin and Hilla-Condji), several awareness seminars were held (involving government authorities and restaurant owners) in collaboration with security services such as Coastal Protection Brigade (BPL) and the Police. During the study period several turtles were recovered by different work teams or by members of the protection Committees setup along the coast.

Diversity and Abundance of Marine Turtles

Recent observations confirm the presence of green turtles (*Chelonia mydas*), leatherbacks (*Dermochelys coriacea*), and olive ridleys (*Lepidochelys olivacea*) (Table 1). The more significant beaches are Hilla-Condji, Grand-Popo, Djegbadji, Togbin and Sèmè. The presence of hawksbills (*Eretmochelys imbricata*) has been confirmed in the region of Hokognoncodji (District of Ouidah), but can be considered rare in Benin. Eggs of the first three species have been recovered and transferred to hatcheries. Slaughter of turtles was reported throughout the coast, as well as seizures of meat by customs, especially in Hilla-Condji.

Protection Committees

Four sea turtle protection committees were officially installed and rendered partially operational. Members of these Committees have the mission to protect local marine turtles and to gather information on the status within their zone of intervention.

Training of Ecoguards (Protection Committees Members)

The present work is aimed at informing the coastal population about the laws and Conventions applicable to sea turtles, as well as training them in techniques of study and protection. The objective is to strengthen the local protection committees and their conservation activities.

Installation of Hatcheries or Turtles Villages (Ecotourism)

Two hatcheries have been built in Hilla-Condji and Togbin, 12 km from Cotonou. Hatcheries are 8 m by 4 m, made with stone blocks 100 cm by 80 cm, enclosed by wooden fencing. The hatcheries are filled with sand to a height of 50 cm and are expected to have a capacity of approximately 115 nests. Nests will be transplanted to the hatcheries during the nesting season. At the time of hatching and hatchling release, villagers and tourists will be invited for sponsorships and the release of hatchlings in sea. These are also opportunities to generate awareness among the general public.

Threats to the Life of Marine Turtles

The main threats to the existence of sea turtles are

offshore fishing, collection of eggs and hatchlings, capture of nesting females along the coast, habitat degradation due to demographic pressure (which has led to increase in homes and tourist resorts on the beach), and uncontrolled capture of sea turtles. In spite of Benin's adherence to the Bonn Convention (CMS), and the laws on nature protection and hunting, the capture of turtles and collection of turtle eggs continues uncontrolled. Table 2 shows the statistics of turtle capture by species and by region during the last nesting season (July to December 1999). Information from coastal villagers reveals that the frequency of leatherback catches depends on their nesting activity. Between July and December 1999, 77 turtles were slaughtered along the Beninese coast despite growing awareness levels in certain sites. Many other turtle kills would have been kept secret. Both turtle meat and eggs are frequently consumed by the inhabitants of the Beninese coast, despite the fact that this is sometimes prohibited or taboo among other ethnic groups (Awlan, Guin.). The leatherback is particularly sought after for its oil, which is used in traditional medicine. In collaboration with the Fisheries Office (Direction des Pêches) and the Coastal Protection Brigade (BPL) vigorous controls are being undertaken since January 2000 in conjunction with the education campaign.

Nesting Sites

No beach in Benin is currently legally protected. It is interesting to note that the peaks of nesting activity have been reported at Hilla-Condji, Grand-Popo, Djegbadji, Togbin and kraké plage. The works in progress will allow us to have a better understanding of the nesting sites and measures to protect them and to enforce existing legislation.

International Cooperation

Until recently no specific scientific study on the sea turtles of Benin has been carried out and thus no reliable data was available on these animals. Research at the national, regional and international level is now underway, including a genetic study of the sea turtle populations in all of West Africa.

Perspectives and Conservation Strategies

The objectives are the development of a system of sustainable management of the species, determination of the exact level of abundance and distribution along the coast for each species, increase of the level of awareness among coastal inhabitants on the need to conserve the resource, and support of the government in the enforcement of national and international laws and conventions.

Action Plan for the Implementation of a Sea Turtle Protection Plan

1. Strengthen informational meetings along the coast.
2. Strengthen local protection committees in each village.
3. Create turtle protection funds.

4. Develop alternative sources of income for turtle poachers.

5. Provide technical training on conservation and tagging techniques.

6. Design scientific research strategy.

7. Develop a database and informational and educational material.

8. Establish partnerships for the exchange of experience in turtle conservation within the framework of a regional program protecting sea turtles in the Gulf of Guinea. Such a program will allow coordination of conservation efforts and management of these migratory species.

CONCLUSIONS

Most coastal residents today are aware of the presence of sea turtles on the beaches of Benin. However, information sessions must be continued and strengthened, preferably by a media campaign to reach the general public, in order to increase awareness and to shift to a sustainable use of this biological resource. Partnership with government institutions such as the fisheries office, the Coastal Protection Brigade and the police will strengthen fieldwork. Regional cooperation for a complete protection of Atlantic and African sea turtles is an essential objective of any national plan given the migratory nature of these species.

ACKNOWLEDGMENTS

The present work has been made possible thanks to the financial support of the Wetland Management Program (PAZH) and by the German Technical Cooperation (GTZ) whose directors must be thanked for the attention they grant to environmental issues. Many thanks to members of the teams working in the field and especially to all fishermen and coastal residents between Kraké-Sèmè and Hilla-Condji, for the interest they grant to the conservation and sustainable use of the biological diversity of Benin. We

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Table 1. Average number of turtles recovered and protected according to species. The data are based on survey results from December 1999.

Zones	Species			Total
	Leatherback	Olive ridley	Green turtle	
Sèmè	2 (5.70%)	8 (16.52%)	2 (11.76%)	12 (11.68%)
Cotonou	7 (20.0%)	14 (28.57%)	2 (11.76%)	23 (22.77%)
Ouidah	3 (8.57%)	6 (12.24%)	4 (23.52%)	13 (12.67%)
Grand-Popo	23 (65.71%)	21 (42.65%)	9 (5.25%)	53 (52.57%)
Total	35	49	17	101

Table 2. Average number of sea turtles caught in the course of last nesting season by species. The data are based on survey results from December 1999.

Zones	Species			Total
	Leatherback	Olive ridley	Green turtle	
Sèmè	7 (18.42%)	6 (21.42%)	2 (18.18%)	15 (19.58%)
Cotonou	6 (15.78%)	5 (17.65%)	1 (5.09%)	12 (15.58%)
Ouidah	12 (31.57%)	11 (39.28%)	4 (36.54%)	27 (35.06%)
Grand-Popo	13 (34.21%)	6 (21.42%)	4 (36.56%)	23 (29.67%)
Total	38	28	11	77

Florida's Sea Turtle Program: Strength Through Diversity

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INTRODUCTION

Florida first initiated sea turtle protection in 1953. Although early laws came too late to prevent the exploitation of sea turtles in Florida, they did pave the way for a cultural acceptance of the loss of sea turtles as a commodity. These early laws, coupled with protection of all sea turtle species when they were placed on the Endangered Species List, appear to have made a difference. Florida's beaches provide habitat for one of the largest nesting assemblages of *Caretta caretta* (loggerhead sea turtle) in the world. Throughout the state, four other species are documented as nesting, and its coastal waters host all life stages of the five species. Today, sea turtle protection in Florida includes a diversity of tasks within programs distributed across federal, state, and local agencies, state and private universities, marine science centers and private non-profit organizations. The Fish and Wildlife Conservation Commission is the primary state agency responsible for sea turtle research and management activities. Staff participate in development of the information necessary to guide recovery efforts (research); review ongoing and proposed human activities that could impact marine turtles and their nesting habitat (management); and are active in educating the public. Program staff are integral to the implementation of the federal recovery plans for marine turtles, including planning, management and administration. Diversity is the mark of the program's funding as well with support derived from sales of a special automobile license plate, decals, research grants, donations, and general revenue from the state's multi-billion dollar budget.

DISCUSSION

The Florida Fish and Wildlife Conservation Commission (FWC) was created by the citizens of the State of Florida through an amendment to the state's constitution in 1998. In 1999, the Florida legislature transferred several programs which were not specifically mentioned in the amendment to the new FWC. The FWC is led by a true Commission which is an appointed body of citizens representing a diversity of viewpoints and interests. The Governor appoints the Commissioners who then must be confirmed by the legislature. They act as the head of the agency and must consider all official matters as a group. The Commission employs an executive director, Dr. Allan Egbert, to manage the day to day affairs of the agency. The Sea Turtle Program (also referenced as the Marine Turtle Program) is divided into two separate units within the Commission. In general, research coordination is within

the Florida Marine Research Institute (FMRI) headed by Ken Haddad. Dr. Buddy Powell and Dr. Anne Meylan are key employees in the Ecosystem Assessment Section. Management coordination is housed within the Office of Environmental Services led by Mr. Brad Hartman. The Bureau of Protected Species Management (BPSM) is a unit of this Office, where I and Dr. Robbin Trindell are employed.

Florida's sea turtle program is characterized by the great diversity present in all aspects of the program. In general, the program components include: independent and dependent research coordinated with the FMRI, management activities coordinated by BPSM, long-term data collection by volunteers, giving advice to regulatory agencies in their decision-making, coordinating with federal resource agencies, oversight of rehabilitation programs of cooperating facilities, dialogue with non government organizations and a successful voluntary funding program. I will be focusing in detail on the diversity of the management program's activities.

There are five species of marine turtles in Florida, loggerhead, green, leatherback, hawksbill and Kemp's ridley. The nesting trends of these species (loggerhead for example) are produced by FMRI and are one of the outputs that are used for management decision-making. In affording protection to these animals, Florida's approach is reaching from the ocean to the beach and back again. We cooperate with federal resource agencies to bring about protection of hatchlings and adults in the ocean, such as through fishing gear limitations. Then we protect the nesting beach habitat (which I will be covering in greater detail) and even reach landward of the nesting beach with such tools as lighting controls.

Florida's program is greatly assisted because of the legal framework the state has established over the years. The most significant of the laws we utilize is the Marine Turtle Protection Act of 1991 (Section 370.12, Florida Statutes). This law provides, in part, that "the department shall recommend denial of a permit application if the activity would result in a "take" unless that "take" is authorized by the U.S. Fish and Wildlife Service (USFWS). Using this authority, BPSM has been able to recommend denial of such actions as building seawalls in nesting habitat and moving marine turtle nests for construction purposes (unless such moving is authorized through a federal process).

The other significant state authority is in Chapter 161, the Beach and Shore Preservation Act and its implementing rules at 62B-33, Florida Administrative Code. This statute provides that "the Department may condition the nature timing and sequence of construction of permitted activities

to provide protection to nesting sea turtles and hatchlings and their habitat. Structures must be “sited and designed to protect marine turtles”. Using this authority, BPSM implements controls over such major activities as beach construction and reconstruction, trying to limit the timing of these projects (in concert with the USFWS) For the purposes of Florida’s statute, “take” is defined as it is under federal law and specifically includes any act which significantly impairs essential behavioral patterns such as breeding, feeding or sheltering. Applying this to habitat has led BPSM and other partners to focus on changes to the beach environment that occur during restoration projects to make sure that these changes are not negatively impacting marine turtles.

The state laws authorizing the regulation of coastal lighting is found in 62B-33, F.A.C. This law states in part that “all forms of lighting shall be shielded or otherwise designed so as not to disturb marine turtles”. Tinted glass is specifically mentioned as one option for minimizing the light shining onto the nesting beach. Although this law applies only to new construction, many areas of existing development create problems for sea turtle hatchlings. The FMRI has published a technical guidance document which illustrates appropriate designs for illumination of beachfront dwellings which can be used to retrofit existing structures as well. This guidance is available through the Commission’s web site.

Many minor structures can be harmful to marine turtles and their habitat. Most of these activities, such as dune walkovers, fences, etc., can be constructed with a minimum amount of government regulation provided that they have no measurable interference with the natural functioning of the beach dune system or with marine turtles or their nesting sites. Inappropriate sand fences can impede turtle nesting or hatchling access to the ocean so the BPSM has focused a great deal on getting the word out on “turtle-friendly” designs for sand fencing.

Some activities may affect marine turtles although they are not directly on the beach or fronting the beach. Thanks to the existence of state law regulating the issuance of environmental resource permits (Section 373, F.S. and FAC Rule 40-4) it is possible to consider the secondary impacts of projects. Such projects if permitted must not adversely impact the ecological value of uplands to aquatic or wetland dependent listed animal species. This stretches

marine turtle protection well landward of the nesting beach for new construction which requires an ERP.

Of course, sea turtles are protected by federal law as are all endangered and threatened species. These federal laws and subsequent implementing regulations have allowed state agencies to enter into cooperative agreements with the federal government for both regulatory purposes and financial support. For example, in Florida, all sea turtle research and data collection is overseen by the Commission because of a Section 6 cooperative agreement. Florida programs have also received funding for many years because of federal endangered species programs. This funding allowed Florida to first establish its extensive network of volunteers who assist in collecting data on sea turtle nesting and strandings. Without these volunteers, we could not have as strong of a regulatory program and we would know very little about the trends in population for Florida’s turtles.

The majority of our sea turtle program funding comes from sales of the marine turtle license plate. We are very grateful to the Sea Turtle Survival League of the Caribbean Conservation Corporation for spearheading the effort to get the license plate established in law. One important feature of this license plate is a provision for scientific and educational grants once the income reaches in excess of \$500,000 on an annual basis. We hope to be able to offer support for many of the scientists and volunteers to expand our knowledge about sea turtles. We also receive funding from sales of marine turtle decals, research grants and other types of donations.

CONCLUSION

Florida’s sea turtle program is going strong after many years in part because of its diversity. We both collect and facilitate the collection of a wide variety of data on marine turtles. We use many different regulatory approaches to address threats to sea turtles and their habitat. We are active on many different levels including international, federal, state, and local. We work with government entities, environmental groups, educational institutions, independent businesses and individual citizens. The future of Florida’s marine turtle species depends, in part, on continued support for this diverse approach.

Improvement in Marine Turtle Conservation and the Use of TEDs in Nicaraguan Fisheries

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Intensive discussions have taken place for the past several years, especially focused on the survival of marine turtles captured by shrimp trawlers which required a demonstration of significant agreement by all relevant

stakeholder groups in the world, on the use of turtle excluder devices in the shrimp fishery. The TED-use requirements allows shrimpers to continue fishing in public trust waters and simultaneously protects sea turtles.

Fishery is an important economic activity for several countries in Latin America. We are ensured that the TED requirements were phased in gradually, and has provided numerous workshops and programs to work with the industry regarding TEDs. With respect to shrimp fisheries, Nicaraguan Fishery Administration (ADPESCA), Ministry of Environment and Natural Resources (MARENA) under the inspection of NMFS and State Department have been working closely with other nations in Latin America to help us develop comparable TED programs. These programs are now in place in several countries in the Caribbean area. In addition NGOs are supporting the ratification for Interamerican Sea Turtle Convention to further promote conservation programs in our countries.

Nicaragua has access to the Pacific Ocean and Caribbean Sea and approximately represents 294 and 457 km of coast line. The running legislation on fish matter was established since 1960s, new proposal legislation is up for approval in the National Assembly (Table 1). Nicaragua, like other Central American countries, has serious problems in the conservation programs because sea turtles enjoy only limited protection. In the Pacific area, turtle eggs are a culinary delicacy for consumers; on the other hand the Caribbean population prefer turtle meat for food consumption, and this is permitted for subsistence use only. In both cases the turtle conservation is seriously endangered. This is an example in which we should balance

socio-economical needs with the biological need of protected resources, for sea turtle conservation is not enough. Additional sea turtle conservation measures are required not only along nesting beach or sea side. In the same way we need to reinforce gear requirements-leatherback conservation zone, state agents in the conservation zone, TED requirement and registration, trawling hours, gear modifications and turtles captures, tow-time restriction, and edit new legislation in some case, etc.

On behalf of Nicaraguan members of Central American Sea Turtle Conservation Network and NGO-NICAMBIENTAL, I want to thank Packard Foundation, Disney Conservation Society, FFI (Flora and Fauna International) and everyone involved. It has been an interesting meeting, involving great personal investment of resources and commitment.

Table 1. Data from the Ministry of Industry and Commerce, Ministerial Resolution No.14-99 La Prensa, February 10, 2000.

Type of vessel	Nationality/Flag	Pacific Ocean	Caribbean Sea	Total (%)
Shrimp trawlers	USA	-	43	43 (49%)
Shrimp trawlers	Korea	-	11	11 (13%)
Shrimp trawlers	Nicaragua	28	2	30 (34%)
Shrimp trawlers	St. Vincent	3	-	3 (4%)
Total		31(36%)	56(64%)	87 (100%)
Long-line vessels	USA	-	1	1 (20%)
Long-line vessels	Mexico	-	1	1 (20%)
Long-line vessels	Nicaragua	1	2	3 (60%)
Total		1	4	5 (100%)

The Repatriation of Captive-Reared Kemp's Ridley Turtles to Quintana Roo, Mexico

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Due to the critical situation of the wild population of the Kemp's ridley sea turtles (*Lepidochelys kempii*) in 1980 while meeting with the INP (National Fishery Institute) and managers of Grand Cayman turtle farm, they decided to keep a stock reserve to initiate the program. They transported from Galveston Texas laboratory of National Fisheries Institute service of the U.S. a hundred juveniles turtles (1 year-old) and 100 hatchlings in Rancho Nuevo Tamaulipas were shipped to Cayman as part of the conservation program.

Between the years 1988 and 1993 the turtles mated successfully, but in 1994 the reproduction program was stopped due to organizational changes in the company and to consider for the program that as their goal at which point they began to observe a recuperation of the wild population

was regain and so they decided to look for alternative means for the repatriation.

In 1997 they initiated negotiations between Cayman Turtle Farm (1983), LTD, INP and Promotora Xcaret S.A. de C.V. for the repatriation of the majority of the Kemp's ridley turtles to the relocation of the Ecoarqueological park located in the state of Quintana Roo México.

In 1999 a visual inspection and selection was made, and the number of turtles for repatriation was determined: 57 females and 53 males the same number as those maintained in isolation.

The final transfer of the turtles occurred on April 10, 1999. Up to now we keep them in quarantine until the brand new turtles tank is finished

Medetomidine, Ketamine, and Sevoflurane Anesthesia in Loggerhead Sea Turtles (*Caretta caretta*)

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The effects of medetomidine, ketamine, and sevoflurane anesthesia were evaluated in six juvenile loggerhead sea turtles (*Caretta caretta*) treated at the North Carolina State University College of Veterinary Medicine for a variety of trauma-related injuries between 1996 and 1999. Loggerheads were induced with 50 ug/kg medetomidine (Pfizer Animal Health, Exton, PA) and 5 mg/kg ketamine (Fort Dodge Animal Health, Fort Dodge, IA) intravenously in the dorsal cervical sinus, intubated, and maintained on sevoflurane (Abbott, N. Chicago, IL) at 0.5 to 2.0%. An ADS 1000 ventilator (Engler Engineering Corporation, Hialeah, Florida) was used to maintain a respiratory rate of 2 breaths per minute and peak inspiratory pressure of 15-18 cm H₂O. Loggerheads were catheterized in the dorsal cervical sinus with a 1610-2P Mila catheter with guidewire (Mila International, Florence, KY). Parameters monitored included times for induction and recovery, heart rate and rhythm, temperature, end tidal CO₂, and venous blood gases. At the end of each procedure, medetomidine was reversed with 0.25 mg/kg atipamezole (Pfizer Animal Health, Exton, PA) intramuscularly.

The mean (+/-SD) induction time was 8.8 +/-3.9 minutes. The combination of medetomidine and ketamine provided adequate jaw and glottis relaxation for easy intubation. Anesthesia times ranged from 110 to 325

minutes. Recovery times from discontinuation of sevoflurane to extubation ranged from 5 to 124 minutes and from administration of atipamezole to extubation, 0 to 84 minutes. Mean (+/-SD) recovery time from sevoflurane discontinuation was 62.0 +/-40.4 minutes (median 65.0 minutes), while mean (+/-SD) recovery time from atipamezole administration was 24.3 +/-31.5 minutes (median 14.0 minutes). Heart rates ranged from 10-20 beats per minute and temperatures, from 23.5 to 26.5 degrees Celsius. Mean (+/-SD) pre-operative venous blood gases values in three sea turtles were: pH 7.50 +/-0.06 units, PCO₂ 40 +/-6 mmHg, PO₂ 25 +/-9 mmHg, and HCO₃ 36.1 +/-0.3 mmol/L. After 140 minutes of anesthesia, intraoperative venous blood pH ranged from 7.53 to 7.60 units, PO₂ from 23 to 58 mmHg, PCO₂ from 28 to 29 mmHg, and HCO₃ from 29.0 to 33.0 mmol/L. Respiratory alkalosis was most likely due to increasing the respiratory rate on the ventilator above two beats per minute in these animals. Intraoperative end tidal CO₂ values were lower than venous CO₂, indicative of significant shunting of pulmonary blood. The combination of medetomidine, ketamine and sevoflurane appears to be a safe and effective anesthetic protocol which provides relatively short induction and recovery times in loggerhead sea turtles.

Hemiovariosalpingectomy in a Loggerhead Sea Turtle (*Caretta caretta*)

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A sexually mature female loggerhead sea turtle (*Caretta caretta*) nested on Bald Head Island, North Carolina, on August 1, 1997. Volunteers monitoring the turtle nesting activity observed a segment of tubular organ protruding from the animal's vent. Approximately 1.5-2 m of prolapsed tissue was precipitously severed and the turtle transported to a local veterinarian. On August 8, 1997, the turtle was referred to the College of Veterinary Medicine at North Carolina State University. Cryohistology of the frozen portion of severed organ confirmed that it was oviduct. The turtle was considered valuable genetic stock and a right hemiovariosalpingectomy was performed in order to preserve the functional side of her reproductive tract. Following surgery, the turtle was returned to a

rehabilitation facility on Topsail Island, North Carolina, on August 9, 1997, and was released on October 22, 1997, at the mouth of the Cape Fear River, North Carolina. The success of this effort was evaluated when the turtle was sighted during subsequent nesting seasons. This animal returned to the Outer Banks of North Carolina in 1999 to lay 142 eggs on June 9, 139 eggs on June 24, and a nest of unknown size on July 6, 1999. Such reproductive success, with above-average clutch sizes, is especially notable because the turtle had only one ovary and oviduct. This case illustrates that even an animal with a compromised reproductive tract can make a substantial contribution to species survival, and that alternatives to sterilization and euthanasia should be considered in such instances.

Corneal Ulceration in Cold-Stunned Kemp's Ridley Sea Turtles

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Each fall in Massachusetts, Kemp's ridley sea turtles (*Lepidochelys kempii*) wash up on the beaches of Cape Cod in a state of severe hypothermia, commonly known as cold-stunned (George, 1997, and Morreale *et al.*, 1993). These turtles are collected by the Massachusetts Audubon Society and are transported to the New England Aquarium in Boston, Massachusetts, for medical treatment. In the fall of 1998, seventeen hypothermic Kemp's ridley sea turtles were brought to the New England Aquarium's Rescue and Rehabilitation Team. Upon arrival, complete health examinations were performed, including diagnostic evaluation to identify secondary medical conditions. These assessments revealed several medical problems including dehydration, pneumonia, ileus, traumatic wounds, and corneal ulcerations.

Corneal ulceration was found in seven of the seventeen Kemp's ridley sea turtles. Clinical signs that accompanied this condition included a decrease or lack of tear production, blepharospasm (indicative of ocular pain), photophobia, and conjunctivitis. Corneal ulcerations were diagnosed with the use of fluorescein stain. Corneal epithelial defects take up fluorescein stain, therefore ulcerations were easily identified as fluorescent apple-green areas when viewed with a cobalt blue ophthalmic light (Slatter, 1990). Once the condition was diagnosed, affected turtles were treated with an ophthalmic antibiotic ointment, oxytetracycline HCl with polymyxin B sulfate (Terramycin7 ointment; Pfizer, Parsippany, NJ 07054). The corneal ulcerations resolved within 12 days in four of the animals. The other three animals did not survive the cold-stunning event and died soon after their arrival at the aquarium.

Histopathology was performed on the eyes of an affected animal that did not survive. Using light microscopy, both eyes were found to have superficial corneal ulcerations, with the adjacent palpebral epithelium containing eosinophilic intranuclear inclusion bodies suggestive of a herpes virus infection. Subsequently, corneal cultures were taken with polyester-tipped applicators (Dacron7 swabs; Hardwood Products, Guilford, ME 04443) for virus identification from several affected animals, but all of the cultures were negative.

The original set of histology slides was then reviewed by a second investigator. While corneal ulceration was readily apparent, the intranuclear bodies in the palpebral epithelial cell nuclei were considered to be hypertrophic

nucleoli. This investigator had commonly seen hypertrophic nuclei in marine turtle tissues. Based on these findings, no specific pathogen was incriminated as the causative agent of the corneal ulcers.

Currently, our veterinary laboratory is investigating possible etiologies for corneal ulcerations in cold-stunned Kemp's ridley sea turtles. These include infection, mechanical injury, and altered tear production. Hypothermia has been associated with decreased function of the salt gland (George, 1997) and a subsequent alteration in tear production, which may lead to compromised corneal protection. In order to evaluate the tear production of cold-stunned sea turtles, our laboratory plans to perform appropriate diagnostic tests, including Schirmer's tear tests, tear sampling, and tear content analysis. In addition, the laboratory will continue to look for an infectious component to this condition by collecting corneal samples for culture, histopathology, and electron microscopy.

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Induction of Egg Laying and Repair of a Plastron Fracture During Rehabilitation of a Loggerhead Turtle

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A 138 kg mature female loggerhead sea turtle, *Caretta caretta*, was brought to Mote Marine Laboratory's Sea Turtle Rehabilitation Program on 14 July 1999. The turtle had crawled onto a beach on Anna Maria Island, Florida, to nest and had fallen off a groin and fractured her plastron. The fracture ran cranio-caudally and involved about 80% of the plastron length including the caudal margin in the inguinal area. The turtle, nicknamed Sadie, was initially confined to a small tank (1.5 m, 1,100 l capacity) to restrict her movements as the edges of the fracture did not appear to be separated.

The initial radiographs revealed that Sadie had not deposited her eggs on the beach. On 29 July it was decided to attempt to induce egg laying because she had failed to deposit the eggs in the tank and she was given multiple intramuscular injections of oxytocin (ranging from 10 to 40 units per injection). Although she deposited 59 eggs over the next three days, some injections produced only a few eggs and most produced none at all. These 59 eggs were placed in an artificially-built nest on the beach where she had stranded, but after 80 days there was no development in any of the eggs. After she deposited the eggs, she was radiographed and found to have a small number of eggs present but additional injections did not stimulate further egg laying. Over the next several weeks, Sadie passed the remaining eggs that appeared to be in a decomposed state with no adverse effects.

During this time it was decided to immobilize the plastron fracture as no healing was evident. On 11 August three stainless steel bone plates were applied with bone screws to the external surface of the plastron, perpendicular to the fracture. At this time, the turtle was placed into a larger tank (3.5 m diameter, 7,400 l capacity). On 1 September it was noticed that the screws had begun to loosen and it was decided to replace the plates with larger plates and larger cancellous bone screws. In addition, short intra-medullary bone pins were applied at 45° angles to the plastron surface around one bone plate and the plate and pins

were covered with methyl methacrylate. At about this time, the turtle was transferred to an even larger tank (9.1 m diameter, 185,000 l capacity). On 8 October, it was found that the covered plate was holding better than the others so the other two plates were covered in the same way. The plates held very well for about three months but then began to loosen. On 14 January 2000 the plates were removed and the fracture site was examined. It was noted that the caudal margin (about 2 cm) of the fracture had fibrosed and there was considerable fibrosis occurring at the internal margin of the fracture. The exterior margin of the fracture was debrided of all dead tissue. It was decided to apply six bone screws, three on either side of the fracture, and stainless steel wire was wound around the screws across the fracture site. It was felt that this would allow fibrosis to continue and also allow the plate screw holes to begin healing. To date, fibrosis appears to be stabilizing the fracture and it is planned that the screws and wires will be removed once the majority of the fracture line has fibrosed. Once the fracture is healed, it is expected that Sadie will be released by mid-to late-summer with a satellite-linked transmitter to allow for tracking of her movements in the wild.

CONCLUSIONS

Although multiple injections of oxytocin induced the laying of most of the turtle's eggs, response was not entirely satisfactory. We would suggest the use of arginine vasotocin (AVT) instead of oxytocin for this species.

Healing of plastron fractures by second intention is adequate as there is so much movement in the normal plastron.

Stabilization of the plastron with bone plates, screws, pins, and methyl methacrylate to allow the healing process to begin was fully acceptable. Less stabilization after the healing process had begun allowed for additional healing.

International Issues Regarding Sea Turtles

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I would like to begin by thanking the organizers of the Sea Turtle Symposium for the opportunity to speak to you today.

Unlike most participants in this symposium, I am not an expert on sea turtle biology and conservation. I do not have much scientific background at all, actually. But for almost ten years, I have been involved in efforts to promote sea turtle protection and conservation through international cooperation. I would like to share with you some observations that I have drawn from this experience.

My presentation will cover three topics relating to international efforts to conserve and protect sea turtles. First, I will review the status of the Inter-American Convention for the Protection and Conservation of Sea Turtles. Next, I will try to describe efforts that are currently underway to develop a comparable agreement to protect sea turtles in the Indian Ocean and Indo-Pacific region. I will close with some thoughts on the recent World Trade Organization case involving the U.S. "turtle-shrimp" law.

THE INTER-AMERICAN CONVENTION ON THE PROTECTION AND CONSERVATION OF SEA TURTLES

This treaty, which was concluded in 1996 after 2-3 years of negotiations, provides a comprehensive framework for addressing sea turtle conservation efforts on a cooperative basis throughout the Western Hemisphere. Twelve nations, including the United States, have signed the Convention. According to the Government of Venezuela, which serves as the depositary for the Convention, three nations have ratified it so far-Venezuela, Brazil and Peru. Two other nations-Mexico and Honduras-have approved ratification of the Convention, but have apparently not yet sent the necessary papers to Caracas. For the Convention to enter into force, eight nations must ratify.

President Clinton transmitted the Convention to Senate for approval in 1997. To date, the Senate has not acted one way or the other on the Convention. However, Senator Helms, who is the Chairman of the Senate Foreign Relations Committee, has indicated that the Convention is one that he could support. The U.S. Administration has been in close contact with his staff and others to urge Senate approval. We have pointed out that, in the United States, both the environmental community and the U.S. fishing industry support the Convention. Indeed, we are aware of no opposition to the Convention whatsoever. On this basis, it is my hope that the Senate will approve the Convention during the first half of this year.

EFFORTS TO NEGOTIATE A COMPREHENSIVE SEA TURTLE AGREEMENT FOR THE INDIAN OCEAN REGION

The United States has been working with other nations in the Indian Ocean and Indo-Pacific region in an effort to begin negotiations toward a comparable agreement for that region. I would say that progress has been slow, but steady. Most recently, at a well-attended meeting hosted by the Government of Australia in Perth, the governments of the region adopted a declaration in which they committed themselves to develop a sea turtle agreement. It was further agreed that a first round of negotiations should take place in the first half of this year. At this point, there appears to be stronger support to develop an agreement that would not be legally binding, at least not at first. I have copies of the Perth Declaration, for those who may be interested.

The Government of Malaysia has indicated that it would be willing to host the first round of negotiations. The United States has made clear that, even though we do not have territory in the Indian Ocean region, we are eager to participate actively in the negotiations and would be willing to support the negotiations, financially and otherwise.

In our view, the Inter-American Convention can serve as a useful model in this effort. However, we also recognize that there are differences between the two regions that will need to be taken into account as the Indian Ocean process moves forward. But certain elements of the Inter-American Convention seem to us to be applicable, particularly its emphasis on protecting sea turtles in a comprehensive way, from all sources of threat.

WTO TURTLE/SHRIMP CASE

As many of you probably know, four countries from the Indian Ocean region-India, Malaysia, Pakistan and Thailand- recently brought a case against the United States in the World Trade Organization. They claimed that a U.S. law prohibiting the importation of shrimp harvested in ways that are unsafe for sea turtles amounted to a violation of U.S. obligations under the WTO Agreement.

In November 1998, the WTO Appellate Body issued a decision in this case. A number of environmental organizations in the United States criticized this decision as undermining efforts to protect sea turtles. But I don't think that this is a fair criticism.

The decision found that the law in question was a legitimate effort by the United States to pursue an important environmental objective-the conservation of endangered sea turtles. It is true, however, that the decision also found that certain aspects of the way in which the United States was implementing the law should be changed.

But these changes did not require any change in the law, and did not weaken the law as it relates to sea turtle protection.

The U.S. Department of State, which is primarily responsible for implementing the law, has instituted the changes recommended by the WTO. We have made the process by which other nations may be certified under the law more flexible and transparent. I would also note that the WTO called upon the United States and the nations that brought the complaint to try to negotiate a multilateral instrument to protect sea turtles. In this respect, the

negotiations that will be getting underway in the Indian Ocean region can be step in the direction that the WTO recommended.

Thank you very kindly for your attention. I would be pleased to answer any questions that anyone may have. Also, for those who may be interested, I have brought along copies of a longer presentation I made recently at a conference organized by the U.S. Court of International Trade, entitled, "Setting the Record Straight on Sea Turtles and Shrimp."

Sea Turtle Conservation and the Big Stick - The Effects of Unilateral U.S. Embargos on International Fishing Activities

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INTRODUCTION

Strengths and weaknesses of U.S. Public Law 101-162, section 609 are examined as an example of complications regarding conservation policies for sea turtles and their habitats. Although informed by biological knowledge, conservation activities are ultimately political in nature-not scientific: the standards demanded in science are not the same as those used in legal, policy and political arenas, so scientists must appreciate that the basic assumptions under which they operate are often not priorities in the realm of policy formulation and implementation.

PUBLIC LAW 101-162, SECTION 609.

Enacted in 1989, and known mostly as a ruling for shrimp embargo, Public Law 101-162, section 609 (hereafter '§609') consists of two parts, each using very different mechanisms to promote the conservation of marine turtles internationally. The first part instructs the U.S. government to advance conservation through international negotiations and multilateral accords. It is the second part of §609 that directs the U.S. government to embargo shrimp products from nations whose commercial shrimp trawling fleets are likely to cause mortality to sea turtles, and that do not apply sea turtle conservation programs equivalent to those in the U.S. Regulations for the implementation of §609 have concentrated on the use of turtle excluder devices (TEDs) to reduce the mortality of sea turtles in commercial shrimp trawling operations. Countries that are found to meet US standards in TED use are certified, and thus permitted to import shrimp into the US (World Trade Organization, 1998). Although this law focuses on commercial shrimp trawling activities, in the first part it refers generally to 'commercial fishing operations,' not specifying a particular fishing method

(103 Stat. 988, 1037: Departments of Commerce, Justice and State, the Judiciary and Related Agencies Appropriations Act of 1989). Hence, it is possible that the first part of §609 could be used to promote conservation actions for sea turtle bycatch, in any commercial fishery. Although not as yet subject to judicial interpretation, Plé (1990) felt that the broad reach of such an interpretation could be problematic.

Section 609 has often been considered to be an important conservation tool, but it has also been the source of considerable discussion and contention, resulting in the expenditure of extraordinary amounts of time and energy from many different sectors: governmental and non-governmental. Intense conflicts have emerged, with people developing firm opinions (either supportive or adverse) about the conservation value of §609. The diversity of organizations and disciplines involved includes people with administrative, environmental, industry, legal, political, research, national and international responsibilities (Howse, 1998; Berger, 1999; Crouse, 1999; Quresti, 1999; Sam, 1999; Shaffer, 1999; Simmons, 1999). Thus, before attempting an objective evaluation, it is fundamental to establish a common base of knowledge and assumptions about this law, so that stakeholders of different backgrounds and perceptions, who deal with marine turtle conservation, can work from a common starting point.

Several assumptions support the scientific logic behind §609. First, marine turtles provide diverse values - material and non-material-to human societies, but their populations have been decimated, or exterminated. Therefore, actions to conserve sea turtles are justified for many diverse reasons (Frazier, 1999). Second, bottom trawling is a major source of mortality to many marine species through incidental capture by the fisheries, and all seven species of marine turtles are known to form part of this 'bycatch.' Systematic studies are few, but data consistently show that bottom trawling is a significant source of mortality to marine turtles (National Research

Council, 1990). Hence, the threat that bottom trawling poses to marine turtles must be mitigated, and therefore, reducing turtle mortality in bottom trawling is a priority. Third, certain TEDs exclude at least 97% of marine turtles from trawl nets. In some cases, these devices actually increase the value of the shrimp catch; and in relation to other material and operational trawling expenses, TEDs are relatively minor. Therefore, TEDs are regarded as an inexpensive means to reduce marine turtle mortality during bottom trawling (Weber *et al.*, 1995).

Other points relate to the motivations of legislators in enacting §609. Mechanized fishing activities-notably bottom trawling-have intensified world-wide, and a major incentive for this fishery is the high price obtained for shrimp and prawns. The U.S. is a major importer of shrimp and prawns; and the U.S. market drives shrimping operations in many other nations. The authors of §609 gave two reasons for drafting the law (Shaffer, 1999). It 'levels the playing field' so that U.S. shrimpers are not at unfair disadvantage due to more stringent restrictions in domestic sea turtle conservation programs, namely mandatory TED use. At the same time, it is meant to promote the conservation of marine turtles on a global basis, especially in regard to commercial trawling operations. U.S. citizens have a right to decide what products they will purchase and consume, and the U.S. government is charged with protecting the rights and representing the needs of its electorate. The government of the U.S., acting on behalf of its constituents, has a commitment to U.S. consumers to provide shrimp that have been caught in an 'environmentally friendly manner. Section 609 was enacted-in part-to reflect the environmental values of the U.S. electorate. Thus, in its origins §609 has both global conservation aims, as well as domestic political goals.

QUESTIONS AND DOUBTS

Despite these validating aspects, and affirmations about the value of mandatory TED use (Crouse, 2000), an examination of §609 raises doubts about its utility as a sea turtle 'conservation tool,' which go beyond legal considerations (World Trade Organization, 1998). The efficacy of §609 as a conservation tool - to promote TED use and reduce turtle mortality in trawls - has depended primarily on the rigor of implementation under the certification process. The most basic question that arises is: does the inspection and certification process by the U.S. government promote marine turtle conservation? Or, rephrased: what evidence is available to show that the status of marine turtle populations in shrimp exporting nations has been enhanced by implementation of §609? More specific questions include: is the certification process for §609 based solely on meeting conservation standards, or are other considerations (e.g., economic, political, or trade) also involved? It is remarkable that there have been cases when nations have lost their certification, and then in a

period of a few weeks, outside of the normal annual cycle of inspections, they have been re-certified. Did their sea turtle conservation programs improve so significantly in such a short period that certification was warranted under such an extraordinary schedule? Independent of the debate about the legality of unilateral actions (Howse, 1998; World Trade Organization, 1998) are questions of the U.S. government's ability to implement §609 requirements and the veracity and rigor of their assessment process. Do the results of brief, spot inspections of foreign shrimp fleets by U.S. officials really reflect the true level of TED use and commitments to sea turtle conservation? Do shrimpers comply with TED requirements when U.S., or even national, inspections are imminent, but behave differently when out of port, and there is no risk of an inspection?

There is also a deeper question. Is the implementation of a national TED program always a higher priority than other conservation actions, not presently recognized by the U.S. government's certification process? When exporting countries respond to the threat of embargo and need for import certification, does the concentration of professional and administrative staff time, fiscal and material resources, political energy, and other limited resources detract attention and resources from other, more pressing conservation issues for sea turtles and their habitats? It is not clear if §609 serves as an efficient conservation tool to reduce sea turtle mortality in shrimp trawls through its focusing on and promotion of TED use in shrimp exporting nations. Section 609 has resulted in legal questions and controversies, notably a dispute at the World Trade Organization (WTO) lodged by India, Malaysia, Pakistan and Thailand: Dispute no. 58 'Shrimp-Turtle' (World Trade Organization, 1998). Among the points contested was the way the U.S. implements §609 and certifies shrimp exporters. The Complainants argued that by certifying nations, rather than shipments, the U.S. transcends providing turtle-safe shrimp to U.S. consumers and is directing the policies of other sovereign states. NGOs retort that it is impractical to monitor compliance of each shrimp trawler or shipment (Kaczka, 1997), raising doubts if shrimp certified on a shipment-by-shipment basis would be caught using TEDs and not 'laundered' from sources that kill turtles during shrimping. Kaczka (1997) argued that implementation of §609 pressures other nations to fulfill their obligations under international law, citing several major treaties, but legal disputes in U.S. courts and the WTO are not yet resolved.

THE CONSEQUENCES OF SECTION 609 AS THE 'BIG STICK'

However, these doubts and shortcomings do not mean that the law is worthless as a 'conservation tool': significant policy landmarks have resulted from debates surrounding §609. These have facilitated ideological shifts regarding the conflict between trade and environment, produced important international precedents and accords, created a

political climate for bycatch reduction, and promoted an arena for the consideration of the environmental impacts of trade and fisheries policies. Notwithstanding that the first part of §609 promotes international negotiations, it is perhaps the implementation of the second-embargo-part of the law that has had the major impact on international relations, well beyond the use of TEDs. The threat of (unilateral) sanctions provides motivation for many governments that would generally not come to the table, to participate in the negotiation of conservation accords in an international arena (Charnovitz, 1994; Howse, 1998; Berger, 1999). This is exemplified by the Inter-American Convention for the Protection and Conservation of Sea Turtles (Bache, *In press a*; *In press b*; This volume).

TEDs are a relatively simple, inexpensive gear modification. Their promotion through the threat of embargo emphasizes the potential, as well as the need, for fisheries to be more selective and less destructive in their operations. This message has general implications, beyond shrimp trawling. Implementation of TED programs to protect charismatic marine turtles serves as a show case for popularizing the need for responsible fishing (Berger, 1999). The resultant high visibility afforded to TEDs and marine turtle conservation advances political awareness and contributes to the pressure to deal with bycatch issues, many of which had been neglected in the past. Although organizations such as the FAO have been involved in global studies and negotiations concerning bycatch and increased fishing selectivity, §609 helps provide a political climate to nurture and expand on these initiatives.

The WTO 'shrimp-turtle' dispute has received a remarkable amount of attention, both popular and academic (e.g., Kaczka, 1997; Howse, 1998; Berger, 1999; Crouse, 1999; Quresti, 1999; Sam, 1999; Shaffer, 1999; Simmons, 1999). Thus, by inciting an international trade dispute, §609 caused increased awareness of the need for conservation activities to protect marine turtles and their habitats, at a global level. Beyond sea turtle conservation, the WTO dispute yielded an Appellate Body (AB) Report (World Trade Organization, 1998) which, although criticized by some NGOs and academics (Sam, 1999; Simmons, 1999), overturned some of the earlier decisions of the Dispute Settlement Panel (DSP) and produced several outcomes of environmental and social significance (Berger, 1999; Quresti, 1999). Two findings of the AB are of particular, substantive importance. The first was that it is not incompatible for a DSP, or AB, to accept and consider unsolicited information submitted by a non-party to the dispute, even if they are a non-governmental organization. This provides a mechanism to enhance transparency and widen representation, allowing for the submission and consideration of third party briefs. The WTO has been repeatedly, and severely, criticized for elitist decision making, with a lack of transparency (Howse, 1998; Simmons, 1999). Providing for third party participation helps to open the WTO to greater accountability and public representation, although there are still concerns about legal

and procedural implications of the AB's finding (Quresti, 1999; Shaffer, 1999; Simmons, 1999). During the shrimp-turtle dispute fundamental questions were asked as to if a government had the right to claim exceptions to normal free trade rules in order to protect endangered species. In overturning another of the DSP's decisions, the AB established a new precedent for interpreting 'exhaustible resources' such that endangered species can be covered in exceptions to trade rules under Article XX(g) of the General Agreement of Tariffs and Trade (GATT) [World Trade Organization, 1998 (para. 134)]. This is a particularly significant clarification given an earlier decision handed down under the GATT panel system whereby the bycatch of dolphins was found not to fall under Article XX(g) exemption provisions (General Agreement of Tariffs and Trade, 1991; Kaczka, 1997). In the terms of the WTO, it means that endangered species-marine turtles in this case have been considered 'exhaustible resources,' an interpretation hailed as 'an environmental breakthrough' (Berger, 1999). Legal implications of the AB's second finding are enormous: it allows for trade regulation based on the way in which products are produced. Former interpretations only permitted commodities to be exempted from normal trade rules on the basis of product characteristics, not considering methods of production. Because production process, as well as the product itself, are both germane to environmental concerns, the AB's interpretation provides a precedent for governments to give protection to environmental (and social) matters, above trade pressures (Berger, 1999).

CONCLUSIONS

Unilateral embargoes can be fundamental for motivating conservation-based negotiations and political actions (Charnovitz, 1994; Berger, 1999; Simmons, 1999). However, it is widely acknowledged that the most effective mechanisms are multilateral environmental agreements, (or 'MEAs'), arrived at through negotiations (Howse, 1998; World Trade Organization, 1998; Quresti, 1999; Shaffer, 1999). A prime example of this is the Inter-American Convention for the Protection and Conservation of Sea Turtles (Bache, *In press a*; *In press b*; This volume; Frazier *In press*).

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A View of the Inter American Convention for the Protection and Conservation of Sea Turtles from Down Under

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INTRODUCTION

Sea turtles are highly migratory species, traveling through a number of nations and the high seas in their lifetimes. Hence initiatives to conserve sea turtles must be

multi-lateral: that is, if sea turtles are subject to by-catch or direct harvest, or are disadvantaged due to habitat destruction or environmental perturbations in one nations, this affects the same sea turtle populations in other countries. The need for international cooperation for sea

turtle conservation and management is not only for the benefit of sea turtles however. In order to ensure equity between range States, all nations through whose territories sea turtles travel must make a commitment to their conservation. Otherwise actions in one nation will detract from gains made by those people in another country who are endeavouring to minimise human impacts upon sea turtles.

The Inter American Convention for the Protection and Conservation of Sea Turtles (IAC), covering the western hemisphere, is the only international treaty specific to sea turtles. It is a positive and significant step towards improved sea turtle management and conservation in the region, and perhaps globally. The mounting body of literature on the IAC has to date been provided almost exclusively not only by nationals of countries involved in the agreement, but by individuals who were active participants themselves (Donnelly, 1996; Frazier, 1997 and 1999; Gibbons-Fly, In press). That the IAC has been proposed as a potential regime that could be used to model a future accord for the Indian Ocean region (McNee, In press) presents the need for an external and independent examination of the IAC. This paper examines both the positive elements of this arrangement warrant replication, and those aspects that could be improved upon in future arrangements.

Summary of the IAC-A Brief History and Evaluation

The IAC has the stated objective to promote the protection, conservation and recovery of sea turtle populations and of the habitats on which they depend, based on the best available scientific evidence, taking into account the environmental, socio-economic and cultural characteristics of the Parties' (Article II). It applies to the land of each party; maritime areas where parties exercise jurisdiction over living marine resources; and their flag vessels on the high seas. Hence the only situations not covered are those of activities in the waters of non-signatory nations or by vessels of their flag on the high seas. In this regard is worthwhile noting that geographic restrictions limit membership to the IAC to 'States in the Americas', these being countries located in North, Central and South America and the Caribbean Sea, as well as other States that have continental or insular territories in this region.

The convention was negotiated between late 1994 and 1996, though informal discussion had commenced prior to this. It closed for signature on 31 December 1998 with 12 nations having signed. The IAC requires eight ratifications before becoming active. To date, the IAC has been received three confirmed ratifications (Brazil, Peru and Venezuela) and several other countries' ratifications are shortly expected to be formalised, including Costa Rica, Honduras, Mexico and Uruguay. The treaty is also on the schedule of the U.S. Senate Foreign Relations Committee. It is, therefore, reasonable to expect that the IAC will receive sufficient support to activate it, hopefully within the next twelve months.

Notwithstanding the current positive outlook, the path

of the IAC has been by no means a smooth one. The IAC's genesis was in response to a regionally unpopular U.S. law known colloquially as section 609 (Frazier and Bache, This volume). This required that only shrimp certified as having been caught in nations with sea turtle conservation measures equivalent to those in the U.S. could import their shrimp produce into the United States. Even within the U.S., this law was not universally applauded. Indeed, the IAC emerged in part due to the U.S. Department of State's dislike of the role they had been assigned as regional police. Hence membership to the IAC was intended to act as meeting all of §609's requirements, and participation in the treaty was to act as an instant qualification for §609 certification. No U.S. regulations to this effect have even been promulgated, though the IAC, in its original form, was heavily focused upon ensuring the use of TEDs in shrimp trawling operations in the Western Hemisphere region.

The Convention text went through four official and numerous additional negotiating sessions. Though there was initially a lack of support or interest from the majority of NGOs and the scientific community, by the third negotiating session the potential of the IAC in furthering sea turtle conservation had been realised. Both the Latin American Reunion and the annual Sea Turtle Symposium began to take an active interest in the development of this arrangement, passing supportive resolutions on the IAC at each of the last four gatherings and at this, the 20th Symposium in Orlando. The result is an arrangement that has evolved considerably beyond its narrow TED origins, to now offer a more comprehensive sea turtle protection and management instrument.

The merits of the IAC are many. These include: acknowledgment of cultural, environmental and socio-political differences between nations; support for environmental education; and consideration of broader sea turtle issues such as subsistence harvest and habitat conservation. There is also an express role provided for science in the Convention, involving the creation of a Scientific Committee and the promotion of research. The arrangement also encourages other cooperative management initiatives-witness the tripartite agreement between Costa Rica, Panama and Nicaragua. Though not all three nations have yet committed to this arrangement, it includes issues such as the creation of a regional management plan, encouragement of technology transfer, and the protection of nesting beaches and essential habitat. Problems and omissions also exist however, stemming from both the IAC's origin as a 'TEDs treaty' and from intrinsic difficulties associated with international and multilateral arrangements. For example, though broadly mentioning the impact of the range of fishing methods upon sea turtles, only TEDs and trawling bycatch are given explicit attention. Other fishing methods which adversely impact upon sea turtles include purseseining (Hall, 1996), gillnetting (Silvani, 1999) and perhaps most significantly longlining (Crouse, 1999; Witzell, 1999). Raised previously by Frazier (1999) are uncertainties related to the logistical and

administrative arrangements of the treaty. These include deliberations on the creation of a Secretariat, and the potential roles of the Scientific and Consultative Committees. More generally, the funding and functioning of these bodies remains undetermined. Though not a weakness *per se*, the structure of the Scientific Committee is not defined—its funding sources remain unclear, as do questions of access to data with respect to the power and scope available to the Committee to mount investigations. Though it will be useful to have the full participation of all ratifying and acceding nations involved in the decision-making process with respect to these issues, any failure to give these questions the serious consideration they warrant, or actions to undermine the creation of a strong and functional structure, would significantly detract from the IAC's potential.

And finally, and perhaps most worrisome, is that the IAC lacks any mechanisms for enforcement or penalty for violation (Bache, In press a).

LESSONS AND MODELS FOR INTERNATIONAL SEA TURTLE CONSERVATION

Notwithstanding these problems, the IAC is flexible enough that they need not develop into major impairments to the initiative's success or to coordinated regional sea turtle protection. Potential remedies to some of these problems, with mind to lessons for other regions, are considered below.

The structure of the IAC is a basic text with annexes for detailed issues. This structure was intended to allow for procedurally easier amendment of technical issues such as TEDs (Donnelly, 1996). In regard to the need to allow for the addition of explicit controls over other fishing methods, this structure provides an avenue through the creation of additional annexes whereby other issues, to date afforded scant attention, may receive more detailed consideration and regulation. This would be facilitated through the introduction and acceptance of additional annexes on—for example—sea turtle longline bycatch, at a regular meeting of the parties. Of course this does not consider the question of whether the IAC itself is the most appropriate means of regulating longline fishing, which is a global concern and often a distant water activity. An alternative to the IAC and perhaps more appropriate forum is that of the FAO, which has already created an International Plan of Action for the take of seabirds in longline operations under the auspices of the Code of Conduct for Responsible Fisheries, a model which could readily apply to sea turtle take.

In a similar way the concerns over the Scientific Committee and the Secretariat could also be redressed through the creation of an annex containing the requisite specifications. The actual structure that these will take however also warrant some discussion, and it would be useful in this regard to be informed by other existing arrangements. Gibbons-Fly (In press) notes the similarity

between the Consultative Committee and the 'International Review Panel' model of the Inter American Tropical Tuna Commission (IATTC), the body which is responsible for the setting of dolphin bycatch quotas and monitoring of adherence thereto in the international Eastern Tropical Pacific yellowfin tuna purse-seine fishery. Although the situations differ significantly, the IATTC scheme provides a valuable model in its inclusion of NGOs as observers, allocation of individual vessel mortality limits with a subsequent prohibition on fishing in ways likely to result in bycatch once this limit has been met, and the encouragement of competition between crews in reducing bycatch through the anonymous ranking of vessels based on their bycatch minimisation performance.

The problem of encouraging compliance and enforcement in the IAC could also benefit from examples provided by other instruments. While the IAC remains focused on TED use enforcement is of reduced concern, as §609 embargo provisions act as *de facto* enforcement measures (Bache, In press a). However, with regard to other sources of fisheries bycatch, new mechanisms will be needed. Indeed the issue of enforcement remains the greatest problem that international, and in particular environmental, treaties face (Boyle, 1991).

There exist a limited number of means by which nations can affect the policies and actions of other countries. In both regional fisheries management organisations (RFMOs) and multilateral environmental agreements (MEAs) the use of a hitherto rarely seen mechanism for encouraging participation and compliance has emerged, and is growing in currency. This is the use of multilateral embargo and port access measures. Existing bodies including the International Commission for the Conservation of Atlantic Tunas (ICCAT), Northwest Fisheries Management Organisation (NFMO) and Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) have created provisions whereby nations that do not comply with the conservation measures decided by these organisations, may have their related products embargoed by all member parties to that treaty. This has resulted under ICCAT in the embargoing of Equatorial Guinea (an ICCAT member-nation) for non-compliance relating to the conservation program for bluefin tuna, and the placement of swordfish embargos on Honduras and Belize (non-member countries) for fishing practices that hinder the effectiveness of ICCAT swordfish conservation measures. In addition, a commitment has been made by a major firm, Mitsubishi Corporation, not to purchase fish caught by flag of convenience vessels in the ICCAT region.

Perhaps the CCAMLR scheme is even more relevant, because the embargo provision contained therein was motivated by both concerns over the longline bycatch of albatross in the Southern Ocean region, as well as uncertainty over the sustainability of Patagonian toothfish harvests by flag of convenience vessels. There have been questions raised in the context of the World Trade Organization (WTO) system as to the compatibility of

MEA and RFMO trade measures with the General Agreement on Tariffs and Trade (GATT) and technical barriers to trade provisions (Brack, 1999). Opinion on this matter is polarised, and as a case of this nature has never been brought before the WTO it is impossible to know the likely outcome of any arbitration. One view holds that the WTO was not intended to supercede existing regional negotiated arrangements and hence the issue of WTO compliance is not of relevance. The alternate view suggests that should an embargoed nation choose to take action before a WTO dispute settlement panel, then the WTO would be justified in ruling on the complementarity of an alternate multi-lateral scheme, especially if the scheme has been applied against a non-member nation to the MEA or RFMO in question. At this point in time however, multi-lateral embargo and access arrangements offer one of the most plausible means by which to encourage nations to participate in and comply with international conservation and management measures and accords.

Finally, and also in regard to enforcement, an alternative approach available is that of eco-labeling. In theory, such programs allow for what economists describe as bringing an externality into the internal cost of the product. That is to say, a new conservation measure is often viewed by producers as an additional and sometimes unnecessary cost to their basic operation. Through the provision of labels, stating that particular products meet certain environmental standards, eco-friendly products receive kudos in the market. These kudos translate to higher prices for the products. And in this way, the increased income then pays for the conservation measure; thus internalising the cost of conservation. As a consequence, the use of TEDs on shrimp trawlers would be viewed not as a burden imposed on fishers, but more simply as just another part of the fishing operations (Bache, In press b). Moreover, the cost of ensuring that shrimp are harvested with minimum turtle mortalities, would be added into the consumer's cost of purchasing the product.

In a recent paper Frazier (In press) holds that well-conceived and constructed multi-lateral sea turtle conservation measures would be 'multi-national, negotiated accords on which actions of common interest are decided by consensus; the best possible information together with the most effective decision-making and evaluation process must be fully incorporated. Finally, there must be mechanisms for motivating compliance of each party with mutual accords, and holding offenders accountable.' The IAC meets many of these requirements, and omissions can by and large be remedied. Negotiators from other geographic regions may be confident of a successful regime should they choose to model a future accord on the IAC; though by taking into consideration some of the criticisms and suggestions outlined above, a more comprehensive and enforceable arrangement for sea turtle conservation in regions outside the Western Hemisphere may be achieved.

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Strengthening of Sea Turtle Conservation Legislation in Costa Rica

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Laws protecting green turtles (*Chelonia mydas*) on Tortuguero beach, Costa Rica, were first passed in 1963. In 1969, protection was extended to encompass waters up to five kilometers off the nesting beach. Tortuguero National Park was created in 1970 and expanded in 1975, increasing protection for the sea turtles, the nesting beach, the adjacent rainforest, and the marine area up to 12 mi offshore. Nevertheless, the tradition of turtle hunting continued in the region. In 1983, a decree was passed to control the fishery of green turtles in Costa Rica's Caribbean waters. Annually 30 permits were issued, each allowing capture of 20 green turtles per month from June through August, for a total legal take of 1,800 green turtles. The quota was not enforced, no studies were ever conducted to monitor the impact of the take, and poaching of green turtles out of Tortuguero National Park increased in the mid-1990s. The existence of a legal market meant that turtles caught illegally could also be sold openly. To

address this situation, 13 organizations, businesses and individuals with interest in the Tortuguero turtles brought a lawsuit to stop the legal fishery. Subsequently, in February 1999, the Constitutional Court of Costa Rica revoked the decree and banned the turtle fishery. A new law, strengthening sea turtle protection nationally, was approved by a legislative sub-commission on the environment, and should become law in 2000.

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Moving Towards Regional Cooperation for Sea Turtle Conservation in West Africa

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The Atlantic coast of Africa covers almost 14,000 km from the straits of Gibraltar to the Cape of Good Hope in South Africa. Our knowledge of sea turtles along this coast has been often superficial and incomplete. However, in the last few years there have been increasing efforts to document the status of sea turtles in this region, and to increase regional cooperation for sea turtle conservation in West Africa. A first step towards regional cooperation was taken in December 1997 in Gabon at the initiative of ECOFAC (Conservation and Rational Utilization of Forests in Central Africa) when five central African countries, Cameroon, Sao Tome and Principe, Equatorial Guinea, Gabon and the Democratic Republic of Congo came together to discuss sea turtle issues. This resulted in the 'Ekwata Resolution' and the creation of projects under

the name of PROTOMAC (Program for Sea turtles in Central Africa). Since October 1999, a scientist, Alexis Billes, has been appointed as the coordinator of PROTOMAC projects. He is posted in Gabon for two years. In 1998 all available information on sea turtles in West Africa was compiled with help from the Bonn Convention on Migratory Species (CMS) (Fretey, 1998). The CMS will publish an updated version of this document in 2000. In 1999, at the initiative of the CMS, an international conference was organized for the conservation of sea turtles in West Africa in Abidjan, Ivory coast, from 25-29 May, with help from the French government, the Ministry of Environment of the Ivory Coast, IUCN, and WWF West Africa. The conference brought together 18 countries: Azores, Benin, Cape Verde, Cameroon, Congo,

Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, Ivory Coast, Mauritania, Namibia, Nigeria, Sao Tome and Principe, Senegal, and Togo. During the course of this meeting representatives of each country presented a report on the situation of sea turtles in their country. Then as a group they highlighted the important issues for sea turtle conservation in this region and developed a Conservation Plan. These issues were: (1) community participation/awareness, education, training, NGO involvement; (2) threat reduction and conservation strategies (other than the ones stated in point 1); (3) collection and dissemination of data; (4) legislation/national policies/enforcement of laws; and (5) funding sources.

A Memorandum of Understanding was also discussed and then offered to be signed by representatives of the different countries on behalf of their governments. The objectives of this memorandum are in summary: to conserve and protect sea turtles at all stages of their life history, where necessary and appropriate; to harmonize national legislation with international conventions such as CITES and CMS; to implement in each country the provisions of the Conservation Plan developed at this meeting, based on the availability of resources; to facilitate exchange of information to coordinate conservation measures in the region; to designate a national correspondent who will serve as focal point for the parties; and to provide CMS a progress report annually on implementation of this memorandum in each country. 'Memorandum of Abidjan' has been signed by 12 delegates in the name of the governments they represent. The memorandum is open indefinitely for signatures from the other countries.

Since this meeting, in an effort to consolidate sea turtle

work and cooperation in the region a 'Kudu Letter' was formed in four languages: French, English, Spanish and Portuguese. The aim of this letter is to keep everyone informed of the ongoing efforts in each country and of the successes and failures of each project. The letter also aims to create a network of field workers, scientists, heads of projects, administrators of the pertinent ministries, staff of NGOs, and potential sponsors.

Although a proper structure remains to be created for regional cooperation, some of the countries have been hard at work in their conservation efforts. Groups and individuals are showing greater interest and are carrying out surveys, monitoring populations, and developing awareness programs. Yet, in a dozen countries there are still no projects on sea turtles. With help from France, a funding proposal is being put together to assist some of the disadvantaged countries and certain priority countries, and to design and make a budget for a National Action Plan, with the hope of submitting an overall funding application to the Global Environment Fund (GEF).

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Conservational Perspectives, Problems and Priorities of Indian Marine Turtles

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The turtles in general are obliged to terrestrial habitat as their place of birth and origin. They again emerge out of their aquatic abode at sexual maturity for laying their cleidic eggs almost in the same terrestrial habitat. For the last few decades, their survival is extremely under anthropogenic pressure in spite of existing Wildlife Protection Acts and Rules. Helpless turtles have been pushed in perils. Conservation scenario of worldwide sea turtles in general and Indian sea turtles in particular is full of frustration, despair and intense anger. Out of seven worldwide species of sea turtles, five species are found in the Indian maritime. Sea turtles have never posed any threat to mankind but in turn they have been threatened in so many ways by human induced activities. Indians, by and large, have been appreciably ethical and aesthical towards all types of marine biodiversity. In the present paper, the conservational perspectives have been viewed regarding the sea turtles as better friends to humans rather than their foes. Besides national efforts, the valuable supports have been received from the international community of turtle's biologists in generating the pressure and also steering the States and Central Government of India declaring Bhitarknika Wildlife Sanctuary in 1975 and Gahirmatha-Orissa a marine sanctuary on 27 September, 1997. Likewise, once again international support is needed in tackling the different problems associated with the conservation and management of Indian sea turtles which has received International State of Art and Issues. (Yadav, 1994, 1996, and 1998) and working out effective conservation building measures (CBMs).

In the present paper, focus has been made towards the multifaceted problems related to anthropogenic activities, habitat degradation and disturbances, illuminations, mortality, predation, over-exploitation, domestic and international trade, Use of TEDS, patrolling, effective enforcement of existing rules and regulations, awareness and education services among the benefitted people and fishermen along the coastal regions of Indian Union. These aspects have been critically evaluated in the light of needs and achievements. Drastic measures to control the present decline of turtle population to erstwhile abundance have been suggested. Potentially important and essentially involvement of coastal people specially fishermen, their children, students of schools, colleges, universities, NGOS, press, media, radio, TV, have been duly emphasized, feasibility of organizing seminars, symposia, workshops, Nature Laboratories, training and follow-up action plans have been evaluated for effectively result oriented conservation building measures (CBMs). Seeking technical, financial, expertise, technology transfer from quarter of international scientific community and organization as

allowable by law should not be neglected, keeping in mind that the Indian sea turtles conservation and management problems are with hurdles with limited resources and remedial options. Marine resources should not be out of scene in the famine of financial and moral support. It should be revived and restored in the best interest of our generations to come. Since the marine turtles resources are shared by international communities. Therefore, involvement of international turtles biologists in reviving population to healthy status is essential, a must, justified and genuine.

As the marine turtles recognize no boundary as migratory species in benefitting the people and involvement, likewise the scientific community throughout the world should not be limited in supporting and raising conservation building measures (CBMs). National as well as international community has great responsibility to ensure sea turtles continued existence and sensible use. The following different measures should be undertaken to control and reverse the marine turtles population decline:

- Convergence of sea turtles feeding and breeding grounds into settlements needed to be controlled.
- Exploitation of turtles and their products have to be legally checked.
- Understanding the turtles biology and protection of fragile ecosystem of coastal zones extending throughout the Indian territory should be developed.
- Development of nationwide monitoring system for marine turtle resources.
- Habitat degradation, sea walls construction, dredging of canals, estuaries and aqua-culture operations should be properly assessed.
- Controlling the light glow, illumination, heated water and industrial wastes release towards the beaches has to be assessed.
- Establishment of marine turtle sanctuaries.
- Patrolling the nesting beaches for avoiding poaching, predation and *in situ* incubation.
- Construction of roads, bridges, fishing, jetties and beach erosion should be urgently assessed.
- Proper attention should be given to transit of vehicles and other sound producing equipment's and it needs to be monitored.
- Feasible methodologies have to be adopted for avoiding high rate of maturity caused by fish trawling, incidental by-catch and stranding of turtles on the beaches.
- Effective enforcement of existing rules regulations for checking the over-exploitation, intentional illegal capture, retention or killing of turtles domestic and international trade for their eggs, meat, skin, bone and other products.

- Sea turtle selling markets of Calcutta, Howrah, Tatanagar and Midnapore need close watch by the Ministry of Environment and Forests.
- Mandatory use of TEDs or TSDs.
- Control over illegal inshore and offshore fishing.
- Development of regional program, institution build-ings, networking of specialist group for framing policies, information, education, conservation awareness, publicity and up-gradation of capabilities of involved staff.
- Involvement of governmental and non-governmental organization (GO and NGOs), fisherman, college and university students etc., academic and research institutions for better and effective conservation and management of marine turtles in India.
- Conservation management training, research and monitoring of conservation building measures (CBMs).
- Involvement of local coastal people and fishermen with their children by recruiting them as volunteers and target groups during Arribadas because they are maximum users of marine turtles resources.

- Publicizing the urgent need of protection and conservation of turtles, nests and their hatchling through news papers, radio, TV and other media in local languages.
- Organizing seminars, symposia, courses for aware-ness, walks and rallies for better awareness in the coastal areas especially during nesting seasons.
- Seeking the expert opinions, fund and support from the international community and biologists like IUCN, MSTG, CCC, FAS etc.
- Feasibility for training and refresher course for educators, managers, technicians, advisors should be assessed.
- Development of policies for Eco-tourism during nesting, closed and open seasons.
- Development of a integrated time bound program such as of five years should be worked out for effective conservation of marine turtles of India.
- Taking of business, political and official circles into confidence in favor of result oriented conservation building measures and strategies development.

Captive Breeding of Olive Ridley Turtle Hatchlings *Lepidochelys olivacea* (Eschscholtz) for Conservation Purposes

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INTRODUCTION

Among the seven species of sea turtles, olive ridleys, *Lepidochelys olivacea* (Eschscholtz), are the most common in Indian Ocean and the same time worst victims of human depredation (Bustard, 1976; Frazier, 1980).

The present study is about the captive breeding of olive ridley sea turtles in Northern Andhra Pradesh coastline (NAP) for conservation purposes.

The State of Andhra Pradesh in India has a coastline of 980 km extending from Kalingapatnam (18°19'N; 14°17'E) in the north to Krishnapatnam (14°17'N; 80°07'E) in the south along the central-east coast of India.

STUDY AREA

Northern Andhra Pradesh coastline (NAP) of 286 km runs through Srikakulam, Vizianagaram, Visakhapatnam and East Godavari districts of Andhra Pradesh located between 16°50' and 18°25' latitudes and 82°10' and 84°10' longitudes (Fig. 1). The coastline between Kalingapatnam in the north and Hope Island in the south has been selected for the present investigation (Fig. 1). This shoreline has diversified geographical conditions ranging from rocky to shallow, sandy shores with several extensions of hills projecting into the sea. Seven rivers with their major tributaries have their estuaries in this area and a number of creeks back

waters and streams also merge into the sea (Subba Rao, 1997).

The area comprises a total of 53 villages, farming into seven zones most of which belongs to fishermen population is about 63,000. A total of 350 fishing trawls, large number of mechanised boats and catamarans operating along this coastline. Visakhapatnam has a major port and also the Headquarters of the Eastern Naval Command of India.

METHODS

The captive breeding programmes involve three main phases namely collection of the eggs of sea turtles; their transportation to the hatcheries; and maintenance of sea turtle hatchlings until one year when they will be in a position to protect themselves for conservation purposes.

First the sea turtle nests were identified with the help of crawl tracks and carefully opened by hand until the top layer of eggs were exposed. Well ventilated wooden boxes were used to carry the eggs. While carrying the eggs in wooden boxes, nest sand was used to cover the intermediary spaces between the eggs and the egg layers. The eggs were arranged in the boxes without changing their axial orientation. Then the eggs were transported by road to the Central Hatchery (Visakhapatnam) as quickly as possible within 12 hour.

As the eggs were brought to the Central Hatchery, they

were placed in sterile petridishes in between moistened cotton layers. Then the petridishes were arranged in the BOD incubator (Fig. 2).

Incubators with the required temperatures (27° to 30° ± 1°C) were maintained. Some nests were hatched in natural conditions (*in situ*) under wire mesh protection. Hatching experiments were conducted both *in situ* and in laboratory conditions (*ex situ*).

Hence, a narrow range of temperature (i.e., 27°C to 32°C ± 1°C) was maintained constantly in our experiments. In artificial hatching, temperature maintenance and moistening of the cotton layers are the essential precautions.

RESULTS AND DISCUSSION

Breeding Ecology

During the breeding season of olive ridleys, a systematic survey was made along the entire coastline of Northern Andhra Pradesh of each zone and data pertaining to the sea turtles based on personal observations were recorded. The olive ridley sea turtles are oviparous animals and nest by annually during winter (December, January and February) and summer (March, April and May) months of this region.

Nesting

Olive ridley sea turtles lay their eggs on the sandy beaches, 50 to 100 m away from the shore line, in the nest pits dug by themselves. Nest and nesting habitat of the olive ridleys was recorded by examining the shore line at regular intervals, during nights with the assistance of a few fishermen tribes. A total of 124 nests of olive ridleys were located during the study period (Table 1).

Nest and Clutch Size

The depth of the nest of the olive ridleys ranged from 40 to 90 cm while the maximum number of nests have a depth ranging between 50 and 60 cm. The clutch size of the olive ridleys has a range of 80 to 145 eggs. The monthly means of clutch size varied slightly. However, the range was long during the latter part of the nesting season. Eggs were arranged in 3 to 4 hour.

Eggs

The identified nests were opened and the nest location, clutch size, egg morphology, size and weight of the eggs were noted (Table 1 in Subba Rao and Raja Sekhar, 1998). The eggs of the Olive ridley sea turtles were white in colour and round in shape with a diameter ranging from 37 to 46 cm and weight ranging from 22.4 to 37 g. The shell was porous, delicate and slightly flexible.

Captive Propagation

Incubation temperature played a crucial role in determining the sex of the sea turtle hatchlings, under

natural conditions (*in situ*) fluctuation of temperatures below 27°C or above 32°C do cause harm to the embryo but will prove lethal if the temperatures are maintained constantly above 32°C and below 27°C in artificial incubations.

Artificial Hatching

A total of 626 in seven clutches of sea turtles were hatched out of 891 eggs laid under laboratory conditions. These clutches two belonged to 1994-95 and remaining five clutches were or 1995 - 96 (Subba Rao and Raja Sekhar, 1998). Altogether a total of 764 eggs were incubated under artificial conditions. On the whole, 626 fertile eggs of 764 eggs from seven clutches have been successfully hatched (81.94%) under complete captive conditions. The hatching period varied from 56 to 62 days. The overall hatching success was 81.94% (Fig. 3) (Table 2 in Subba Rao and Raja Sekhar, 1998).

Eggs During Incubation

During the period of incubation, the eggs of olive ridleys had showed several variations in size, weight and colour etc. These variations were recorded in the hatchling experiments under laboratory incubation regularly. The eggs increased gradually for the first two weeks in size and weight. The total increase in weight during the incubation period, was 2.1 g.

Hatchlings

Immediately after emergence from the eggs, the hatchlings were dark black in color and weighed between 15 and 18 g and had a size of range 36-41 mm in carapace length and 34-40 mm of carapace width (Table 3 in Subba Rao and Raja Sekhar, 1998).

Captive Rearing

Out of 626, a total of 579 hatchlings of the olive ridleys hatched from *ex situ* were reared in captive conditions breeding for one year. The hatchlings were reared in artificial tanks of different sizes, some independently, some in pairs and some in groups depending upon the size of the tank, usually 50 x 100 cm.

Food and Feeding

In captivity, different varieties of food items were offered considering their size, age and response of the hatchlings. The newly born hatchlings of olive ridleys did not feed on any of the food items provided until they were 5 to 6 days old and later they were fed on marine algae, Gracillaria species. On the whole, food types such as marine algae, polychaetes, crustaceans, molluscs and marine fish were offered to the hatchlings during captive rearing (Table 4 in Subba Rao and Raja Sekhar, 1998).

During the first two months, the hatchlings were fed mainly on marine algae and molluscans. They rarely attempted on other varieties of which, artificial food types such as boiled eggs and meat pieces had consumed. From

the fifth month onwards, feeding on marine algae loss decreased gradually and marine fish was increased. However, feeding on molluscan varieties ranked high throughout the rearing experiments. Preference of various types of food by olive ridley hatchlings were shown in Table 4 in Subba Rao and Raja Sekhar, 1998. The food consumed by an individual hatchling increased from 19.5 g. On the seventh day was 0.75 g to 103 g at the end of one year when the body weight of the hatchling was 712.5 g.

Growth

Growth of the hatchlings of sea turtles was studied for 12 months under captive conditions, in terms of size (carapace length), weight of the body before feeding. At the end of one year, the hatchlings had an average increase of 712.5 g in weight, 145.5 mm in carapace length and 142 mm in carapace width. As the hatchlings grew, several changes were occurred in their physical appearance, markings on the soft parts and structure of the carapace. The plastron and the carapace was toughened, with prominent edge formed into angular projections. Growth of the second claw was observed on the flippers from the fifth month onwards. After one year growth the hatchlings were released into the Bay of Bengal.

ACKNOWLEDGMENTS

My sincere thanks are due to the Secretary, University Grants Commission, New Delhi for financial assistance to

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Table 1. Monthly distribution of identified nests of olive ridley sea turtles during 1993-96.

Month	1993-94		1994-95		1995-96		Total	
	N	%	N	%	N	%	N	%
December	2	9.1	2	5.6	6	9.1	10	8.06
January	4	18.2	6	16.7	7	10.6	17	13.71
February	14	63.6	18	50.0	28	42.4	60	48.39
March	2	9.1	10	27.7	25	37.9	37	29.84
Total	22		36		66		124	

Fig. 1. Study area of Northern Andhra Pradesh coastline for olive ridley sea turtle conservation and management.

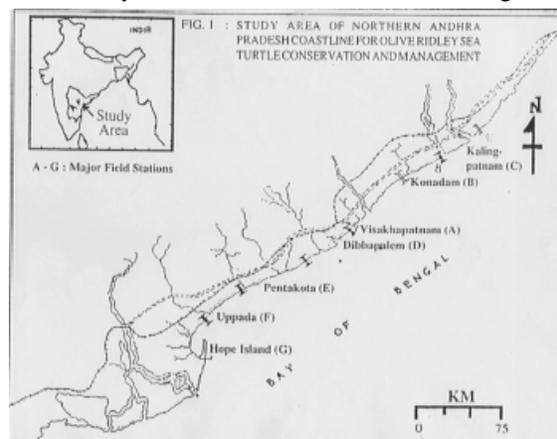


Fig. 2. Eggs of olive ridley turtles were arranged in petri dishes in between moistened cotton layers for artificial incubation.

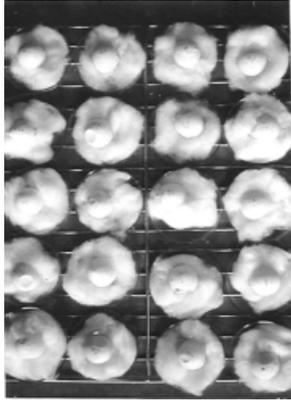


Fig. 3. Sequence of hatching of olive ridley sea turtle for *ex situ* conservation.



The Raine Island Green Turtle Rookery: Y2K Update

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Raine Island in the northern Great Barrier Reef (GBR) of Queensland, Australia, supports the largest remaining nesting concentration of green turtles, *Chelonia mydas*. In high density nesting seasons, an excess of 10,000 females may be ashore simultaneously for nesting within a single night on this 1.8 km circumference coral island (Limpus *et al.*, 1993). No total tagging census across an entire season has been conducted for this rookery or at the adjacent smaller island, Moulter Cay, which supports a similar density of nesting. On average, tens of thousands of green turtles are estimated to breed annually on these two islands. Several thousand additional green turtles nest annually on other islands of the northern GBR and Torres Strait, including Bramble Cay, Murray Islands, Milman Island and No.7 and No.8 Sandbanks. Norman *et al.* (1994) determined that the green turtle nesting populations of the northern GBR and Torres Strait constitute a single discrete stock that is genetically separate from the stocks that breed in the southern GBR and Gulf of Carpentaria (GoC) (Fig. 1).

These northern GBR rookeries support breeding females that migrate from feeding areas with mixed stocks throughout eastern Indonesia, southern and eastern Papua New Guinea, Vanuatu, New Caledonia and northern Australia (Fig. 2). This same region supports the world's largest harvest of green turtles with many tens of thousands (possibly >100,000) of green turtles harvested annually (Limpus, 1997). In Torres Strait and southern Papua New Guinea, the harvest is largely of big females with >90% of the harvested turtles originating from the northern Great Barrier Reef stock. Small numbers of nesting females and eggs are harvested at Murray Island and other northern GBR rookeries. In addition, because of the natural topography of Raine Island, from as few as tens to as many as thousands of nesting females die annually from heat exhaustion as they return to the sea.

Nesting densities at Raine Island fluctuate over three orders of magnitude between breeding seasons (Fig. 3) in response to El Nino Southern Oscillation (ENSO) climate change (Fig. 4; Limpus and Nicholls, 2000), making it difficult to determine population trends, even with 25 years of population census data.

On average, female marine turtles recruiting to breed for their first breeding season (newly recruited adults) are significantly smaller than turtles with a past breeding history (remigrants) (Limpus, 1991; Parmenter and Limpus, 1995). The mean size of females within the nesting population will be determined by the relative proportion of newly recruited adults and remigrants. Although no attempt

has been made to tag every female green turtles nesting each year at Raine Island, 1500-2000 females have been tagged in most seasons since 1976. In recent years, it has become apparent that there has been a significant downward trend the mean size of female green turtles nesting at Raine Island (Fig. 5). This is consistent with a significant reduction in the proportion of remigrant (larger) turtles in the breeding population. Similarly in recent years there has been a significant upward trend in remigration interval recorded for green turtles at Raine Island (Fig. 6). Given that remigration interval of females returning for their second breeding season is on average longer than the remigration interval of older turtles (CJL, unpubl. data), the upward trend in remigration interval for the Raine Island females (Fig. 6), in the absence of an increasing population, is also consistent with a reduction in the proportion of older remigrant turtles in the population.

For logistical reasons, very little monitoring of the hatchling production of the Raine Island nesting population has been attempted. Massed hatchling emergence at Raine Island was recorded by Ben Cropp in February 1975 in the film documentary "Islands of Tragedy". Research teams at the island during February-April in the early 1980's experienced no difficulty in encountering very large numbers of emerging clutches on a nightly basis. In recent years, the situation appears to have changed. The island has been visited on once at hatchling emergence time in recent years. Following the massed nesting of December 1996, in February 1997 it was difficult to encounter more than isolated emerging clutches in a night. On examination of eggs within the beach, it was found that a very high proportion of eggs had been killed by flooding following heavy rain and storm surge flooding associated with Cyclone Justin. Similar flooding of the nesting habitat was observed at Bramble Cay at the same time. In December 1999, while recording a record level of nesting at Raine Island, the research team encountered an extended period of record level rain at the island and the nesting habitat was again flooded as a result of the current big La Nina climate event. The water table was so elevated that turtles were observed laying eggs into egg chambers full of water. There are too few seasons of observations to draw definite conclusions at this time but if high failure of hatchling production occurs too frequently at Raine Island, the northern GBR green turtle population could be at risk. Whether the recent failures of hatchling production at Raine Island are the result of habitat change or result from climate change can not be determined from the available data.

CONCLUSION

Given the very large regional green turtle harvest biased towards large turtles and a nesting population that is not obviously increasing, these data from 25 years of monitoring of the Raine Island nesting population are consistent with a changing nesting population structure resulting from a reduction in the proportion of "older" turtles. This change in population structure is interpreted as an early warning signal that the northern GBR green turtle nesting population is in the early stages of decline.

Given the recent failures in incubation success at Raine Island and the consequential impact on future population stability, hatchling production is identified as an additional significant parameter for future monitoring for this population.

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Fig. 1. Nesting distribution of green turtles in northern and eastern Australia.

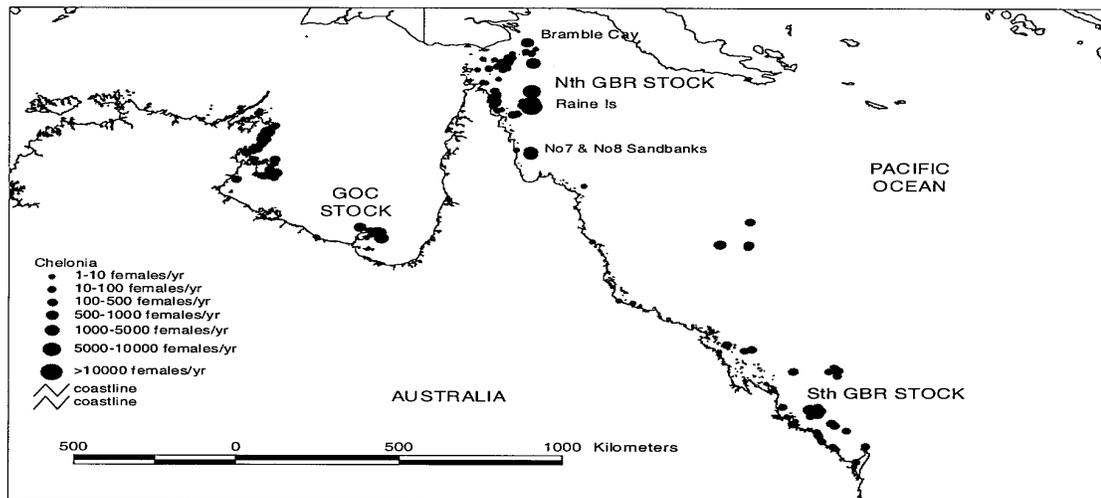


Fig. 2. Post nesting migration recaptures of green turtles tagged at nesting. Lines do not represent migratory paths but link recaptures to respective nesting beaches.

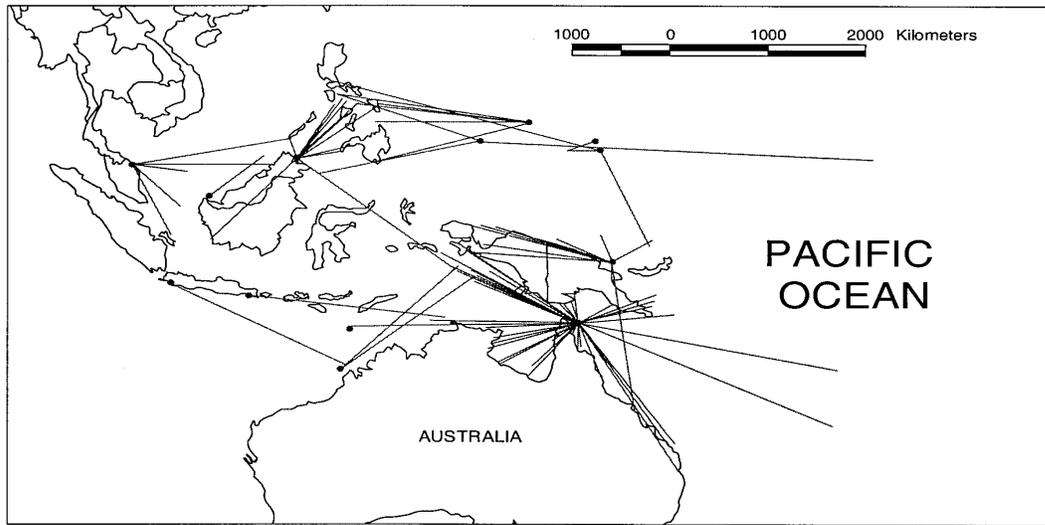


Fig. 3. Total tagging census at Heron Island and mean nightly tally count (early December) at Raine Island. The asterisk represents a maximum count if >10,000 turtles were recorded in one night.

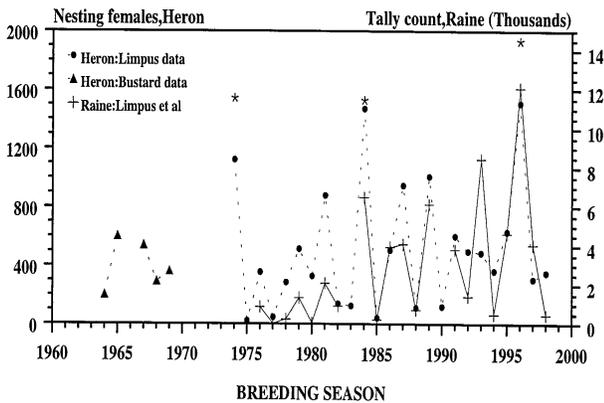


Fig. 5. The mean curved carapace length (CCL) of nesting females at northern Great Barrier Reef rookeries.

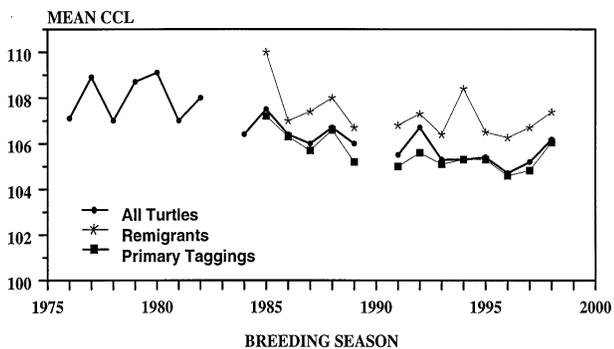


Fig. 4. Correlation of green turtle nesting census data with ENSO data illustrating the impact of climate on nesting density (after Limpus, 2000).

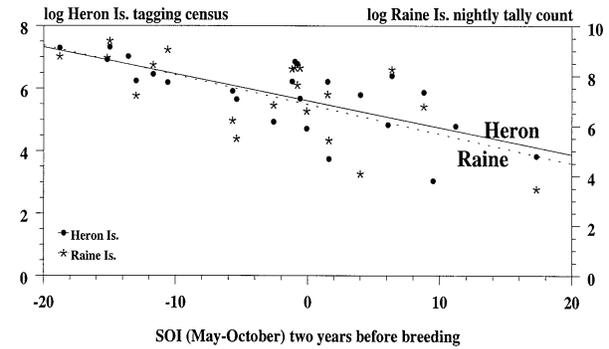
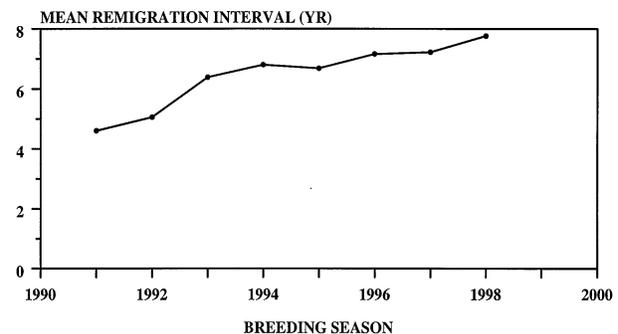


Fig. 6. The mean remigration interval by nesting season of green turtles at northern Great Barrier Reef rookeries.



An Analysis of Tagging Data on the Green Turtles of Redang Island, Malaysia

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INTRODUCTION

A long-term tagging and monitoring programme of the green turtles nesting at Chagar Hutang beach in Redang Island, Malaysia was initiated in 1993 by the Sea Turtle Research Unit (SEATRU) of University College Terengganu-UPM. Chagar Hutang beach, which is only 330 m long, is the major nesting beach on Redang Island where around 40-60 percent of the total nestings of the island occurs. The duration of monitoring was conducted through the peak nesting season for each year ranging from five to seven months. Standard metallic flipper tags were used and double tags were applied, one on each front flipper, immediately after the turtle has finished laying the eggs. Two types of tags were used, the larger 4.5 cm Titanium tags from Australia and the smaller 3 cm Inconel tags from the U.S. Other data were also collected like time for each nesting activity, curved carapace length (cm), curved carapace width (cm), nest location, number of eggs, etc. All the field data were recorded on standard nesting and tagging forms. These include retained, removed and new tags applied. Each identified turtle is given a Turtle I.D. which is retained even though the tags have changed. The data collected were transferred into a computer database for storage and analysis.

RESULTS AND DISCUSSION

The nesting green turtles measured on average 99.7 cm (curved carapace length) by 88.3 cm (curved carapace width) each producing on average 98 eggs per clutch. The nesting frequency of green turtles at Redang Island, averaged over the years since 1993, gave a modal frequency of 6-7 successful nestings per individual per season. Some individuals nested up to 10 or 11 times per season. The nesting frequency distributions were very much affected by duration of monitoring. The internesting intervals of most of our green turtles were from 9-11 days. Assessing the internesting intervals on a 10-day cycle gave us some idea of the percentage of nestings that were missed because the turtle nested somewhere else or the workers slept on the

job. We obtained 92% of the nesting recorded for the first cycle which indicated that monitoring of the tagged turtles were close to saturation. The number of turtles tagged per year ranged from 63 to 140 individuals. Over the last seven years, a total of 560 nesting green turtles have been tagged. Even after seven years of near saturation tagging on this beach, over 50% of the nesting turtles were still without tags or tag scars. Possible reasons are they nested previously on some other beaches or outside the study period hence not tagged previously; they took more than seven years before returning to nest again; tag loss error; and a high adult mortality resulting in a high percentage of new recruits.

Though a higher percentage of the turtles nest after an interval of three years, this accounted for only about 20%. Within a nesting season, the probability of tag loss is negligible for both inconel and titanium tags. Between seasons however, tag loss was high with tag loss probability for titanium tags lower (averaging at 0.2) compared to the inconel tags (averaging 0.4). In general, the growth rates of the nesting green turtles were very slow with most at less than 0.5 cm per year. Population parameters obtained from any tagging program is often underestimated sometimes severely, due to constraints of not being able to record every nesting turtle, monitor every possible nesting beach for that population or tag loss. Finding ways to correct for these are crucial especially if these parameters are to be used to fine tune population models for predicting impacts of various threats.

ACKNOWLEDGMENTS

The authors wish to acknowledge all the research assistants, volunteers and workers in the collection and entry of data. The symposium organizers and the David and Lucille Packard Foundation are also gratefully acknowledged for making our participation in this symposium possible. This research was funded by the Ministry of Science, Technology and Environment under the IRPA Grant No: 01-02-04-173.

The Status of Sea Turtle Conservation in Baja California, Mexico: from “Black Steer” to Sacred Cow

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Thirty years ago the Baja California sea turtle fisheries were near their production peak. Caldwell (1962) referred to the black turtle as the ‘black steer’ in reference to its abundance and importance as ‘the chief source of meat in that barren peninsula. Less than 20 years later regional turtle populations had been nearly extirpated resulting in drastic management efforts and ultimately a complete ban on turtle products in 1990. Our recent findings indicate that the majority of black turtles foraging in Baja California waters originate on rookeries in Michoacan, Mexico. Since the 1990 ban, black turtle populations have continued to decline. This may be partially the result of contemporary bycatch of sea turtles, direct harvest for illegal markets and

continued local use of turtle products, estimated at an annual take of more than 5,000 turtles annually. If black turtle populations are to recover, conservation and protection efforts must encompass the feeding areas as well as the rookeries. Human dimensions of turtle conservation must also be addressed, namely the strong tradition of sea turtle consumption, the political motivation to maintain the status quo and the increasing impact of artisanal and commercial fisheries. Discussions of these issues have begun at the annual meetings of the Baja California Sea Turtle Conservation Network, a grassroots organization composed of primarily fishermen and local residents

Hawksbill Turtle Reproduction at Mona Island, Puerto Rico: 1989-1999

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INTRODUCTION

Mona Island has long been recognized as an important nesting site in the Caribbean for sea turtles, in particular for the hawksbill (*Eretmochelys imbricata*). The island’s relative isolation, uninhabited status as a natural reserve and general inaccessibility has contributed to the endurance of a sizeable nesting hawksbill population. Studies to document the extent of turtle nesting activities were first carried out by Thurston in 1974 and again from 1984 to 1989 by various researchers (Richardson, 1990). Although these studies were of rather variable duration and intensity, they provide a valuable basis for comparisons with current levels of nesting activity on the island.

In 1994, the Mona Island Research Hawksbill Group initiated nesting surveys with a systematic methodology in place. The personnel brought to the island for this work were trained on Mona to be able to distinguish nesting activities resulting in nests from so-called “false crawls”. However, in 1989 and 1990, R. van Dam conducted nesting surveys using the same methodology and coverage as we are using nowadays. Therefore, comparisons of 1989 and 1990 can be used directly with surveys conducted from 1994 to 1999.

STUDY AREA

The 7.2 km of sandy beaches are located at the southeast part of Mona Island. There are approximately 23 named beaches. Beach lengths vary from less than 20 m at

the U beaches to more than 500 m at Sardinera-Mujeres Beach. Either *Suriana maritima*, *Conocarpus erectus* or *Coccoloba uvifera* generally dominates beach vegetation. The Casuarina trees reportedly introduced and planted during the 1930’s to reduce erosion at the southwestern coastal plain coincide with sea turtle nesting habitat at Sardinera, Carite, Mujeres and Carabinero beaches.

METHODS AND RESULTS

Most of the data regarding nests per individual turtles, remigration interval and re-nesting intervals were gathered during the 1984-1989. During those years, researchers concentrated efforts on night patrols to encounter nesting female turtles. Beginning in 1989 until present all, efforts focused on crawl counts. All beaches were surveyed at least twice a week for identifying nests from false crawls. Nests were marked with flagging tape, to prevent double counts and false crawls were crossed with a vertical line. At least 30% of the total nests were excavated to measure hatchling success and nest productivity.

Nesting patterns and characteristics are shown in Tables 1 and 2. Mating occurs during the months of September through November. While the nesting season occurs all year ‘round, there is a peak during the months of August through December (Fig. 1). Nest and hatchling production has increased during the past ten years (Figs. 2 and 3). During the 1999 nesting season a minimum estimated of 62,000 hatchlings were produced.

DISCUSSION

Mona Island is considered as one of the most important hawksbill nesting grounds in the Caribbean Region with more than 500 nests per season during the last two years (Meylan, 1999). Since 1989 to 1999 there have been a 62% increase in hawksbill nests at Mona Island. We attributed these increases to one or a combination of several factors: the nesting periodicity, research effort, and conservation effort. We have not detected any trends of nesting periodicity on the Mona Island hawksbill nests. The increase reported from 1990 to 1994 can be explain by a better beach coverage effort and a real increase of nests.

The conservation factor is considered the most important one. Federal and State laws have protected marine turtles in Puerto Rico since 1973. Also the implementation of CITES to control the international trade have probably contributed to this increase. Although illegal take continues and poaching of eggs too, the levels of take are much less than 1970's and 1980's. Data on satellite telemetry (Van Dam and Diez, personal observations) together with DNA studies (Bowen *et al.*, 1996; Diaz-Fernandez *et al.*, 1999) suggests that hawksbills from Mona Island migrate to other locations in the Caribbean region. Therefore, commercial or sustainable fishing in other geopolitical areas may have an impact on hawksbills nesting at Mona Island. The recent reduction on the legal Cuban harvest of 5000 animals to 500 animals by the year 1994 may be linked to the increase in Mona Island nesting numbers (Carrillo *et al.*, 1999). However, it seems that the already in existence continuous take of 500 individuals would not have a major impact on the Mona Island nesting population (Fig. 3). Hence, we are still expecting more increases on nests numbers, since nests have been protected from predation of feral pigs since 1989.

ACKNOWLEDGMENTS

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We give special recognition to Jim Richardson for his interest in the hawksbills of Mona Island since the early days. Project Support came from: Japan Bekko Association, Departamento de Recursos Naturales y Ambientales de Puerto Rico, U.S. National Marine Fisheries Service and U.S. Fish and Wildlife Service.

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Table 1. Breeding population morphometrics (straight carapace length in cm).

	N	Mean (SD)	Range
Female	47	82.8 (5.56)	70.8 - 92.3
Male	65	79.0 (4.05)	68.2 - 85.9

Table 2. Breeding female nesting parameters.

Nesting parameter	Value
Mean clutch size	140
Mean hatching success	79.2%
Meancrawl effort	1.99
¹ Nests per female	4.5
¹ Remigration interval	2-3 years
¹ Interval of days between nests	15.3

¹Data obtained from Olsen, 1985, and Richardson, 1990.

Fig. 1. Seasonal nesting distribution. Monthly mean of total annual nests at Mona Island for 1990, 1991, 1994, 1997, 1998, and 1999.

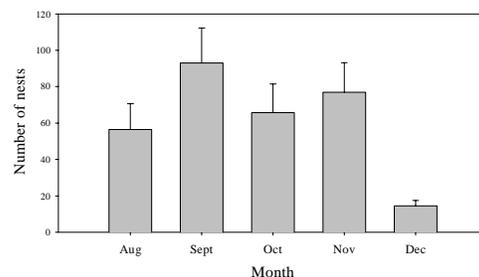


Fig. 2. Number of nests and maximum estimated number of hatchlings at Mona Island from 1990 to 1999.

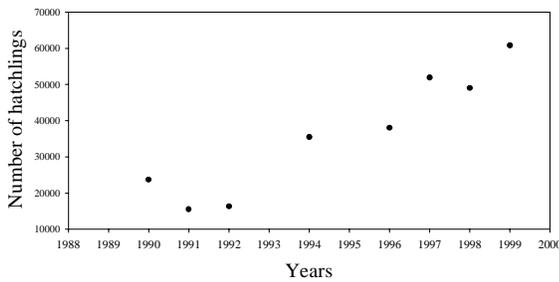
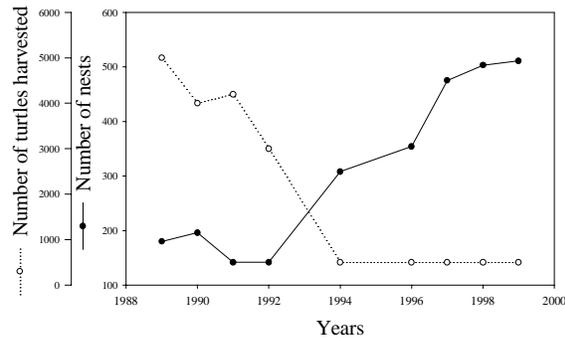


Fig. 3. Relationship between estimated annual harvest of hawksbills in Cuban waters and number of hawksbill nests at Mona Island, Puerto Rico.



The Leatherback on the Move? Promising News from Suriname

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INTRODUCTION

Biotopic is a Dutch foundation for international nature conservation. Since 1995, Biotopic has executed yearly projects on sea turtle conservation in Suriname in collaboration with STINASU, the Foundation for nature conservation in Suriname. In 1999 we saw an explosive increase of leatherback nests on a newly formed beach in Suriname, called Samsambo, formerly known as the Eilanti-spit. Nowadays more than half of the world population of leatherback females lay their eggs on the beaches of the Guyana Shield region. This region consists of Guyana, Suriname and French Guiana. Main nesting beaches are found in the estuary of the Marowijne river, the border river between Suriname and French Guiana. These beaches are situated in the Galibi Nature reserve on the Surinam side and in the Amana Reserve on the French Guianese side. Another important nesting beach is Matapica in Suriname.

BACKGROUND

Figure 1 depicts the yearly total number of nests laid in the Amana, Galibi and Matapica. Though fluctuations are large in Amana and Galibi, some trends can be distinguished. High numbers of nests were laid between the beginning of the 1980's and the beginning of the 1990's. After 1992 a decline is visible. Both reserves suffer high percentages of poached nests, sometimes up to 80% at certain beach sections. Furthermore, we suspect that commercial fishery causes high mortality numbers amongst reproducing females.

STUDY AREA

Biotopic started its activities in Suriname in 1995. Part of the program were expeditions to more remote beaches. One beach of special interest was Samsambo. This beach recently evolved in front of the Eilanti beach. Eilanti was formerly known as the main olive ridley nesting beach in the western Atlantic.

In 1995 Samsambo had a length of approximately 4.25 km. The sandbank was partially connected to the mainland with a mudflat, covered by mangrove. The beach is very dynamic. During spring tide periods almost all of the sandbank is inundated. Spring tides frequently changed the shape of it. In 1994 the sandbank had been qualified as a new potential nesting beach for sea turtles.

RESULTS

In 1995 we counted 275 leatherback nests on Samsambo (Fig. 2). Less than 5% of the nests were found poached. This low percentage shows that this nesting beach was still unknown. However no nests were observed emerging, probably due to frequent inundation during spring tide periods. A second, relatively small stretch of beach to the west, separated from the bigger part by a creek outlet, seemed to be less frequently visited and therefore was not monitored.

In 1997 Samsambo still had similar characteristics as in 1995 (Fig. 2). We counted about 400 leatherback nests of which nearly half was found poached. During this nesting season first hatchling tracks were observed on Samsambo. Although the sandbank was still unstable during spring tides, further beach nourishment probably caused more optimal

conditions for egg development.

In 1998 the Samsambo seemed to be connected to the mainland with almost the entire length of it by an accessible mangrove plateau. In 1998 we counted almost 1500 leatherback nests of which more than half was found poached (Fig. 2). However this year many hatchling tracks were observed. The actual number of nests might have been higher since monitoring periods were not frequent and the separate west section was still not monitored despite more frequent nesting, though still in small numbers compared to the main section.

In 1999 further beach nourishment united the two separate sections, forming a stretch of almost 7 km of beach. This year we counted about 4200 leatherback nests. The estimation of the total number of nests is over 10,000 nests (Fig. 2). Half of it was found poached. However an increasing amount of hatchling tracks has been observed during the nesting season.

DISCUSSION

This brings me to the discussion. First of all I will discuss beach dynamics. The beaches of the Guyana Shield are constantly influenced by accretion and abrasion. Examples of a highly dynamic beaches within the region are Matapica in Suriname and Point Isere in French Guiana.

Samsambo seems to be stable at present. Beach nourishment caused widening of the beach, development of little dune formations and elongation on both ends. These processes indicate stabilization. Next to this, development of mangrove forests with trees up to 15 m and sightings of big mammals, or their tracks, support this development. On the other hand, through the centuries, the coastline of the Guyanas has been changing dramatically. Samsambo could very well evolve into a beach type similar to the Matapica beach and start to move westward along the coast. Samsambo might even disappear within a decade.

For now Samsambo seems to be a nesting beach with ideal conditions for the leatherback turtle. There are two hypothesis that might explain the recent increase of the amount of nests. First, nest beach shifting could be an explanation. In this hypothesis, nest beach fidelity of leatherback females is low. The high numbers of females visiting French Guiana in the period between 1984 and 1994 (Fig. 1) could have shifted to Samsambo. However results of tagging programs don't show a high exchange of nesting leatherback females between Galibi and Amana.

Another possibility for the recent increase at the Samsambo could be large recruitment of young adults to the breeding population. The fact that the average time to reach sexual maturity is determined at around 13 years, in combination with the high numbers of nests between 10 and 20 years ago (Fig. 1), support this hypothesis. A combination of both theories could also be a possible explanation.

CONCLUSION

Last years estimation of more than 10,000 nests puts Samsambo between the five most important nesting beaches in the world for the leatherback turtle. Question is what caused this increase. Continuation of monitoring and a pit-tagging program in collaboration with French Guiana, might give us the answer. Whatever caused the recent increase of leatherback nests on Samsambo, it is very promising to see that the leatherback turtle have found and invaded a new beach in its struggle for survival.

ACKNOWLEDGMENTS

We would like to thank STINASU, WWF-Suriname, the WWF/Kawana-team, Henk Reichart, the village authorities of the Galibi villages and the David and Lucille Packard Foundation for supporting our efforts.

Fig. 1. Yearly number of nests laid in Amana, Galibi, and Matapica.

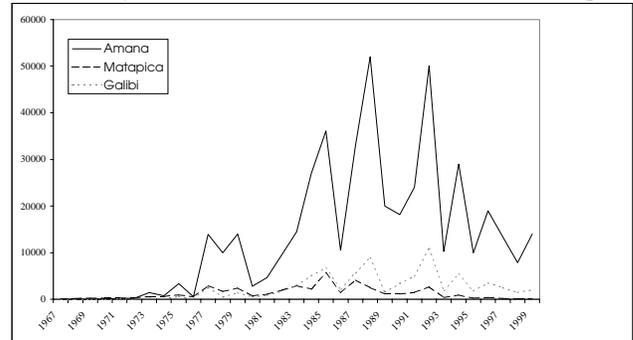
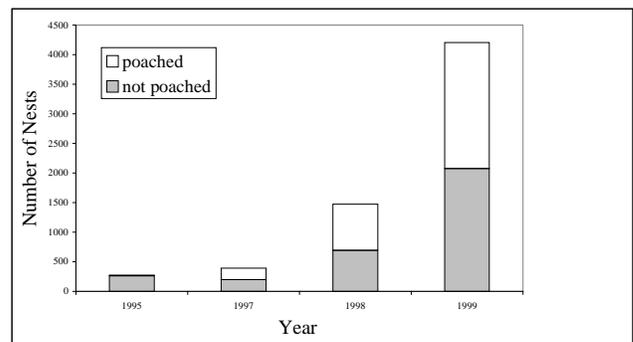


Fig. 2. Number of leatherback nests on Samsambo in 1995, 1997, 1998, and 1999, and proportion that were found poached.



Imminent Extinction of Pacific Leatherbacks and Implications for Marine Biodiversity

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The world-wide effects of fisheries on marine species are often difficult to determine. Many fisheries are unsustainable, but we only recognise this after they collapse because we cannot accurately quantify the population size of target and non-target species. Sea turtles and other long lived species are particularly affected. However, sea turtles provide us with a rare opportunity to accurately determine population size of a non-target species because we can accurately count them when they come ashore to nest.

We have used our tagging data from Playa Grande, Costa Rica, to construct a mathematical model which for the first time allows us to predict the numbers of new and remigrant turtles in any given year. This model predicts extinction in the next decade at best, with the number of nesting turtles dropping below 50 by 2004. Our data indicate that the most likely cause of population decline is from unsupportable adult mortality of at least 30% annually. Our model also shows that recovery of the

population cannot be achieved by conventional beach-based conservation actions to increase production of hatchlings. Data show that bycatch of leatherbacks by fisheries accounts for almost all anthropogenic adult mortality of this species. We are able to accurately measure the decline of leatherbacks and so they provide us with a vital indicator of the fate of other long-lived marine species. If the present fisheries practices continue, they will not only cause the extinction of Pacific leatherbacks, but will also catastrophically alter the entire Pacific Ocean ecosystem.

We introduce the concept that sea turtles have more than just their intrinsic value; they are also important in providing us with a quantifiable indicator of oceanic biodiversity. We must think beyond turtles and apply the knowledge gained from them to the effects of fishing on the marine environment as a whole. In addition, we must change our focus from traditional beach-based conservation efforts to programs aimed at preventing adult mortality from current fishing practices.

The Status of the Flatback Turtle, *Natator depressus*, in Eastern Australia

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INTRODUCTION

Information from the early 1900s (based on old photographs and interviews with fishermen) indicates that there were several large but unquantified nesting aggregations of flatback turtles (*Natator depressus*) including Peak Island, Wild Duck Island, Lammermoor Beach and Rabbit Island within the central Great Barrier Reef region of eastern Australia (Donat, 1936; Pitt, 1995; CJL, Unpublished data). Nesting surveys of the same areas in the 1980s show that nesting now is scarce at some of these sites (Lammermoor Beach, Rabbit Island). There has been local concerns regarding the conservation of flatback turtles in eastern Australia (EA) for several decades.

METHODS

Systematic *N. depressus* research commenced in EA in 1968 (Limpus, 1971). Adult turtles have been tagged with monel (NBTC #49 and #19), titanium (Stockbrands) and PIT tags (Limpus, 1992, Parmenter, 1993). Nesting distribution data has been derived from tagging census, aerial surveys, and beach surveys and turtles measured for midline curved carapace length (Limpus *et al.*, 1993). This

paper reviews the current information on *N. depressus* within EA, using distribution and census data within the Queensland Turtle Database of the Queensland Parks and Wildlife Service and the turtle research database of the Central Queensland University.

RESULTS AND DISCUSSION

The Australian endemic *N. depressus* has a discrete nesting population in EA that is well separated from the almost continuous nesting distribution of the species across northern Australia (Fig. 1). The EA nesting population concentrates at three major rookeries (Wild Duck Island, Peak Island, Curtis-Facing Island) and numerous lower density rookeries in the southern and central Great Barrier Reef region. Peak Island and Wild Duck Island supported large *N. depressus* nesting populations back at least in the 1920s and 1930, respectively. Tag recoveries indicate that the adult females migrate from through out the Great Barrier Reef lagoon to breed at these rookeries (Fig. 2). There is no evidence of adults from EA rookeries leaving the Australian continental shelf waters. Post-hatchling flatback turtles disperse from the nesting beaches and take up a pelagic life history phase

that is similarly restricted to continental shelf waters (Limpus *et al.*, 1994; Walker and Parmenter, 1990) where they feed on macroplankton in surface waters. The adults are carnivorous, feeding on a range of soft-bodied, benthic invertebrates.

There are consistent differences in the timing of the nesting seasons, in size of nesting females, number of eggs per clutch and size of eggs between the EA nesting population and the adjacent nesting population concentrated in eastern Gulf of Carpentaria (Limpus *et al.*, 1993). These data are consistent with the EA nesting population being reproductively isolated from the northern Australian population(s). Population genetics research now supports this conclusion (Moritz *et al.*, 1998). This EA population forages and breeds within a single nation and lives almost totally within a World Heritage Area and within the world's largest multiple use marine park (Great Barrier Reef Marine Park). Approximately 70% of the total annual nesting for this stock occurs within National Parks or equivalent.

Data spanning 32 years of tagging studies provide insights into the population trends and conservation status of this EA stock: tagging census studies at the minor rookery of Mon Repos and adjacent beaches on the Woongarra Coast since 1968 (Fig. 3), nightly census studies (average number of females ashore per night at peak nesting season) at Wild Duck Island, which is the second largest east coast nesting population, since 1981 (Fig. 4) and track count census data from the intermediate sized nesting population at Curtis Island since 1970 (Fig. 5). These demonstrate no obvious trend in the size of the annual nesting population at these rookeries over three decades, which is presumed to span about one generation.

On average, females recruiting to breed for their first breeding season are significantly smaller than turtles with a past breeding history (remigrants) (Parmenter and Limpus, 1995). A constant mean size of turtles at three rookeries across three decades (Fig. 6) is indicative of a long term, approximately constant ratio of first time breeders to remigrants in these populations.

With long term mark recapture studies using secure tagging methods, the rate of recruitment of first time breeders into the adult population (adult recruitment rate) can be estimated by measuring the proportion of untagged females entering the annual nesting population. This adult recruitment rate, measured using the total nesting populations at widely scattered EA rookeries (Wild Duck Island, Woongarra Coast), are similar, in the range of 10-20% and approximately stable over several years (Fig. 7). A similar adult recruitment rate has been estimated at Peak Island, the largest EA rookery (Parmenter and Limpus, 1995). Adult recruitment rates in the range of 10-20% are what we expect for an approximately stable marine turtle population.

The comparison of the limited abundance data from early this century and present reduced breeding numbers at some sites are suggestive of a substantial population decline having occurred within the EA genetic stock of

flatback turtles within the last century. However, the results of rigorous tagging studies at multiples sites (annual census; stable adult size; low, stable adult recruitment rate) over the last three decades of this century are indicative of currently stable populations for this EA stock. No comparable data sets exist for assessment of the status of the flatback turtle stocks of northern Australia.

With its distribution effectively contained within the Great Barrier Reef World Heritage Area and the Great Barrier Reef Marine Park and with ~70% of annual nesting occurring within National Parks, the EA N. depressus stock has the potential for being the most secure population of marine turtles globally. This is supported by the current population stability of this stock.

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Fig. 1. Distribution of nesting beaches of the flatback turtle, *N. depressus*, in northern and eastern Australia.

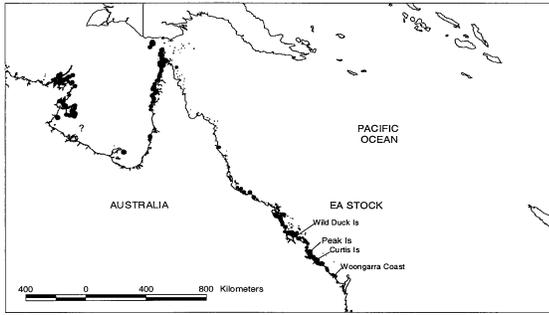


Fig. 2. Distribution of post-nesting tag recoveries of adult female *N. depressus* originally tagged while nesting at central Queensland rookeries.

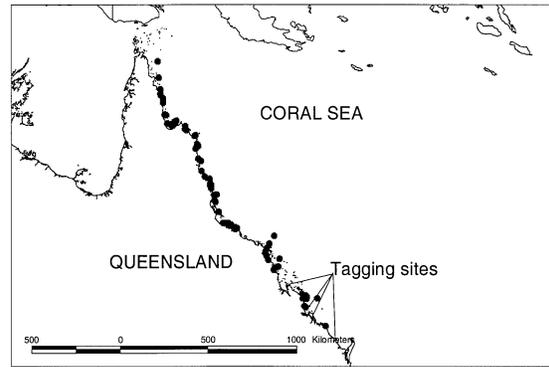


Fig. 3. Total annual nesting population of *N. depressus* on the Woongarra Coast.

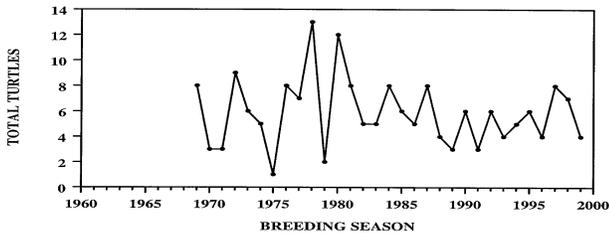


Fig. 4. The long-term mid-December track count index on Wild Duck Island.

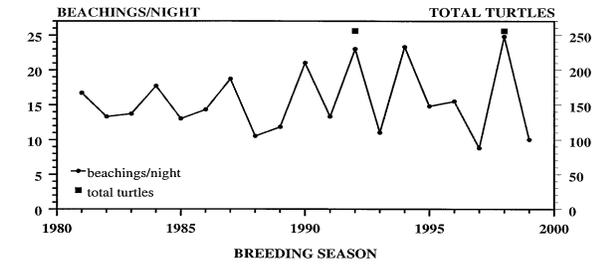


Fig. 5. The annual census of *N. depressus* on Curtis Island.

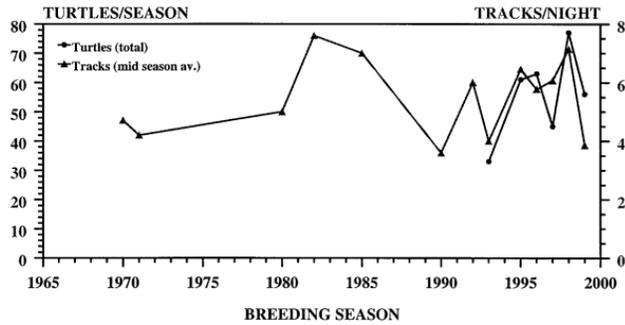


Fig. 6. The mean curved carapace length (CCL) of nesting female *N. depressus* in east Australia. The Woongarra Coast data are pooled for 2-year intervals.

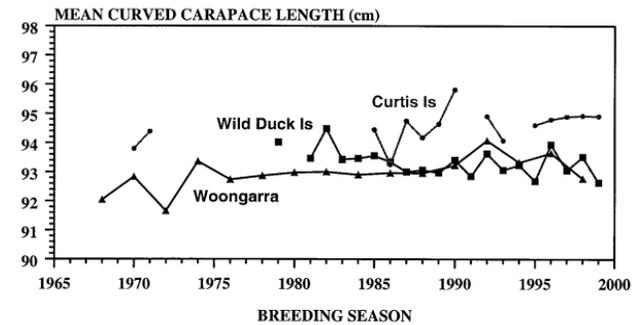
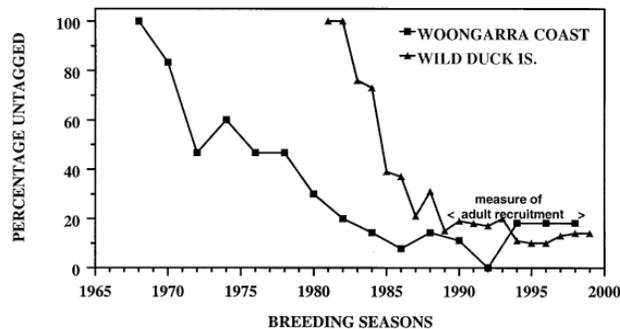


Fig. 7. Tagged populations and estimation of recruitment of *N. depressus* in east Australia.



Analysis of the Stomach Contents of a Hawksbill Turtle Entangled in a Net in the Peninsula de Paria, Sucre State, Venezuela

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Within the evaluations of the incidental catch of sea turtles conducted under the project “Conservation of the sea turtles in Cipara beach, Peninsula de Paria”, a dead hawksbill turtle was found entangled in an artisanal gill net in July of 1999. The turtle was a female, with a standard curved carapace length of 51 cm and a curved carapace width of 46 cm. The analysis of the stomachal content showed a marked preference for the incrustant invertebrates of the Class Demospongiae, which represented a 94.8% of the dry weight of the total sample of sponges, including three species. *Chondrila nucula*, (Choristida,

Chondrillidae) was the most abundant species (75% dry weight); *Tethya* sp. (Hadromerida, Tethyidae), covered a 15% of the dry weight and, it was found a third sponge that could not be identified, representing a 10% dry weight of the sample. The remaining 5.2% of the total dry weight was composed by calcareous-rocky substrate associated to the reef (3.8%) and marine algae (*Sargassum* spp.). The diet composition reflects the composition of the turtle feeding area, where it was observed a wide area of massive reefs very rich in associated species, as the incrustant sponges.

Feeding Habits of Black Turtles (*Chelonia mydas agassizii*) in the Magdalena Bay Region, Baja California Peninsula, Mexico

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INTRODUCTION

The coast of the Baja California Peninsula, Mexico, plays an important role for many species of sea turtles (Clifton *et al.*, 1982; Nichols *et al.*, 2000). Magdalena Bay, a 1390 km² bay located on the Pacific coast of the Baja California Peninsula, is thought to provide important feeding and developmental grounds for Pacific green turtles (*Chelonia mydas agassizii*), locally known as tortuga negra, or black turtles. However, knowledge of black turtle ecology in this region is limited. An understanding of the biology of sea turtles is essential to assessing the natural resources on which this species depends during different time periods (Alvarado *et al.*, 1990; Lutz and Musick, 1996). Therefore, the purpose of this study was to examine the feeding habits of black sea turtles in the Magdalena Bay region in order to determine what resources these turtles use during their residence in the area.

METHODS

The study site, Magdalena Bay, is made up of a chain of relatively shallow, narrow channels that run north and south,

parallel to the coast. Magdalena Bay forms the central part of a large lagoon system, the Magdalena-Almejas complex. The ocean connects to the bay through a channel between the barrier islands, Margarita Island and Magdalena Island. In the western part of the bay, coastal upwelling causes low temperatures and high nutrient concentrations, which contribute to a very productive ecosystem.

The feeding habits of black turtles living in the Magdalena Bay region was assessed by analyzing stomachs obtained from incidentally caught sea turtles. The stomachs were preserved in alcohol until analyzed. First the stomachs were weighed with contents, and then weighed again once the contents had been removed. The different groups of organisms found in the stomachs were separated, identified, and weighed. The relative abundance of the groups in the stomachs was determined by calculating the percentage of each group by weight in every stomach. These percentages were then averaged to determine the relative abundance of each group for all turtles. This method, as opposed to calculating a percentage based on total weight, was used so that stomachs from larger turtles would not disproportionately affect the relative abundance of each group. This calculation was performed in order to compare the stomach contents of turtles caught during the summer to those caught during the fall months. This

method was also used during the fall study to compare three stomachs removed from turtles caught within the bay to one stomach that was removed from a turtle caught on the Pacific side of Magdalena Island.

RESULTS AND CONCLUSIONS

A total of 11 stomachs were collected throughout the study period, seven from the summer, and four from the fall, 1999. The results indicate that there was little difference between the feeding habits of black turtles in the summer and the fall. Both sets of data have the same groups of organisms: *Gracilariopsas*, *Ulva lactuca*, *Rhodymenia*, *Phyllospadix*, and invertebrates, with the red algae, *Gracilariopsas* being predominant during both seasons (Figs. 1 and 2). This algae made up 56.9% of the total stomach content weight in the summer collected stomachs and 63.9% of those obtained in the fall.

When comparing the stomach contents of turtles captured inside and outside the bay, it was observed that the variety and types of organisms varied in the stomachs from the two locations. The stomachs from turtles caught in the bay contained several groups including *Gracilariopsas*, *Ulva lactuca*, invertebrates, and a variety of other groups in small quantities (Fig. 3). The stomach from the turtle caught in the Pacific had only two groups, *Phyllospadix* and *Rhodymenia* (Fig. 4). *Gracilariopsas* made up the majority (85%) of stomach contents from in the turtles captured within the bay (n = 3), and sea grass (*Phyllospadix*) was predominant (70.6%) in the stomach from the Pacific caught turtle. Also present in the stomachs from bay-captured turtles was an invertebrate species, which was not found in the turtles from the Pacific coast. The organisms appear to be a species of tunicate, but a positive identification is still pending.

The similarity in the feeding habits of black turtles between summer and fall may indicate that the resources available remain constant throughout these two seasons, or it may be a result of feeding preferences of the animals. Surveys of the bay should be conducted to determine if the

resources are consistently available throughout the year, or to verify that turtles are selectively feeding. The study should also continue to explore the feeding habits of black turtles throughout the year, to see if there are differences between other seasons. The substantial difference in feeding habits of turtles inside the bay and along the Pacific coast may be a reflection of resource availability. If possible, this study should be continued to see if the difference between Pacific caught turtles and bay caught turtles is consistent when analyzing numerous samples.

ACKNOWLEDGMENTS

The School for Field Studies, Center for Coastal Studies and the Marshall Foundation contributed invaluable financial support and SEMARNAP provided research permits to enable this project to be possible. Appreciation is extended to Rodrigo Rangel and the community of Puerto San Carlos for their generous contribution of local knowledge as well as to Rafael Rios Manas at the Universidad Autonomous de Baja California Sur for assistance with algae identification.

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Fig. 1. Relative abundance of contents in stomachs (n = 7) of black turtles caught during the summer months: June-August 1999.

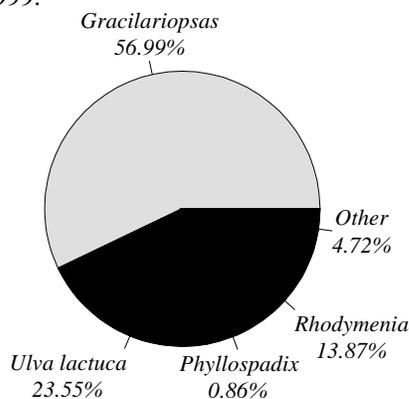


Fig. 3. Relative abundance of contents in stomachs (n = 3) of black turtles from within Magdalena Bay, Fall 1999.

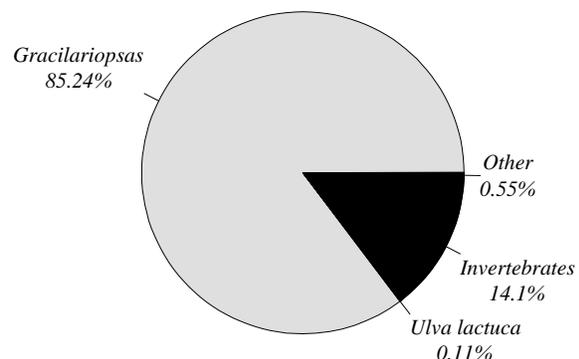


Fig. 2. Relative abundance of contents in stomachs (n = 4) of black turtles caught during the fall months: October-November 1999.

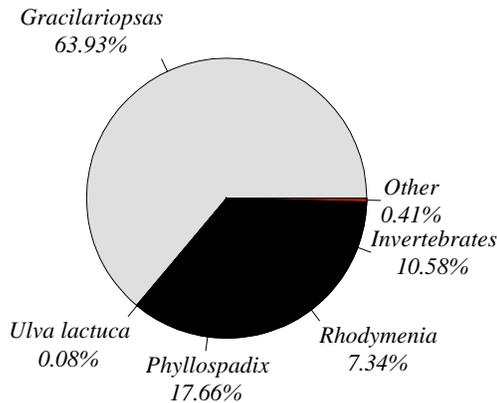
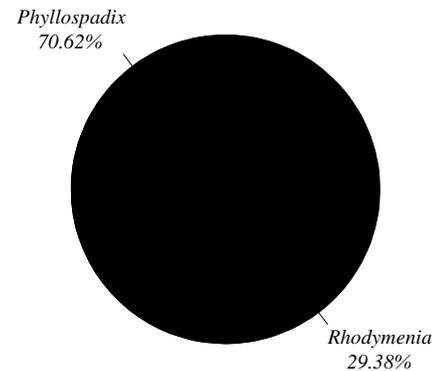


Fig. 4. Relative abundance of contents in a stomach (n = 1) of a black turtle from the Pacific side of Magdalena Island, Fall 1999.



Projeto Tamar's Station in Ubatuba (São Paulo State, Brazil): Sea Turtle Conservation in a Feeding Area

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Projeto TAMAR-IBAMA, the Brazilian Sea Turtle Conservation Program, was created in 1980 by IBAMA-the Brazilian Institute for the Environment and Renewable Natural Resources, a federal government agency-and is co-managed by Fundação Pró-TAMAR, a NGO. TAMAR has now 21 stations, monitoring over 1000 km of the Brazilian coast and three oceanic islands. After 10 years of monitoring the main Brazilian nesting beaches, in 1990 TAMAR decided to start working at feeding areas having high levels of incidental capture by local fishermen. The first station in a feeding area was created in Ubatuba, due to the availability of a sponsorship for an initial survey there. That survey made clear the great number of incidental captures in Ubatuba, mainly of juvenile green turtles (*Chelonia mydas*), qualifying this area as an important conservation spot. Regular fieldwork started in January 1991. Ubatuba is currently TAMAR's most southern station.

Ubatuba is a municipality located on the northern coast of the State of São Paulo, in southeastern Brazil. Its coastline is about 100 km long. The city of Ubatuba is located at 23°26'S, 45°05'W, right on the Tropic of Capricorn. More than 70 beaches exist in Ubatuba, some of them quite isolated. Many beaches are occupied by traditional communities for which artisanal fishing is the main income source. Ubatuba also harbors a small-scale commercial fishery, targeting mainly shrimp. Regularly

both kinds of fisheries incidentally capture sea turtles. TAMAR works year round in Ubatuba, focusing mainly on the interaction between artisanal fishing (mostly fishing weirs) and sea turtles. Fishermen are regarded as partners in the conservation work.

From 1991 to 1998 the TAMAR station in Ubatuba recorded 2515 captures of sea turtles. Four species have been found there: the green turtle (n = 2475 or 98.41% of total records), loggerheads (*Caretta caretta*, n = 13 or 0.52%), hawksbills (*Eretmochelys imbricata*, n = 23 or 0.91%) and the leatherback sea turtle (*Dermochelys coriacea*, n = 4 or 0.16%). In Ubatuba, green turtles are generally juveniles, and loggerheads are generally juveniles or sub-adults, although, for both species, there is a slight overlap between the range of curved carapace length observed in Ubatuba and that observed for nesting females in the Atlantic ocean. Hawksbills are juveniles, always smaller than nesting females in the Atlantic. Leatherbacks (all of them were found dead, stranded or floating near the coast) are sub-adult, except for one turtle which is well into the size-range observed for leatherbacks nesting in Brazil and elsewhere in the Atlantic.

This poster briefly describes the field methods employed by TAMAR in Ubatuba, presents an overview of the data collected between 1991 and 1998 and an assessment of the conservation status of sea turtles there. A complete report will be published elsewhere.

Diet Composition of the Loggerhead Sea Turtle, *Caretta caretta*, in the Northern Adriatic Sea: A Preliminary Study

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INTRODUCTION

The loggerhead sea turtle *Caretta caretta* is the most abundant marine turtle species in the Mediterranean basin. Despite a decade of intensive research, little is known about the biology and ecology of the species away from its nesting habitats in the region. A few studies on the feeding habits of the loggerhead carried out in Mediterranean have shown the chiefly carnivorous, but opportunistic nature of *C. caretta*, supporting other studies on feeding ecology, and defining the species as a carnivorous generalist, foraging primarily on rather different invertebrates in nearshore benthos within distribution range (Bjorndal, 1985; Dodd, 1988; Plotkin *et al.*, 1993; Mortimer, 1995).

The Adriatic Sea was considered as a possible feeding area for *C. caretta* (Argano *et al.*, 1992). Numerous tag recoveries in Croatia, mostly grouped in the northern Adriatic, and analysis of bycatch (Lazar and Tvrtkovic, 1995), further emphasized this area as a probable foraging ground for the loggerhead population nesting in Greece (Lazar *et al.*, 2000). The relatively shallow coastal waters of northern Croatian Adriatic, with rich benthic communities (Vatova, 1949; Gamulin-Brida, 1967), represent a suitable and available food resource for the species. However, the feeding ecology and feeding habitats of *C. caretta* in the Adriatic remained totally unknown, except for sporadic remark in a paper by Steuer (1905). Therefore, in this paper we present preliminary results on diet composition of the loggerhead in the northern Adriatic Sea, and the benthic communities used by *C. caretta* as feeding grounds.

METHODS

A general necropsy was performed on four carcasses of loggerheads found in the Kvarner region and the western coast of Istrian Peninsula, the Northern Adriatic Sea, Croatia. The esophagus, stomach and intestinal tract were removed, guts contents were rinsed through fine-mesh sieve, and preserved in 76% ethanol. Food item samples were categorized and identified to the lowest possible taxon, preferably at species level. Samples were dried at 105°C for 24 hour, and weighed for each identified taxon. Percent occurrence and percent dry weight were also calculated.

RESULTS AND DISCUSSION

Curve carapace length of analysed specimens ranged from 47.8 cm to 85.4 cm (\bar{x} = 68.2, SD = 19.1, n = 4). Digestive tract contents were categorized into 10 major identified groups: Porifera, Cnidaria (Anthozoa), Annelida (Polychaeta), Mollusca (Gastropoda), Crustacea (Decapoda), Echinodermata (Holothuroidea, Ophiuroidea and Echinoidea), Tunicata (Ascidiacea), Vertebrata (Pisces), Algae (Rhodophyta), and Spermatophyta, plus marine debris. The dry weight of the digestive tract contents from individual loggerheads ranged from 11.63 to 295.93g.

The highest ranked prey in this study was echinoids, occurring in all samples and accounting for 67% of the total prey dry weight. Spines and fragments of plates belonged to the genus *Echinus*, while identification at species level was only possible for *Echinus acutus*.

The second highest ranked prey was sponges, which were found in 50% of samples, and accounted for 15% of the total dry weight. Fragments of *Tethya aurantium* were common in analysed samples. Although not so highly ranked, sponges were described for the loggerhead diet in Mediterranean basin (Steuer, 1905; Laurent and Lescure, 1994).

It is interesting that Croatian loggerheads, originated from the same Greek nesting population as that in Tunisia (Margaritoulis, 1988; Lazar *et al.*, 2000) feed upon different major prey groups within Mediterranean Basin. Whether decapod crustaceans and gastropods are predominant in the diet composition of loggerheads in Gulf of Gabès in Tunisia (Laurent and Lescure, 1994), the feeding regime of *C. caretta* studied seems to be based upon echinoids and sponges.

Decapod crustaceans were the third ranked prey for northern Adriatic loggerheads, but they accounted for only 8% of the total dry weight. Paguridae were the dominant family. Species of genera *Pagurus* and *Paguristes* seems to be the most common crustaceans in the diet of *C. caretta* in Mediterranean (Laurent and Lescure, 1994; Godley, 1997).

Other items in loggerhead diet include polychaetes (4% d.w.), holothurians (3% d.w.), and gastropods (2% d.w.), while other taxa, and marine debris, were represented with a percentage of total dry weight less than 1%. It should be emphasized that dry weight percent of *Aphrodita aculeata* (Polychaeta, Annelida) in the digestive content of

one loggerhead (CCL: 47.8 cm) was as much as 93%. The presence of *A. aculeata*, the exclusive species of community of coastal detrital bottoms, suggest a preferred benthic community for the feeding of loggerheads in the northern Adriatic. Some other species identified in the digestive tract, although not so exclusive, may also belong to this community (*Ophiothrix fragilis*, *Echinus acutus*, *Tethya aurantium*), as well as species of the genera *Harmothoe* and *Holothuria*.

Ecological preferences of prey species suggest that two loggerheads studied have feed in the benthic community of coastal detritic bottom, between about 30 and 50 m depth. The other two loggerheads probably searched for a food in slightly deeper water, on sediment rich in silty fraction, presumably within the biocoenosis of coastal terrigenous ooze.

CONCLUSIONS

Although the number of samples was too small for detailed analysis, and despite the fact that some soft-bodied organisms may have already been digested and therefore overlooked, and that the percentage dry weight is biased in favour of prey groups that have indigestible parts, the following preliminary conclusions may be suggested: (1) the loggerheads in the northern Adriatic have a chiefly carnivorous diet regime. They primarily feed upon a variety of benthic invertebrates and, occasionally, fish; (2) echinoids and sponges seems to be the two highest ranked prey groups in the dietary composition of the loggerheads in the northern Adriatic Sea (Croatia), with 100% and 50% occurrence, and 67% and 15% of total dry weight, respectively; (3) results support the theory of the opportunistic feeding habits of the loggerhead sea turtle. Even more, it seems that the same population in different sub-regions base its diet upon different major food groups, depending on the diversity of local benthic communities; and (4) communities of coastal detrital bottoms seem to present probable feeding habitats of *C. caretta* in northern Croatian waters. Considering distributional pattern of relevant benthic communities in the Kvarner region and in the Velebit Channel, this area may represent a loggerhead foraging habitat in the Adriatic Sea.

ACKNOWLEDGMENTS

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Dietary Components of Pelagic Loggerhead Turtles in the North Pacific Ocean

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INTRODUCTION

Loggerhead turtles are circumglobal inhabiting temperate, subtropical, and tropical waters of the Atlantic, Pacific and Indian Oceans. Loggerheads have been found in nearshore waters off China, Taiwan, Japan, Australia, and New Zealand in the Western Pacific and are seen offshore of Washington and California State and Baja California, Mexico in the Eastern Pacific (Dodd, 1988). Nesting areas in the Pacific Ocean are mainly on the western side, Japan and Australia, with no known nesting in the Eastern Pacific. Mean growth rates for juvenile loggerheads in the North Pacific have been estimated at 4.2 cm/year (Zug *et al.*, 1995). Loggerheads have an extended pelagic stage, which can last until sexual maturity. Transpacific migrations of juvenile loggerheads have been documented from mitochondrial DNA testing of loggerheads found feeding off of California and Baja identifying these turtles as being from Japan and Australia (Bowen *et al.*, 1995). Recent pelagic satellite tracking of juvenile, sub-adult, and adult size loggerheads indicate that they are active in their migration, swimming against weak geostrophic currents and following subtropical fronts as they travel from east to west across the Pacific (Polovina *et al.*, 2000).

Loggerhead turtles were taken as by-catch in the international high-seas driftnet fishery which targeted squid and albacore (Wetherall *et al.*, 1993). National Marine Fishery Service (NMFS) observers aboard commercial driftnet vessels operating between 29.5°N and 43°N latitude and 150°E and 154°W longitude collected 52 dead loggerheads between 1990 and 1992 (Fig. 1). Sea surface temperatures ranged from 17-20°C in the area of capture. Specimens obtained were of juvenile, sub-adult, and adult sizes ranging from 13.5 cm to 74 cm curved carapace length (CCL). Few studies have been done on pelagic diets, the most comprehensive lists of dietary items for loggerhead turtles come from nearshore foraging areas. The main objective of this paper is to summarize the major dietary components found in loggerhead stomachs from turtles that were obtained as by-catch in the pelagic high-seas driftnet fishery in the North Pacific Ocean.

METHOD

NMFS observers obtained 52 dead loggerhead turtles. Whole specimens and excised stomachs were frozen and transported to a laboratory for analysis. Stomachs were examined from anterior to posterior. Gross observations

of stomach contents were made and then contents were sorted to the lowest identifiable taxonomic level. Major faunal components were identified, quantified by volume, and the percent contribution for each major component was calculated (Forbes, 1999). Frequency of occurrence of major components was also calculated.

RESULTS AND DISCUSSION

Most identifiable stomach contents were found in the anterior portion of the stomach and contents varied. A taxonomic listing of diet items identified for the loggerheads of the pelagic North Pacific is shown in Table 1. The most frequently occurring prey items were: *Janthina* sp., *Carinaria cithara*, *Velella velella*, *Lepas* sp., *Planes cyaneus*, and *Pyrosomas* (Figs. 2 and 3). Other common components were fish eggs, amphipods, and plastics.

Loggerhead turtles appear to be omnivorous predators of the neuston or surface layer, feeding both by swallowing floating prey whole and biting off prey items from larger floating objects. *Velella velella*, commonly known as “by-the-wind-sailor” (Eldredge and Devaney, 1977), was a common prey item and typically found intact, indicating the turtles swallowed these floating prey items whole. One stomach sample was almost entirely filled with this prey indicating the turtle had encountered a dense patch of *Velella*. The presence of the bluebottle (*Janthina* sp.), a predatory gastropod, was not unexpected given the presence of its primary prey species, *Velella*. *Janthina* has been noted as a prey item in the Azores and South Africa (Dodd, 1988), but this is the first record of this prey item in the pelagic Pacific Ocean. The pelagic crab, *Planes cyaneus* (Dana, 1852) and gooseneck barnacles, *Lepas* spp. usually occur on floating objects with *Planes* sometimes even riding on *Velella* (Chace, 1951). The low mean percent volume of *Planes* (Figure 3) indicates that this prey item was probably taken opportunistically, although it is not known whether they were ingested with other prey items or actually grazed off larger floating objects. In contrast, *Lepas* often had very high percent volumes (up to 88% of total gut content) indicating the turtles were actively grazing these prey. Their consistent presence in samples verify the hypothesis that loggerheads feed not only by swallowing prey whole, but also by biting prey off larger floating objects. Small chunks of styrofoam were still attached to the bases of some *Lepas* specimens indicating that the turtle had bitten off some substrate as it grazed off

the floating debris. *Pyrosomas*, the fiery bodies which comprise a major part of leatherback diets (Davenport and Balazs, 1991), were also present in loggerhead stomach samples. In stomach samples that contained *Pyrosomas*, this prey item often comprised a high percent of the total gut content (Fig. 3), indicating that the turtles were encountering dense patches of this prey item. The presence of the heteropod *Carinaria cithara* (Benson, 1835) was unexpected, although they have been previously recorded as turtle forage in the western North Pacific by Okutani (1961). Heteropods are found in the upper photic zone (within 100 m of the surface), but are not typically a neustonic species. Recorded heteropod densities are variable (<1/1000 m³ to 150/1000 m³, Seapy, cited in Lalli and Gilmer, 1989), but clearly in this area of the Pacific, heteropod densities are sufficient at shallow enough depths to make this an attractive prey item for the loggerheads.

Among other floating items that often occurred in loggerhead stomachs, one common element, found in 23% of the stomachs, was fish eggs, some identified as flyingfish eggs, *Hirundichthys speculiger*. Amphipods were another common item (42% of stomachs), but comprised a very small fraction of total gut content (less than 1%), indicating that they were not a targeted prey item. Amphipods were possibly ingested incidentally as epiphytes on other items or part of the gut contents of other prey items. While the total number of pelagic fish (Lanternfish and Hatchetfish) in these samples was very low, their presence at all was somewhat surprising. These fish stay below the photic zone during the day and migrate up to near the surface at night. Loggerheads would likely only ingest dead or debilitated fish that were stranded near the surface rather than actively hunt and chase these species. In contrast to previous expectations, the proportion of man-made drift debris was lower than anticipated. Although plastics were found in 38% of the stomachs examined, they comprised a very small fraction of the total gut content (1% or less). Some items included: small plastic beads, thin plastic sheets, polypropylene line and even a small plastic fish, similar to individual soy sauce containers.

Loggerheads in North Pacific pelagic habitats are opportunistic feeders that ingest items floating near or at the surface. They will also actively forage at deeper depths if high densities of prey items are present. Continuing studies of the loggerhead should include diet items to characterize the pelagic ecology and habitat of this species.

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Table 1. Taxonomic listing of diet items.

Mollusca	Gastropoda (Molluscs)	<i>Ptenoglossa</i> - Family Janthinidae - <i>Janthina</i> sp. (incl. <i>J. janthina</i> and <i>J. prolongata</i> = <i>J. globosa</i>) Heteropoda - Family Carinariidae - <i>Carinaria cithara</i> Benson 1835 Euthecosomata - Family Cavoliniidae - <i>Cavolinia globulosa</i> (Gray 1850); <i>Cresseis</i> (?) sp. Thecosomate Pteropods <i>Nudibranchia</i>
	Cephalopoda (Squid and Octopus)	Squid fragments and paralarvae <i>Octopus</i> sp. paralarvae
Crustacea	Cirripedia (Barnacles)	Family Lepadidae (Gooseneck Barnacles) - <i>Lepas</i> sp.; <i>Lepas anserifera</i> Linnaeus 1767; <i>Lepas anatifera anatifera</i> Linnaeus 1758
	Amphipoda (Amphipods)	Gammaridea Hyperiidea - Family Hyperiidae - Unidentified spp.; <i>Lestrigonus</i> sp. Family Lycaeidae - <i>Lycaea</i> sp. Family Oxycephalidae - <i>Oxycephalus</i> sp.
	Decapoda Brachyura (Crabs)	Family Grapsidae - <i>Planes cyaneus</i> Dana 1852; <i>Planes</i> sp.
	Isopoda	
	Euphausiacea	Euphausiid
	Mysidacea	Mysid
Cnidaria		Unidentified species (jellyfish)
	Hydroida	<i>Veleva veleva</i> Linnaeus 1758 (by-the-wind-sailor)
Urochordata		<i>Pyrosoma</i> sp.
Vertebrata		<i>Salpa</i> sp.
	Pisces (Fish)	Family Myctophidae (Lanternfish) - <i>Electrona</i> (?) sp. Family Sternoptychidae (Hatchetfish)
		Family Exocoetidae (Flyingfish) - <i>Hirundichthys speculiger</i> (eggs)
Annelida	Polychaeta (Polychaete Worms)	Family Alciopidae
Algae	Phaeophyta (brown algae)	<i>Cystoseira</i> sp.

Fig. 1. Distribution of 52 loggerhead turtles caught in the high-seas driftnet fishery in the North Pacific Ocean, 1990-1992.

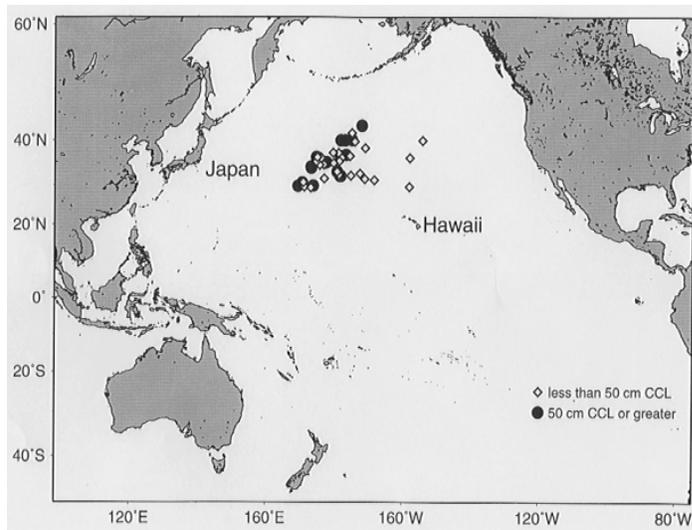


Fig. 2. Frequency of occurrence (% stomachs present) of each of six major prey items found in loggerhead stomachs.

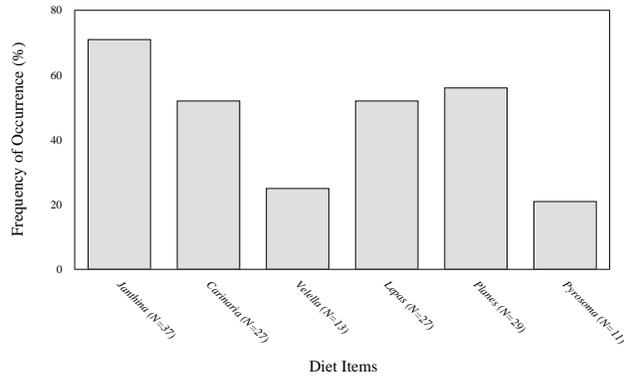
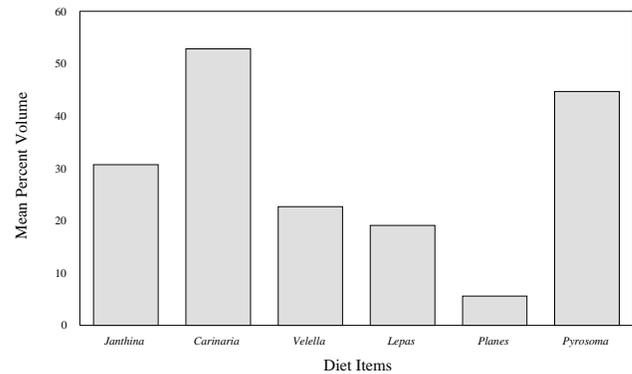


Fig. 3. Mean percent volume of six major prey items found in loggerhead stomachs. Mean and standard deviation shown above each bar.



A Preliminary Analysis of Growth Data of Juvenile Loggerhead (*Caretta caretta*) Sea Turtles from North Carolina and New York, USA

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Determining the age at which sea turtles mature is vital to understanding sea turtle demography, thereby facilitating conservation management practices. However, as sea turtles cannot be aged based on external characteristics, it is only possible to estimate the age at maturity using indirect methods such as measuring the growth rates of wild, recaptured turtles. Previous studies have documented a higher rate of growth for wild, juvenile loggerhead (*Caretta caretta*) sea turtles in the southern Bahamas and Florida than in Virginia. The National Marine Fisheries Service sea turtle program in Beaufort, North Carolina has been conducting mark-recapture studies in Core and Pamlico Sounds, North Carolina since 1988, and has tagged a total of 978 loggerhead sea turtles, most of which were incidentally captured in commercial pound nets. Data from the New York State Marine Turtle Project were also included in the analysis. Straight-line measurements of carapace length (notch-tip) taken for each turtle ranged from 41.4-103.0 cm. External Inconel Style 681 tags applied to both rear flippers and internal passive integrated

transponder (PIT) tags injected into the left front flipper enabled identification of recaptured turtles. Growth rates (carapace length initial-carapace length at recapture/years at large) were assigned to a 10 cm size class based on the mean of the initial and recapture length and averaged. Multiple t-tests were used to calculate differences in mean growth rates among the recaptured loggerheads from the different regions of the western Atlantic. To date, 29 loggerheads have been recaptured after being at large for 11 months or more, allowing for measurable growth. Similar to Virginia, North Carolina and New York had slower growth rates compared to Florida and the Bahamas although these differences were not always significant. Differences in growth rate have been attributed to the seasonal availability of food as well as the costs associated with seasonal migrations. Growth rates may also vary depending upon the genetic composition of the respective populations. This may have important ramifications for the management of the declining northern nesting population of loggerhead sea turtles.

Immunosuppression and Fibropapilloma Disease in Wild Green Sea Turtle Populations (*Chelonia mydas*)

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INTRODUCTION

Green turtle fibropapillomatosis (GTFP) is a severely debilitating disease characterized by epizootic tumors of the skin, flippers, periocular tissues, carapace and plastron (Campbell, 1996). The tumors, which vary in size and morphology, limit the turtle's capacity to move and find food. While GTFP has been investigated intensively, little has been ascertained as to its cause. Possible causal agents of this disease include parasites and herpesvirus (Herbst, 1994). Pollution, water temperatures and genetic factors have also been suggested as variables of etiology (Balazs and Pooley, 1991). In the context of understanding the etiology of this disease it is important to determine the sea turtle's immune system. Although immunosuppression is strongly correlated with fibropapillomatosis in captive green sea turtles, we have no knowledge of the immune status of diseased turtles in the wild (Cray, 1999). This investigation marks the first study of immunosuppression in wild sea turtle populations.

METHODS

Forty-eight juvenile green sea turtles (*Chelonia mydas*) from three separate populations were used in this study: a group (n = 15) from the Port Canaveral Trident Basin, a group (n = 6) from south of the Sebastian River Inlet and another group (n = 27) from the Indian River Lagoon in Brevard County, Florida.

Approximately 2-6 ml of blood was drawn from the dorsal cervical sinus of each turtle and transferred to a sodium heparin 3 cc vacutainer. Packed cell volumes, lymphocyte cell differentials, serum protein gel electrophoresis and in vitro cell proliferations were performed at the Department of Pathology, University of Miami, School of Medicine. Serum protein values were obtained by the Beckman Paragon Electrophoresis System and measured with a densitometer. Lymphocytes were isolated from whole blood by using Histopaque-1077 and washed three times. The viable cell yield was determined by staining with Trypan Blue using standard hemocytometer methodology. The lymphocytes were then stimulated with concentrations of Phytohemagglutinin, Pokeweed mitogen, PMA, Ionomycin, Concanavalin A and lipopolysaccharide, and complete media as a control in triplicate. After 48 hours of incubation at 37°C, cells were pulsed with Promega CellTiter 96TMAqueous One Solution Cell Proliferation

Assay. Optical densities were then taken every hour for three hours.

RESULTS

Preliminary results indicate that lymphocytes from papilloma turtles did not proliferate as vigorously as those from non-papilloma (healthy) turtles after stimulation by mitogens. The best mitogens for overall stimulation were PMA + Ionomycin 0.3 uM and Concanavalin A. In non-papilloma lymphocytes, the maximum stimulation for PMA + Ionomycin 0.3 uM was 1.53 and for ConA, 1.76. Cell differentials were also performed to determine the number of lymphocytes each individual displayed. Non-papilloma turtles have a higher lymphocyte count and a decreased number of heterophils than turtles with fibropapillomas. Packed cell volumes (PCVs) ranged from 14% to 40% encompassing both groups. Normal hematocrit values for *Chelonia mydas* range from 26% to 31%. Lower PCVs indicate anemia while higher PCVs indicate dehydration.

Individuals from the Trident Basin where there is zero prevalence of GTFP responded best to lymphocyte stimulation and had normal PCVs.

DISCUSSION

These results indicate that individuals from wild populations of *Chelonia mydas* respond to varying concentrations of mitogens in the same manner as captive green turtles. That is, lymphocytes from healthy sea turtles proliferate to a greater degree than those of GTFP turtles. Hence, wild sea turtles with GTFP may be immunosuppressed. This is an important finding since many of the papilloma associated pathologies could be secondary to a compromised immune system (Duncan, 1975, Sundberg *et al.*, 1994). Previous studies, support the hypothesis that an altered immune function is associated with tumor development (Cray, 1999). Whether immunosuppression is the cause of fibropapillomatosis or is caused by the disease is an extremely important etiological question that must be addressed. This ongoing study will look at wild populations to determine the effects of seasonal variations of immune status relative to temperature as an environmental stress. We will look at in vitro cell proliferation after incubating at 18°, 28° and 37°C.

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Ecology and Behavior of Green Turtles Basking at Kiholo Bay, Hawaii

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INTRODUCTION

The long-term study of juvenile and subadult green turtles at Kiholo Bay, Hawaii over the past 13 years has shown an approximate ten-fold increase in this population. Along with the increased numbers, we have noted changes in foraging and resting behavior at this location (Balazs *et al.*, 2000; Balazs, 1996; Rice and Balazs, 2000; Harrington *et al.*, This volume). Of particular note is the increase in the number of turtles that are emerging to bask ashore. Whittow and Balazs (1982) conducted the most extensive study to date of basking green turtles at East Island, French Frigate Shoals in the Northwestern Hawaiian Islands. Their work with adult females and males showed that the animals basked in areas exposed to trade winds, apparently to reduce thermal stress. Basking turtles also exhibited certain behaviors such as flipping sand onto their carapace in order to keep their internal body temperature below harmful levels. The reasons presented for basking behavior at French Frigate Shoals include safety from predators, an increased rate of digestion and egg maturation for the adult females involved in nesting at this important breeding site. Balazs (1974), working with 121 captive post-hatchling

green turtles, noted frequent basking behavior on emergent tiles placed at either end of a holding tank. "On occasion the blocks were so crowded with basking turtles that the animals were lying one on top of the other." The behavior observed at Kiholo Bay may be a natural one precluded by outside factors (hunting by man) until recently.

At Kiholo, green turtles normally rest nocturnally underwater in the enclosed four hectare lagoon with a narrow entrance channel known as Wainanali'i lagoon. Work done at Kiholo between 1987 and 1994 saw no evidence of basking (Balazs *et al.*, 2000; Laber and Waller, 1994). Since that time, the number of basking turtles observed has climbed dramatically to where it is now considered a normal behavior. This study examined the ecology and behavior of the basking turtles at Kiholo in an effort to understand their characteristics and significance to overall sea turtle life history strategies.

METHODS

Basking behavior was monitored by observers on 17 days between October 1999 and February 2000. There were

a total of 116 hours of observations. Basking episodes were counted when the duration was at least 10 minutes and at least one-half of the turtle's body was out of the water when basking commenced. Times of emergence, prevailing weather conditions, tide level, environmental temperature (Te), substrate temperatures (Ts) near basking turtles and carapace temperatures (Tc) of basking turtles were recorded approximately every 30 minutes, when it was possible to do so without disturbing the turtles. When turtles returned to the water, the time and the reason for the return were recorded. The deep-body temperature (Tb) was taken after varying basking durations, and under varying environmental conditions with a Cole-Parmer Digi-Sense thermister thermometer (model 8522-10). The lubricated flexible probe was inserted at least 15 cm into the colon to reach the deep-body regions. Ts and Tc were taken from a distance with an Omegascope OS530 series hand held infrared thermometer and Te was estimated using a black globe (Casella and Co., London) painted with Nextel Black Velvet Coating (Minnesota Mining Co.) suspended approximately 5 cm above the substrate. This distance was an approximation of the midpoint of the turtles' bodies. The rationale for the use of the black globe was presented by Whittow and Balazs (1982). Breath-hold intervals were measured by viewing continuous video tapes of the basking animals. This was necessary because the small respiratory movements made by basking turtles were nearly unobservable. Individual turtles were identified by numbers lightly etched into the left and right second lateral scutes.

RESULTS AND DISCUSSION

The lagoon is salt water with a substantial amount of fresh ground water running into it. The surface water (down to ~0.5 m) has a temperature between 20-22°C and a salinity of 8 - 15 parts per thousand (ppt). The subsurface water (>0.5 m) has a temperature of 24-26°C and a salinity of 28-30 ppt. Sea water outside of the lagoon is 28 to 36 ppt. Basking behavior was observed only within the confines of the Wainanali'i lagoon, and two interconnected mixohaline tidal fish ponds at Kiholo (Harrington *et al.*, This volume). The north side of the pond is solid basalt and the south side is composed of basalt rocks and boulders with a small sand beach at the southeast end. The highest concentration of basking was found to occur in the southwest half of the lagoon where the largest turtles haul out. Smaller turtles do use the north side by hauling out on the solid basalt rock, a difficult task for the larger subadults. Basking was initiated during the daylight hours only, although basking did extend into the night on many occasions. However, when turtles were resting in shallow water and the tide went out, leaving them dry, they remained in place. There was a peak of basking activity in the mid-morning (0900 and 1000 hours) and then again in the early afternoon (1300 and 1400 hours).

Duration

The length of basking episodes was found to vary greatly. The 35 complete basking episodes recorded had an average length of 2.6 hours (± 0.41 , range: 13 minutes to 11 hours). The longest recorded basking period was 11 hours, but there were turtles that basked for more than 11 hours but were not observed reentering the water. Based on three nights of observation, the average number of turtles that continued basking after sunset was four.

Site Utilization

As is the case with the known green turtle's diel foraging and resting behavior at Kiholo Bay, basking site selection by individual turtles was quite predictable. We are not yet able to predict when a turtle will bask, but in cases where we have identified individuals (lightly etched carapace numbers or natural physical characteristics), we could usually predict where they would bask. Most turtles we have identified basked repeatedly within a few meters of a given site unless there was a disturbance or other turtles occupying the area. In some instances, the turtles will return to the exact same spot (within an area of 0.5 m²).

Basking Frequency

Turtles that were captured and marked could be identified during subsequent basking episodes. There were 12 carapace-numbered turtles that were found basking in the lagoon subsequent to their in-water capture and marking by us. Based on the number of times that they were observed basking, and the total number of observations, a rough estimate of the basking frequency was made. On average, a specifically numbered turtle was found basking on every third observation. Observations indicate, however, that basking tends to occur in episodes with a turtle basking on several consecutive days and then not basking at all for several days. More data are needed. The average basking episode lasted 2.6 hours and occurred on the average of once every three days. Thus, an average of 3.6% of the turtles' time is given to basking behavior. Work done at Punaluu (Rice *et al.*, 2000) showed that a turtle there utilized 3.2% of its time in basking behavior. Adult turtles studied at French Frigate Shoals were estimated to spend 4.6% of their time basking (Whittow and Balazs, 1982).

Behavior During Basking

Turtles that were hauled out and basking were generally very still with their eyes partially open. As the basking episode progressed, their degree of alertness decreased and many closed their eyes and remained oblivious of most stimuli. In some cases, the animals appeared comatose even after they were captured for deep-body temperature measurements, indicating that they were indeed in a state of deep "sleep." These animals would lie absolutely still throughout the duration of the basking episode, moving only slightly to take a shallow breath. Breathing during these basking episodes did not involve the usual raising of

the head to take in air. The turtles would, in many cases, not raise their heads and could only be observed to breath by watching the carapace rise. Breath-hold duration varied a great deal between animals and during individual basking episodes. The average breath-hold duration for a large turtle was 3.0 minutes (± 0.43 , $n = 7$) and 4.1 minutes (± 1.24 , $n = 11$). The average for a medium size turtle was 3.1 minutes (± 0.05 , $n = 6$) and 1.2 minutes (± 0.07 , $n = 44$). For a small turtle (carapace #2, 7 kg), the average was 4.8 minutes (± 1.6 , $n = 11$) with a range of 26 seconds to 15.4 minutes on one occasion. In a subsequent 50 minute count (on a different day) for the same turtle, the average period of apnea was 1.5 minutes (± 0.06 , $n = 35$).

Temperature Regime

Substrate and environmental temperatures were recorded approximately every 30 minutes during observations of basking behavior. These temperatures were compared with deep-body temperatures recorded from basking turtles. The average deep-body temperature (T_b) of turtles that were basking for at least 3 hours (between 0800 and 1700 hours) was 30.3°C (± 0.74 , range = 26.9°C to 34°C). Average carapace and environmental temperatures were 33°C (± 0.67) and 35.7°C (± 0.45), respectively, for the same time period. The surface temperature of the water in the lagoon was 20 - 22°C and the subsurface temp was 24-6°C. Within two hours, basking turtles could warm up internally to as much as 10°C above ambient temperature, depending on environmental conditions. They appear to reach thermal equilibrium between 32-34°C. Since this study was conducted during the fall and winter months in Hawaii, environmental temperatures were lower than would be expected during the summer months. None of the animals measured had T_b s that were critically high (Lutz and Musick, 1996) and, as a consequence, we believe that few of the turtles returning to the water were stimulated by overheating. This may not be so during the warmer months at Kiholo Bay. At night, T_b was lower depending on the amount of time after sunset and the size of the turtle. We speculate that the turtles remain out of the water after dark because they have a positive deep-body heat bank which takes hours to dissipate and reach equilibrium with T_e . The external temperature of the carapace of these turtles drops very rapidly in step with the decreasing environmental temperature. While more data are needed, there is a steady decline in T_b over time in the evening, and the length of night basking is dependent on the time it takes T_b to decrease to near ambient water temperature. Once that is reached, the animal is stimulated to return to the water. The recent deployment of remote, interactive video cameras (SeaTurtleCam) at Kiholo Bay will significantly enhance our ability to learn more about the basking phenomenon at this special place (Balazs *et al.*, This volume).

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Deformities in Hatchling Olive Ridleys

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The study in the deformities in hatchling olive ridleys starts like an anxiety of knowing more about the biology of these individuals, and because of the little information that exists about this topic, the external and internal factors that could be affecting in its embryonic development. Since here a little study took place in the Tortugario of the Monterrico Natural Reserve in the Pacific coast of Guatemala, with the hatchlings of *Lepidochelys olivacea* (olive ridley). Basically the study consists of direct observations of the deformities of the hatchling, and the percentage of hatchling with these deformities, and

between them.

From 8000 eggs that were incubated, we had 7560 hatchlings from which 0.57% presented any kind of deformities. It could be mentioned that 21 individuals present the right side of the carapace destroyed, nine present one of the front fins shorter than the other, seven present the left side of the carapace destroyed and six the carapace destroyed in the central part. These are primary results and could be used to initiate a better monitoring program of the hatchlings, to know more about these deformities and the cause of them.

Use of Serum Testosterone to Evaluate the Sex of Juvenile Hawksbill Sea Turtles Inhabiting Buck Island Reef National Monument

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INTRODUCTION

The hawksbill, *Eretmochelys imbricata*, is an endangered sea turtle, which is well known for inhabiting coral reef environments. Buck Island Reef National Monument is major nesting area for hawksbills in the Caribbean and is also a developmental habitat for juvenile hawksbills. Buck Island Reef National Monument consists of an undeveloped island and its surrounding reef area. The island is located approximately 2 km north of St. Croix in the U.S. Virgin Islands and is administered and protected by the National Park Service (Hillis, 1990). For these reasons, Buck Island Reef National Monument is an optimal location for sex ratio studies, given that it represents a natural and unexploited nesting beach and foraging ground for hawksbill sea turtles.

Sea turtles possess temperature-dependant sex determination or TSD (Mrosrovsky, 1994). The sex ratios resulting from TSD are of conservational interest since they can affect the recovery of an endangered population (Mrosrovsky, 1983; Hanson, 1998). Further, knowledge of naturally occurring sex ratios is a prerequisite to understanding the ecological and evolutionary significance of TSD (Bull and Charnov, 1989). The purpose of this study was to estimate the sex ratio of juvenile hawksbill sea turtles inhabiting Buck Island Reef National Monument. To accomplish this, serum testosterone level was used as a method of predicting the sex of juvenile turtles.

METHODS

Blood samples were collected from foraging juvenile hawksbills caught on the reef surrounding Buck Island. Blood samples were obtained from turtles captured during 1996 through 1998. Whole blood cells were separated from the serum using a centrifuge, and the serum was frozen and shipped to the University of Alabama at Birmingham (UAB), and then were stored at -80°C to prevent degradation.

A radioimmunoassay (RIA) was utilized to determine levels of circulating testosterone in juvenile hawksbills. Testosterone was extracted from 250:1 of serum in each of the samples using three ml of ethyl ether. The testosterone RIA was conducted in a fashion similar to that described by Wibbels et al. (1987), using antisera obtained from Wein Laboratories. Standard tubes were prepared with 100:1 of testosterone (Sigma Chemical) at known concentrations ranging from 1.56 pg/ml to 200.0 pg/ml, while sample tubes received 200:1 of the extracted serum. One hundred to one aliquots of a 1:10 dilution of testosterone antibody and 3H-testosterone were added to the extraction and standard tubes, and were then incubated overnight at 4°C . Following incubation, 1 ml of dextran-coated charcoal was added to each tube to absorb the unbound testosterone. The tubes were vortexed and incubated for 15 minutes at 4°C , then centrifuged at high speed for 15 minutes at 4°C . The bound testosterone was poured off into liquid scintillation vials to which three milliliters of scintillation cocktail was added. The samples counted on a scintillation spectrometer. The counts were used to generate a standard curve for the assay and estimate the testosterone level in each sample.

To validate the RIA, juvenile hawksbill serum samples from two Caribbean habitats located in Panama and Mona Island, whose sex was previously verified by laparoscopy, were examined using the assay described above. The samples were assayed in a blind fashion, where the sexes were unknown to the assayist. Based on the values obtained in the assay, a sex was assigned to the samples. The estimated results were then compared to the laparoscopy data, which gave a known sex to a given set of values in the assay.

RESULTS AND DISCUSSION

Seven female and 13 male juvenile hawksbill samples whose sex was verified through laparoscopy were used to estimate ranges for male and female testosterone levels. The testosterone levels of the female turtles were

consistently lower than those of the males. Female samples were observed in the range of 63.61-88.66% bound (when extracting 250:1 of serum), and respectively ranged from 24.71-203.56 pg/ml, while male turtles are represented by a percent bound ranging 8.24-54.2% and testosterone concentrations from 290.5-1120.13 pg/ml. The ranges of male and female testosterone levels did not overlap. Based on these ranges, juvenile samples of unknown sex were assigned a sex based on their measured testosterone levels. Any samples that fell in the intermediate area between male and female ranges were not assigned a sex.

Forty-two individual juvenile hawksbills have been analyzed in this study to-date. Thirty samples were predicted to be female, ten were predicted to be male, and two fell into the intermediate area and were not assigned a sex. These results indicate a female-biased sex ratio of three females: one male (n = 40) at Buck Island Reef National Monument. These data support previous sex ratio studies conducted at Buck Island which employed histology-based studies and monitoring nest temperatures to estimate hatchling sex ratios (Wibbels *et al.*, 1999). Similarly, female-biased sex ratios of hawksbill hatchlings from Brazil have recently been reported by Godfrey *et al.* (1999). Overall, the results suggest a female bias in the group of juvenile hawksbills inhabiting Buck Island Reef. Additionally, the results indicate that testosterone level provides a practical and effective means of estimating the sex ratios in the immature portion of a sea turtle population.

Continuation of this study will provide a larger foundation upon which the overall sex ratio of juvenile hawksbills at Buck Island Reef National Monument will be based. Future studies will include evaluation of additional samples and evaluation of sex ratio by size class and time of year.

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Reproductive Endocrinology of the Leatherback Turtle, *Dermochelys coriacea*

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The reproductive endocrinology of the leatherback turtle (*Dermochelys coriacea*) was studied. Blood samples were collected from 124 nesting turtles during the 1996-97 and 1997-98 nesting seasons at Las Baulas National Park, Costa Rica. Plasma testosterone, estradiol, progesterone and corticosterone levels were measured by radioimmunoassay. Hormone levels were correlated with nesting event and relative reproductive condition.

Testosterone and estradiol levels declined over the course of the nesting season. Progesterone levels were more variable over the course of the nesting season. Corticosterone levels also decline slightly throughout the course of the nesting season and did not indicate any signs of elevated stress. These results further contribute to our understanding of the reproductive biology of the leatherback turtle.

Long-Term Trends in Reproductive Characteristics of Loggerhead Sea Turtles on Wassaw Island, Georgia, USA

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INTRODUCTION

The southeastern U.S. is considered one of the most important loggerhead sea turtle (*Caretta caretta*) rookeries in the world (Bowen and Karl, 1996). The majority of loggerhead nesting in this region occurs in Florida and approximately 10% of the population deposit their eggs on barrier island beaches north of Florida (Dodd, 1988). These relatively small islands allow biologists to develop and implement research practices and monitoring efforts that may not be considered cost effective or feasible on larger beaches where turtles nest en masse (Richardson, 1999). Thus, Georgia supports three of the longest running saturation tagging programs in the U.S: the J.I.A. Turtle Project on Jekyll Island (sporadic since 1958, continuous since 1969); the University of Georgia/L.C.I.T. Turtle Project on Little Cumberland Island (continuous since 1964); and the Caretta Research Project on Wassaw Island (continuous since 1973).

The Georgia barrier islands remain in a relatively natural state because of their inaccessibility and the good stewardship of those who have owned them (Johnson *et al.*, 1974). However, the future development of the coastal region of Georgia is now of major public interest. Various proposals for dredging, mining, recreational development, and preservation have stimulated much controversy in the press and at public hearings. It has become an important goal for sea turtle biologists and government agencies to accurately assess the status of the apparently declining loggerhead sub-population north of Florida (Marine Turtle Expert Working Group, 1996). Data collected by long-term saturation tagging projects has become increasingly valuable to government agencies for developing updated management plans for different loggerhead sub-populations (Marine Turtle Expert Working Group, 1996). However, much tagging and nesting information regarding the nesting habits of reproductive female loggerheads north of Florida remains largely unpublished (Witzell, 1998). A summary of the long-term saturation tagging data collected from nesting loggerheads on Wassaw Island, Georgia from 1973-1999 is presented.

METHODS

Wassaw Island was patrolled May through August from dusk through dawn for nesting loggerheads. Patrol teams only approached turtles once nesting had begun. Turtles were measured, checked for PIT and flipper tags and/or scars and, if not tagged, tagged appropriately. Nests that were considered to be in ideal locations were left in situ,

while nests that were deemed in danger of tidal inundation were either relocated to areas higher up in the dunes or moved to an open air, self release hatchery on the beach. Both in situ and relocated nests were protected with galvanized screening to deter animal predation. Nests were monitored daily throughout their incubation for signs of predation, erosion, or hatchling activity. Nests were exhumed three days after first emergence. Nest contents were examined to determine the hatching success.

RESULTS AND DISCUSSION

Long-term trends on Wassaw Island were compared to Richardson's (1978, 1978, 1981) data on Little Cumberland Island, GA. Differences between the historical data sets may be explained by the difference in beach length, as LCI (~4 km long) is considerably smaller than Wassaw Island's beach (~11 km long) and there is a greater possibility of seeing more turtles on a shorter beach; the establishment of another long-term tagging project just north of LCI on Jekyll Island, which would allow for the increased number of observed immigrants on LCI per season and decrease the average number of neophytes observed (there are no long-term saturation tagging programs neighboring Wassaw Island); and a high recruitment rate of new turtles into the nesting population.

SUMMARY

The Caretta Research Project has been successful in contributing twenty-seven years of continuous tagging data on Wassaw Island. This long-term, consistent database will prove to be invaluable to governmental agencies in order to evaluate present policies and develop more effective species management and conservation practices. Tagging databases can also be used to complement various kinds of sea turtle research. Improvements in our methodologies have resulted in more accurate evaluations of population structure and nesting trends as our ability to encounter and identify individual turtles has increased. Collaborations with institutions and individuals working on islands adjacent to Wassaw are imperative if we are to maximize the amount of information that can be collected as a result of saturation tagging. Additionally due to the dynamic nature of the Georgia barrier islands, it is quite possible that individually marking turtles may be our best means for monitoring the unpredictable redistribution of nesting efforts by loggerheads.

ACKNOWLEDGMENTS

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Relationship Between the Environmental Temperature and the Nesting of the Kemp's Ridley Sea Turtle

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INTRODUCTION

Temperature is one of the environmental variables with more influence in the physiology of the reptiles. In the case of the marine turtles, the temperature of the water affects their distribution and migrations. On the other hand, the eggs deposition of Kemp's ridley turtle is diurnal, and it is possible that the variations of the air temperature have influence in the nesting behavior.

The objective of this paper is to correlate the monthly and weekly abundance of nests in the nesting zone of

Rancho Nuevo (coordinates: 23-24°N and 97.25-98°W) with the sea surface temperature (SST) from migratory corridors and nesting zone and with the air temperature (AT) of the nesting beach.

This paper has two sections, in the first the features of sea surface temperature (SST) is described and in the second those from air temperature (AT). In both some aspects of the relationship between SST and AT with the abundance of the nests are included. Both sections have their own methods and results. At the end of the abstract a general discussion is included.

Sea Surface Temperature

The sea surface temperature in the western continental shelf of the Gulf of Mexico (GM) is influenced by the interaction of several oceanic and meteorological process (White and Downton, 1991; Sturges, 1993). The variations in space and time of the SST between the coordinates 21-27°N of this region, during winter and spring between 1989-1993 and 1996-1998 were described.

METHODS

The data of the abundance of nests during 1989-1993 come from the Natural Reservation (30 km) and those of 1996-1998 from the whole protected zone along from Barra de Chavarría to Soto la Marina (90 km). Monthly and weekly mean values of multichannel sea surface temperature (MCSST) data calculated from the NOAA Advanced Very High Resolution Radiometer (AVHRR) were used. The sources and features of images are in the Table 1.

The data of temperature were extracted along seven straight lines or transects drawn over parallels 21-27°N on every monthly image using the GIS IDRISI v.2 Windows. These values were used in statistical analysis to describe the distribution of temperature over migratory corridors and the nesting beach. In order to make comparisons of every transect between years, single factor Analysis of Variance (ANOVA) and Duncan's multiple range test were applied (Zar, 1974). The same procedure was done to compare between transects. Two types of thermal gradients of each transect were calculated: seasonal or gradient winter-spring (GWS) from lapse January-July; and spatial (GS), calculated along every transect. Both were estimated with a simple linear regression equation, assuming that the slope was equivalent to the gradient. The difference (D Temp) between serial months was obtained subtracting monthly mean data of every transect from January to July. Mean temperature, thermal gradients (GWS and GS) and the difference (D Temp) obtained from each transect were related with monthly data on the number of nests using a simple linear correlation analysis. The mean temperature of a polygon (TP) drawn over monthly and weekly images was calculated (23-24°N and 97.75-97.25°W). It had a surface of 5054 km² and includes the continental shelf that is in front of nesting beach.

The frequency distribution curves of nesting over a gradient of temperature were done with the abundance of the nests on the beach and the TP. Both weekly and monthly frequency curves were done. The data were adjusted using the equation of the normal distribution and the method of no-linear optimization GRG2 of Lasdon and Warren included in the SOLVER function of the EXCEL worksheet (Microsoft, 1997). If any frequency distribution was polymodal, it was split into separate normal distributions with Battacharya's method (Sparre, 1985)

RESULTS

A front like a plume is recognized in all of images of the periods November-April and June-September. Its vertex is between parallels 23°-24°N and it parts from the coast with a NE direction. The spatial and time variations of this front define some of the latitudinal changes of SST on the continental shelf. Northward from parallel 24°N the SST was lower, meanwhile GWS and GS were greater than southward this parallel.

Spatial gradients changed also according with the characteristics of the front. They were greater when temperature was colder near the coastline than on the external border of the continental shelf.

Relation Between SST and the Nesting

Monthly frequency distribution of nesting over a gradient of temperature (1989-1993) shows that nesting is more frequent near to 26.5 °C, nevertheless with the weekly values (1996-1998) two peaks are observed, the first around 23°C and another one between 25-27 °C. However, the last is less evident than the first.

The monthly distribution of the nests on the beach showed inter-annual differences and they were significantly correlated with temperature, seasonal thermal gradients (GWS) and differences between March and April (D Temp). The sign of the regression's slopes suggests that in those years when the magnitude of these variables is high, the number of nests is greater in April and diminish toward the end of the nesting season (June-July). These results also seem indicate that the number of nests registered in May is less dependent on the temperature, nevertheless it is possible that there is weekly or daily variations that must be analyzed later on.

The slopes' signs of regression equations calculated between the GS of the parallels north of 24°N and the number of nests were negative. At this moment it is not possible to elaborate any explanation with the available data.

Air Temperature

In this section, we show the trend of temperature anomalies and between 1979 and 1998 and summarize the results of the identification of daily and annual cycles in order to elaborate hypothesis about the relationship between the nesting and the temperature. A complete description of temperature cycles and time series methods has already been given (Jiménez *et al.*, 2000).

The temperature data of two weather stations located on the limits north (Soto la Marina) and south (Punta Jerez) of the nesting zone was submitted to time series analysis. Also curves of frequency of nesting over an air temperature gradient (curves of tolerance) were done with the daily mean temperature registered on Rancho Nuevo camp in the nesting months between 1981-1985 and the nesting data of same days.

METHODS

The standardized anomalies of temperature from Soto la Marina were calculated from 1979 to 1998. Their trend was estimated with an analysis of simple linear regression; this technique was also applied to relate the annual anomalies and the annual number of nests.

The spectrum analysis, a kind of time series analysis was done with monthly and daily mean temperature (Jenkins and Watts, 1969; Konyaev, 1990). Data of Soto la Marina (SM) were used at both time scales. Punta Jerez (PJ) at monthly scale only.

The daily cycles were calculated from spectrum made with the data obtained between March 1 and August 31 of every year of the lapse 1979-1996. With the yearly calculated spectrums a mean spectrum was obtained. The daily frequency of the nesting was analyzed with spectrum analysis like the temperature data. In order to correlate the cycles of temperature with the cycles of nesting, Coherence analysis was applied.

The curve of tolerance elaborated between the temperature of Rancho Nuevo and the number of nests on the beach was adjusted of similar way to the elaborated with the SST.

RESULTS

The trend of the thermal anomalies during the period 1978-1998 has been growing. The time series analysis detected four types of long and medium term cycles in the spectra of frequencies of temperature from SM and PJ: eleven years, 2-7 years related with El Niño-Southern Oscillation (ENSO), annual and half-year. To this scale only is described the possible effect of ENSO on the region .

ENSO affects the whole zone of nesting and possibly the feeding grounds of the North of the Gulf of Mexico and the SE of USA (Ropelewski and Halpert, 1986; White and Downton, 1991). Cross correlation analysis of the Multivariate ENSO Index (Wolter, 1987) and the temperature of SM indicates that they are out of phase by approximately five months. It also shows that the winter temperature in SM is lower than the normal after "El Niño".

The time series analysis of daily data of SM showed that the most evident cycles were of 3-7 days. These cycles have been described for other points of the Northeastern and Eastern of the Mexican coast and although the authors don't explain their origin, they seem to be the result of sinoptical events (e.g., atmospheric front passage).

Relation Between AT and the Nesting

The nesting was more frequent near the 27.5°C. But at 23.8°C there was another peak of nesting although in less quantity. The trend of the annual anomalies, like the nesting, has been growing since 1987, nevertheless the increment of the nesting should be consequence of the effort invested in the protection. The influence of the temperature in this

tendency can be important, but in this moment we do not know its magnitude. However, the consequences of the increment of temperature should be varied because this trend has been "accompanied" with the decrement of relative humidity, cloudiness and pluvial precipitation (no included here).

On the other hand, the preliminary results of the relationship between the nesting and Multivariate ENSO Index point out that it is possible that the nesting is more abundant after extreme values of the Niño, as it happened in 1998, nevertheless the information is still scarce. At daily scale the most significant cycles of nesting were of 3-7 days. The analysis of coherence showed that the relationships between the cycles of three and seven days observed in the nesting frequency and the cycles of temperature were significant and that they happened in phase (at the same time). For the characteristics of the 'arribazones' it is possible that these cycles are used to synchronize the massive nesting.

DISCUSSION

The magnitude of both thermal gradients and SST measured over the migratory corridors and the nesting ground have influence to trigger the nesting activity and the monthly distribution of nest on the beach. There is a linear and positive correlation between these variables and the number of nests laid during April.

In both cases, SST and AT depend on global and local events. According to the frequency curves there are two peaks of nesting, the first happens when SST and AT reach 23°C. Maybe this value triggers the nesting behavior and the other 'arribazones' are consequences of a cyclic patterns of the nesting activity. However the coherence of the cyclic patterns of AT and nesting activity indicates that the AT could be a cue that contributes 'the timing' of physiological mechanisms.

In the other hand is possible that the increase of air temperature and the decrease of relative humidity, cloudiness and pluvial precipitation affect the sexual differentiation of the hatchlings and the survival of the embryos.

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Table 1. Characteristics of the images. Images from NOAA were obtained at <http://podaac.wwww.jpl.gov> and the equation converts the digital numbers to valid MCSST values from MCSST User's Manual (Vazquez *et al.*, 1995). Images from INP/ICMyL were obtained with Terascan System installed at the Instituto de Geografía, Universidad Autónoma de México.

Type	No.	Lapse	Frequency	Spatial resolution (km)	Accuracy (°C)	Source
1	60	I 1989-XII 1993	monthly	9	0.3	NOAA
2	42	III-VII from 1996 to 1998	weekly	1.1	0.5	INP/ICMyL

Does Artificial Lighting Determine the Location of Florida's Sea Turtle Nesting Beaches? If So, What Are the Implications?

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INTRODUCTION

Sea turtles characteristically nest at remote sites—those where there are few large predators to threaten the survival of females on land. If those sites also possess characteristics that promote nest survival and hatchling recruitment to nursery areas, then they may eventually become “major” rookeries.

Florida's beaches annually host large numbers of sea turtle nests, especially loggerheads. Most nests (>91%) are placed in the Southeastern portion of the state (Meylan *et al.*, 1995) at five sites: Juno Beach, Jupiter Island, Hutchinson Island, Melbourne Beach, and Canaveral National Seashore (Witherington and Koeppe, 1999). Is this the result of the “natural” processes, that is, those that have governed the selection of major nesting sites in the past? No one knows! And unfortunately there are no good historical data. Thus, while we know that sea turtles have nested in Florida for centuries (Catesby, 1731; Audubon, 1826; True, 1884; Murphy, 1890), we do not know where in

Florida they previously nested in greatest abundance.

Two of us (MS and BEW) became intrigued with the possibility that the present location of major nesting sites in Florida might be shaped by coastal development generally, and artificial lighting (hereafter, lighting) specifically. We made contact with our coauthor (CDE) who, for many years, has used night-time satellite imagery to map human demographic patterns.

A comparison between his images and the distribution of nests on Florida's East coast suggested that the two variables (geography of lighting and nesting density) were spatially related. The following correlations were evident.

1. Nesting by loggerheads, leatherbacks, and green turtles on Florida's East Coast is geographically localized. Most nesting occurs primarily between 27-29°N latitude (between West Palm Beach and Canaveral National Seashore).

2. Within those latitudes, most nests are placed on the same beaches. Loggerheads and green turtles nest in abundance at the same locations. Leatherbacks nest

primarily at sites to the South (Juno Beach, Jupiter Island, and Hutchinson Island.). However recent reports (Ehrhart, 1999) suggest that nesting densities are increasing substantially at some northern beaches (such as Melbourne Beach).

3. At the major nesting sites, there is little coastal lighting. In fact, a substantial proportion of the increase in nesting at these sites may reflect two trends: (i) an increase in nesting state-wide, and (ii) a tendency of the turtles to avoid other locations where coastal development (and exposure to lighting) is on the increase.

COASTAL LIGHTING AND THE DISTRIBUTION OF NESTS ON INDIVIDUAL BEACHES

What Are the Implications?

1. The major nesting beaches in Florida might be located at sites that fail to optimize hatchling survival because they are chosen on the basis of “unnatural” criteria.

Over most of their long history, the presence (or absence) of artificial lighting has not determined the selection of nesting beaches! Other physical and biological factors are involved (review: Mortimer, 1981).

One of these is proximity to major ocean currents—those that can promote the transport of hatchlings to, and the survival of juveniles within, open ocean nursery habitats (Collard and Ogren, 1990; Musick and Limpus, 1996). Because of its proximity to the Gulf Stream, the southeastern coast of Florida is probably a “prime” nesting area. Nesting loggerhead, leatherback, and green turtle populations are gradually increasing there, which is reason for cautious optimism. But we don’t know whether that increase might be faster if nesting occurred at other locations on Florida’s east coast, or if nests were distributed more evenly over the same geographic area.

2. Nest “concentration” within a few dark sites could increase as a consequence of future coastal development.

If current trends in coastal development continue, the proportion of nesting that occurs among the few remaining dark sites might increase. Such a trend concentrates nesting (and hatchling production) within localized areas. Recent studies suggest that aquatic predators congregate at locations where large numbers of hatchlings enter the

ocean (such as on-the-beach hatcheries; Wyneken and Salmon, 1996 and 1997). Rates of aquatic predation (currently unknown) at major nesting sites might already be proportionally higher than those at minor nesting sites (where they are low; Witherington and Salmon, 1992). The concentration of nesting at a few locations also increases the potential impact of major storms (hurricanes) that by chance could strike at dense nesting locations.

Our management strategies should continue to focus upon lighting problems. Since it is unlikely that Florida’s coastal development can be halted, we must instead attempt to minimize its impact. General guidelines and specific actions are outlined by Witherington and Martin (1996). To these we add the following:

- Protect existing refuges from encroaching development in the surrounding area.
- Promote the development of additional parks and wildlife refuges.
- Enhance the value of nesting surveys by plots of nest locations, and make routine the completion of annual lighting inspections. These data are essential for establishing “baselines”. Baselines, in turn, make it easier to identify changes caused by lighting, and to devise evaluate lighting modifications designed to solve these problems.

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Spatiotemporal Distribution of Marine Turtle Nests in South Brevard County (Florida, US) and the Archie Carr National Wildlife Refuge 1989-1999

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The Florida coastline from Melbourne Beach to Wabasso Beach is the most important nesting area for loggerhead turtles (*Caretta caretta*) in the Western Hemisphere. More than 25% of loggerhead and 35% of

green (*Chelonia mydas*) turtle nests in the United States occur here. Why turtles nest on some beaches and not others is speculative. Potential marine factors include: smell, low-frequency sound such as surf noise, magnetic

fields, characteristics of offshore currents, and the presence of offshore reefs. Potential terrestrial factors include: beach slope, sand texture, dune vegetation, artificial lighting, and other human activities. Furthermore, whether these navigation cues are learned as hatchlings or as adults is unknown. Thus, present nesting patterns may reflect conditions from past decades or centuries. In this study, we quantified the annual spatial distributions of nests over the last decade in terms of their autocorrelative properties along a 40.5 km stretch within this critical reproductive zone. Such spatial analyses allow for an interpretation of behavioral patterns in relation to

environmental parameters and can be critical for developing management principles that may guide land acquisition for reserves. Nesting patterns of loggerhead and green turtles were non-random, favoring the southern half of the study area. Perhaps due to low numbers, leatherback (*Dermochelys coriacea*) nests were not different from random for most years. Loggerhead and green turtle nests exhibited similar clinal patterns. They were positively autocorrelated at distances less than 10 km and negatively at distances greater than 30 km. These patterns were significantly correlated interannually.

Evaluation of the Pivotal Temperature in the Production of Sexes of Leatherback Turtles in the Monterrico Natural Reserve, Guatemala

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The present investigation took place in the Tortugario of the Monterrico Natural Reserve, natural area for the conservation of flora and fauna, located southeast of the Republic of Guatemala along the coastal line between Taxisco and Chiquimulilla, Santa Rosa.

The Centro de Estudios Conservacionistas-CECON- from the Facultad de Ciencias Químicas y Farmacia of the Universidad de San Carlos, since 1979 administrate the area, which is a wetland of big importance because of its hydrological, biological, and ecological significant value.

The investigation tries to stable a technique for the incubation of leatherback eggs, in which you can obtain the biggest percentage of hatchlings, evaluating the pivotal temperature in the proportion of sexes. Twenty-eight nests of 15 eggs each were located in the sand for incubation at different depths: 23 cm, 33 cm, 43 cm.

The temperature was monitored daily three times a day (6:00, 12:00, 18:00), also the curved carapace length of the hatchling. Cesar Augusto Flores contributed in the effect of the study.

Continued Thermal Monitoring of Praia Do Forte, Bahia, Brazil

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INTRODUCTION

Sexual differentiation in sea turtles is determined by the temperature of the eggs during the middle third of incubation. This system of interest in both theoretical and practical terms, because the sex ratio of hatchlings produced by a nesting population has the potential to be far different from the one male to one female ratio predicted by the traditional theory of parental investment in offspring (Fisher, 1930). In practical terms, sea turtle management and conservation projects sometimes involve the manipulation of eggs or their incubation environment, which can alter the sex ratio by changing the thermal environment, either directly or indirectly. For these reasons, amongst others, it interesting to study the seasonal pattern of sex ratio production of sea turtle hatchlings on different nesting beaches.

In terms of the sea turtles nesting on mainland beaches in the state of Bahia, Brazil, previous estimates for loggerhead and hawksbill hatchling sex ratios have suggested a bias heavily skewed (>80%) towards females (Marcovaldi *et al.*, 1997; Godfrey *et al.*, 1999). These estimates were derived from data on pivotal incubation duration and incubation periods, and were validated directly by a limited study based on histological analysis of gonadal development of loggerhead hatchlings (Mrosovsky *et al.*, 1999), and indirectly by a limited study of sand temperatures on nesting beaches (Naro-Maciel *et al.*, 1999).

However, it is known that seasonal sex ratios of turtle hatchlings can vary widely over years (e.g., Janzen, 1994; Godfrey *et al.*, 1996). Thus, whenever possible, long-term

monitoring of sex ratios, either directly or indirectly, should be conducted in order to uncover long term variations. In this spirit, we have continued to monitor the thermal environment of the nesting beach at Praia do Forte, Bahia, which is one of the main nesting areas for loggerhead and hawksbill sea turtles in Brazil.

METHODS

For the 1998/1999 and 1999/2000 nesting seasons (which run from September through March), we monitored sand temperatures at two transects on the nesting beach at Praia do Forte. We used the same methodology as Naro-Maciel *et al.* (1999), which is as follows: each transect was comprised of three sites (High, Mid, and Low), each of which was separated by 5-7 m in distance. High corresponds to the vegetation line; Mid corresponds to middle open beach; and Low corresponds to lower beach, close to the high tide line. At each site, we deployed Cu/Cn thermocouple probes at 30 cm and 60 cm depths, which is similar to other sand temperature monitoring projects (Mrosovsky and Provancha, 1992; Godfrey *et al.*, 1996; Baptistotte *et al.*, 1999; Naro-Maciel *et al.*, 1999). The thermocouples were left in place the duration of the nesting season. Occasionally, thermocouples were replaced due to loss or damage, and in some cases, monitoring was halted due to excessive erosion by high tides.

The thermocouples were read at 07:30 am, ± 60 minutes, a minimum of five times per half month period. These readings were converted to mean daily temperature by adding a correction factor. The correction factor was

derived by recording temperatures every three hours for a 24 hour period, and comparing the mean of all readings with the value at 07:30 am. Several "around the clock" readings were carried out during the two seasons, and the correction factors for the daily 07:30 am readings were matched with the nearest "around the clock" reading. The thermocouples and digital reader (BAT-12, Omega Corporation) were calibrated against a mercury thermometer which turn was calibrated against a certified Hg thermometer.

For statistical analysis, comparisons were made for each site and depth between years, using one-way ANOVA, with a Student-Newman-Keuls post-hoc test.

RESULTS AND DISCUSSION

During the 1998/99 sea turtle nesting season in Praia do Forte, sand temperatures at both 30 cm and 60 cm were well above the pivotal temperature of loggerheads and hawksbills (Figs. 1 and 2). The upper limit of the transitional range of temperature (TRT-the range of incubation temperatures which result in both sexes) for loggerheads and hawksbills is 30.6 °C (Marcovaldi *et al.*, 1997; Godfrey *et al.*, 1999); therefore, sand temperatures above this temperature likely produces all females. In 1998/99, for both depths the sand temperature in Km 07 was above the TRT, likely producing all females. For Km 02, the low and mid transects were close to the TRT, so a majority of females were likely to be produced (more than 50%). This conforms to the previous studies which reported warm sand temperatures and short incubation durations, indicative of female-biased sex ratios of hatchlings.

During the 1999/00 nesting season in Praia do Forte, the sand temperatures at both transects and both depths were close to and sometimes below the pivotal temperature for both species (Figs. 3 and 4). The cooler sand temperatures were the result of abnormally frequent rainfall during the months of October, November, and December. Although direct estimates of sex ratio are not possible, it is likely that many more male hatchlings were produced in 1999/00 than in other years, at least during the first half of the nesting season. At the current time, a third of the nests are still incubating on the beach, a majority of which were laid by hawksbill sea turtles. It is possible that warm weather, which is normal for this period of year, during the remainder of the season will result in mostly female hawksbill hatchlings. Continued monitoring will resolve this question.

Statistical comparison between the two seasons showed that for all depths and sites there was a significant difference between the two seasons, except for the low sites at 60 cm depth for Km 02 and also for Km 07. In addition, on average the temperatures of Km 02 were always cooler than Km 07. This is probably due to differences in sand colour and albedo between the areas (Maciel *et al.*, 1999). Normally, the sand temperatures are far enough above pivotal temperature such that this slight

thermal difference between the two areas does not have an impact on sex ratio. However, in abnormal seasons, such as 1999/00, when sand temperatures are closer to pivotal, different thermal characteristics between the two areas may result in different sex ratios.

Although the 1999/00 nesting season likely produced more male hatchlings than normal in Bahia, on average mostly female hatchlings are produced in this areas. This is in contrast to the nesting beaches in Espírito Santo, to the south, where sand temperatures are cooler (Baptistotte *et al.*, 1999) and incubation durations of loggerhead nests are longer (Marcovaldi *et al.*, 1997), which are suggestive of a greater production of male hatchlings. Further south, in the state of Rio de Janeiro, a large nesting population of loggerheads probably also produces a large proportion of male hatchlings, based on limited information of incubation durations in hatcheries (Eron Lima, personal communication). Future studies of sand temperatures in this region are planned.

In the case of hawksbill turtle nests, northern Bahia is home to more than 90% of all hawksbill nests laid in Brazil (Marcovaldi *et al.*, 1999). Normally warm weather conditions produce nearly all female hatchlings (Godfrey *et al.*, 1999); however, abnormally cool seasons that occur occasionally may be critical in producing male hatchlings needed to maintain the population. Studies of gene flow between this nesting population and other populations would reveal if there is interchange among wider populations, or if the number of mating males in the Brazilian population is limited by low male production on beaches in northern Bahia.

ACKNOWLEDGMENTS

Projeto TAMAR is affiliated with IBAMA and co-managed by the Fundação Pró-TAMAR. We thank Domingos for help in the field. Financial support for this project came from Petrobras, FNMA, and the Natural Sciences and Engineering Research Council of Canada. Special thanks to Eugenia Naro-Maciel for donating the temperature equipment to Projeto TAMAR.

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Fig. 1. Sand temperatures recorded at Praia do Forte, Bahia, Brazil, during the 1998/99 nesting season at a depth of 30 cm. The lower histogram is the distribution of loggerhead (filled columns) and hawksbill (empty columns) sea turtle nests with the thermosensitive period for sexual differentiation for each particular half-month period (right-handed axis). Pivotal temperatures come from Marcovaldi *et al.* (1997) and Godfrey *et al.* (1999).

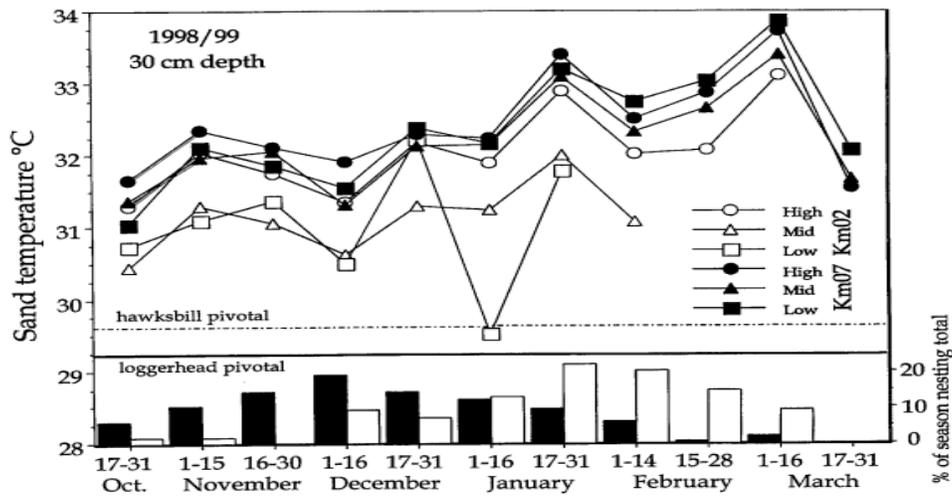


Fig. 2. Sand temperatures recorded at Praia do Forte, Bahia, Brazil, during the 1998/99 nesting season at a depth of 60 cm. The lower histogram is the distribution of loggerhead (filled columns) and hawksbill (empty columns) sea turtle nests with the thermosensitive period for sexual differentiation for each particular half-month period (right-handed axis). Pivotal temperatures come from Marcovaldi *et al.* (1997) and Godfrey *et al.* (1999).

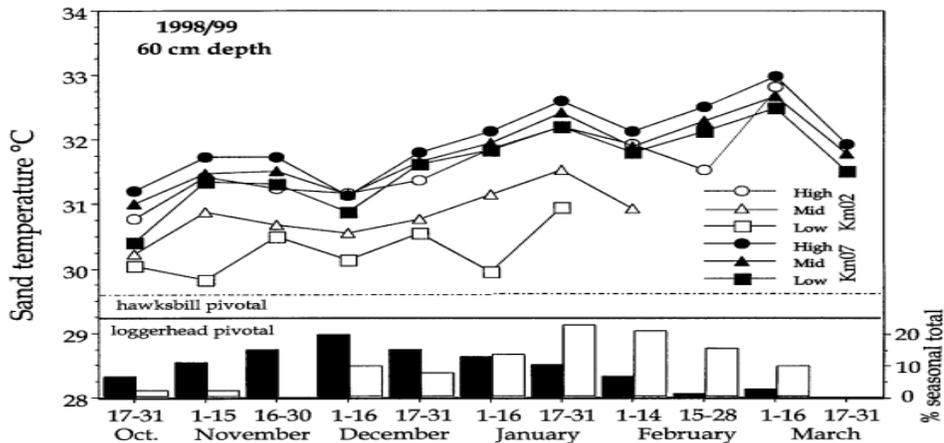


Fig. 3. Sand temperature recorded at Praia do Forte, Bahia, Brazil, during the 1999/2000 nesting season at a depth of 30 cm. At the time of writing, the nesting season was still in progress.

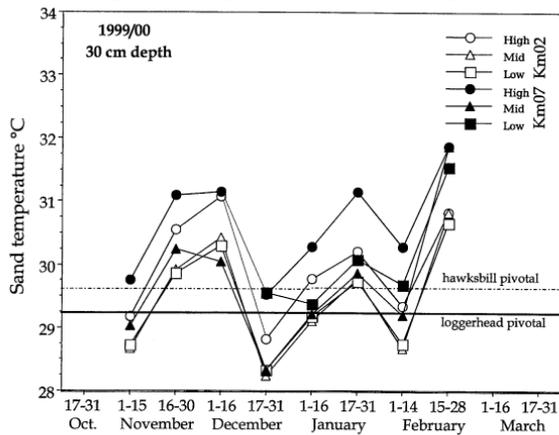
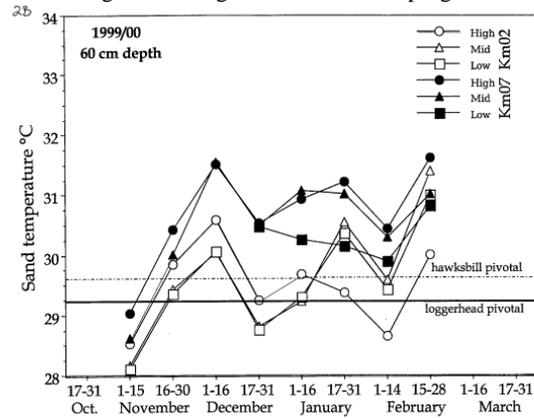


Fig. 4. Sand temperature recorded at Praia do Forte, Bahia, Brazil, during the 1999/2000 nesting season at a depth of 60 cm. At the time of writing, the nesting season was still in progress.



Evaluation of Incubation Temperatures in the Nests of Kemp's Ridley Sea Turtles During the 1999 Nesting Season

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INTRODUCTION

A variety of reptiles, including all sea turtles, possess temperature-dependent sex determination or TSD (Mrosovsky, 1994). Past studies have suggested that TSD has the potential of producing biased sex ratios, and in some cases (e.g., strong male biases), such biases could decrease the effectiveness of sea turtle nesting beach conservation programs (Mrosovsky and Yntema, 1980; Morreale *et al.*, 1982; Mrosovsky, 1983; Wibbels *et al.*, 1989). Therefore, it is advantageous to monitor hatchling sex ratios produced in sea turtle conservation programs. Traditionally, such studies have been conducted by histological examination of hatchling gonads, which requires the killing of hatchlings (Yntema and Mrosovsky, 1980). Several more recent studies have employed alternative methods in an attempt to predict sex ratios without killing hatchlings (Mrosovsky and Provancha, 1992; Godfrey *et al.*, 1996; Marcovaldi *et al.*, 1997; Hanson *et al.*, 1998). Several of these studies have estimated sex ratios based on incubation temperatures in the nests.

The current study is part of a three year project started in 1998 which is utilizing temperature data loggers to examine nest incubation temperatures in large numbers of Kemp's ridley nests over three consecutive nesting seasons. The current study reports the incubation temperatures and predicted sex ratios from nests during the 1999 nesting season. This sex ratio project and the Kemp's Ridley Recovery Program is coordinated by Instituto Nacional de la Pesca (Marquez-M., 1994).

METHODS

Hobo temperature data loggers, Hobo Pro temperature data loggers, and Optic Stowaway data loggers (Onset Computer Corp., Pocomsett, MA) were used to monitor sand temperatures and nest temperatures. They contain a thermistor probe, and at the temperatures common in sea turtle nests, are precise to approximately 0.3°C or better. The data loggers were calibrated in custom incubators which maintain a constant internal temperature of +0.2°C. Prior to use in nests, they were programmed to record temperature approximately once per hour. The data is downloaded by reconnecting the data loggers to a personal computer.

Data loggers were used to monitor sand and nest temperatures in egg corrals at Rancho Nuevo, Tepehuajes, and Playa Dos beaches in the state of Tamaulipas, Mexico. Sand temperatures were monitored throughout the nesting season in all three corrals. This was accomplished by burying several dataloggers at midnest depth (approximately 30 to 35 cm) throughout each corral. These dataloggers were buried during April and recovered in late August. Data loggers were also placed directly into the approximate center of the egg clutches to monitor temperatures within individual nests in the egg corrals at Rancho Nuevo, Tepehuajes, and Playa Dos throughout the nesting season.

RESULTS

The sand temperatures (at nest depth) throughout the 1999 nesting season were similar in all three egg corrals. In general temperatures rose above 30°C by late April, however, several 1 to 2°C decreases in sand temperatures were evident during May (due to variability in weather). During June, sand temperatures ranged between approximately 30 to 33°C. During the 1999 nesting season, temperature was monitored in a total of 87 nests. The nests in which temperature was monitored were laid on dates ranging from early April to mid July, which included the great majority of nesting. Average temperature during the middle third of incubation (i.e., the thermosensitive period) was calculated for each of the nests monitored. The average temperature during the middle was then used to predict the sex ratio of the nest. In nests which received data loggers, nests laid before May 2nd were predicted to produce a variety of sex ratios ranging from male-biased to all females. The great majority of nests laid after that time period were predicted to produce 100% females, although a few nests were predicted to produce a female biased sex ratio (i.e., some males were produced).

DISCUSSION

Several previous studies provide estimates of the effects of specific temperatures on sex determination in the Kemp's ridley (Aguilar, 1987; Shaver *et al.*, 1988). Those studies suggest a pivotal temperature near 30°C (temperature producing a 1:1 sex ratio) and that temperatures of approximately 31°C or greater produce most or all females. Using those data as a reference, nests laid early in the 1999 nesting season (e.g., April) would be predicted to produce a variety of sex ratios ranging from male-biased to 100% female sex ratios, whereas, nests laid during or after early May would be predicted to produce all or mostly females. These predicted sex ratios are based on the average incubation temperatures during the middle third of incubation (i.e., the thermosensitive period). Since Kemp's ridley nesting normally begins in April, extends through May and June, and decreases during July, these data suggest an overall female bias during the 1999 nesting season. These data are similar to those collected during the 1998 nesting season which also suggested a female bias. Thus, during the past two nesting seasons (1998 and 1999), both males and females have been produced, but an overall female bias is indicated.

ACKNOWLEDGMENTS

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other agencies and universities, including the Universidad del Noreste, the Gladys Porter Zoo, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the University of Alabama at Birmingham. This research was sponsored in part by the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, and the Mississippi-Alabama Sea Grant Consortium under Grant # NA56RG0129. This research was carried out under Mexican permits from Secretaría de Medio Ambiente, Recursos Naturales y Pesca Permiso de Pesca de Fomento No.170498-213-03 0982, Secretaría de Relaciones Exteriores Permit No. DAN-02702, Direccion General de Investigacion en Procesos para el Desarrollo Sustentable Official Letter No. AOO-DGIPDS-111, and Secretaría de Hacienda y Crédito Público Official Letter No.326-SAT-II-2711.

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Latitudinal Variation of Sand Temperatures and Sand Colors of Loggerhead Nesting Beaches in the United States and Japan

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Major nesting beaches for loggerhead sea turtles in both the United States and the Japanese Archipelago are distributed within the same latitudinal range of 25-37 degrees North. We compared the latitudinal differences of thermal characters of 17 loggerhead nesting beaches in the United States and Japan. We used data loggers to record

sand temperatures of each rookery every hour throughout the reproductive season in 1999. Sand reflectance was also measured for each rookery with a spectrophotometer. In this paper, we describe these results and discuss the effects of the thermal environment on reproduction and the distribution of rookeries.

Developmental Energetics of the Loggerhead Sea Turtle (*Caretta caretta*) at Gulf Islands National Seashore, Florida

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Preliminary results of developmental energetics in loggerhead sea turtles (*Caretta caretta*) indicate undeveloped eggs have a caloric value of 6800 calories/gram and are 36.1% lipid by dry mass. By stage 28 (approximately 78%) of development (Miller, 1985), the yolk sac is 52.7% lipid and the caloric value has increased to 7547 calories/gram. The embryo at this stage is 30.0% lipid by dry mass and has a caloric value of 6304 calories/gm. These values compliment the results of Kraemer and Bennett (1981) who found that posthatching yolk in loggerhead turtles had a caloric value of 7949 calories/gm. while hatchlings had a value of 6712 calories/gm. The increase in percent lipid and caloric value of the yolk during development indicates that protein is likely the primary component of the egg being absorbed during development.

Protein analysis of undeveloped eggs, developing embryos, and hatchlings is ongoing. Once complete, a developmental bioenergetic profile for loggerhead turtles nesting in northwest Florida will be constructed.

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Early Swimming Behaviour of Hawksbill Turtle Hatchlings (*Eretmochelys imbricata*)

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Emerging hawksbill hatchlings (*Eretmochelys imbricata*) undergo a hyperactive period called the 'swimming frenzy' (Dial, 1987; Wyneken, 1990; Wyneken, 1996). This swimming activity enables hatchlings to move away from reefs and other nearshore habitats in which underwater predators are more numerous and active (Wyneken *et al.*, 1994; Wyneken and Salmon, 1990). The swimming behavior of hawksbill turtle hatchlings has not been documented in any region or study. The present study was carried out to determine the characteristics of the hawksbill hatchling frenzy and postfrenzy period, including duration and behavior them in seawater-filled wading pools over the first six days of their life.

Trials were conducted at Gulisaan Island (6°09'N; 118°03'E), in the Turtle Islands Park, Sabah, Malaysia. A total of 25 hatchlings (20 from the hatchery and five from in situ nests) were observed. Trials were run in two meter diameter and 50 cm deep wading pools filled with seawater. Hatchlings were tethered with a monofilament fishing line, which was in turn connected through a central arm to a copper plate switch which controlled a activity timer (Fig. 1). When the hatchlings were active the switch was closed and the timer was turned on. When the hatchlings were inactive, the switch opened and the timer stopped. The activity (swimming period) was recorded four times daily

for six days after emergence. Hatchlings were fed three times daily at random times after day three. A total of 23 hatchlings were observed for their initial swimming locomotor patterns over 10-20 minutes. Swimming behaviour was noted according to locomotor patterns such as powerstroke, rear flipper kicking and doggy paddle.

Hatchlings actively swam when placed in the experiment pools. Hatchlings only swam about 25% of daytime on day one, but daytime swimming duration increased after the second day (Fig. 2). Swimming activity was highest during daylight hours on days four and five. After the second day, hatchlings were active for only 3-10% of the nighttime hours (Fig. 3).

Hatchlings swam less in their first and second days after emergence than on days three and four, in contrast to the opposite found for green and loggerhead turtles. Hawksbill hatchlings were also less active at night for the duration of the trials. A swimming mechanism dubbed 'rear flipper kicking' was used by 60% of hatchlings (n = 23), while the remaining 40% used powerstroking as their primary locomotor pattern and doggy paddle only when breathing. These findings differ from those of other sea turtle species, and represent a different overall survival strategy for hawksbill hatchlings.

The results indicated that hawksbill hatchlings only

swam for about two hours on their first night at sea. Hawksbill hatchling swimming was unlike the frenzy swimming behavior of green, loggerhead and leatherback hatchlings. Hawksbills were less active on days one to three, but daytimes swimming duration was increased on day four and five, unlike in other species.

Early passive swimming behavior suggests hawksbills are transported away from natal beach by tides or nearshore and oceanic currents until the third day, when hatchlings swam more actively during the daytime.

Whereas green turtle hatchlings use speed and coloration to evade predators in nearshore waters, hawksbills chose to remain motionless until away from the nearshore, predator-rich environments. The “less vigorous” start to hawksbill offshore migration suggests a survival strategy whereby less active or inactive hatchlings attract less attention by predators than active swimmers.

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Fig. 1. Activity timer.

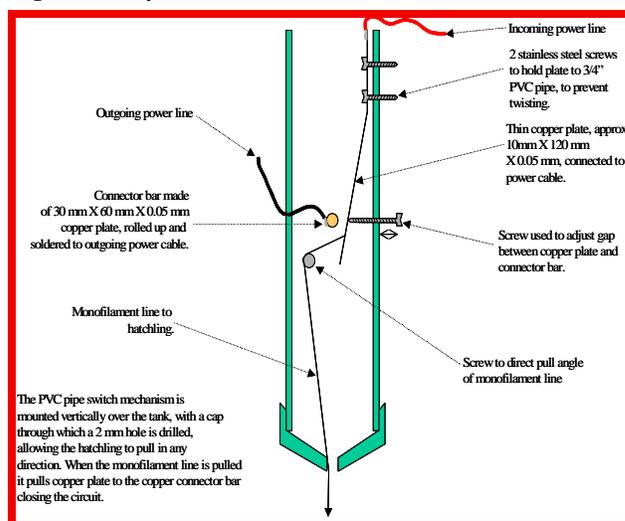


Fig. 3. Swim duration over the first six days for 25 hatchlings (x = means, outliers = range, boxes = standard deviation). Shaded areas represent nighttime hours.

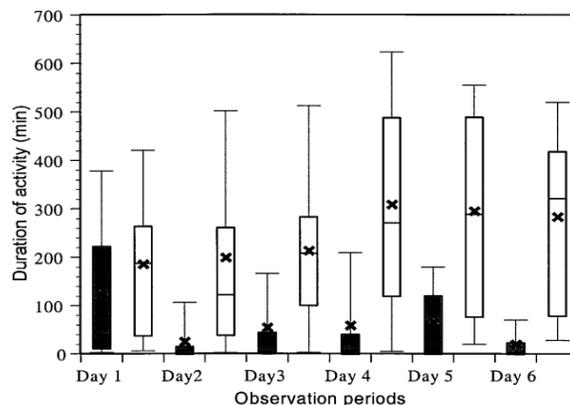
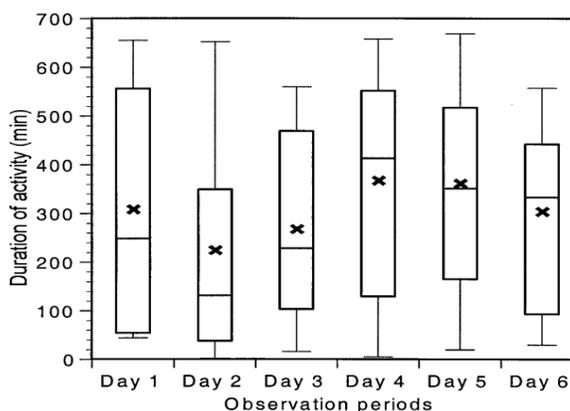


Fig. 2. Total activity for each day (x = means, outliers = range, boxes = standard deviation).



Thermal Tolerances and Timing of Sea Turtle Hatchling Emergence

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Timing of sea turtle hatchling emergence from the nest is important as a major factor in survival of hatchlings, which is the basis for the entire life table of a species. Temperature has long been thought to be the primary factor in timing of sea turtle hatchling emergence from the sand (Neville *et al.*, 1988; Mrosovsky, 1968; Bustard, 1967). In this study we tested the three prevailing hypotheses regarding the role of temperature in timing of hatchling emergence: (1) threshold temperature (Bustard, 1967); (2) rate of temperature change in the upper levels of the sand (Hays *et al.*, 1992; Witherington *et al.*, 1990); and (3) negative thermotaxis in the upper layers of sand (Gyuris, 1993).

We recorded sand temperatures in the sand above emerging nests between 1600 and 0600 at 10 minute intervals at depths of 0, 5, 10, 15 and 30 cm, December 1998 through February 1999, on relocated olive ridley (*Lepidochelys olivacea*), Pacific green (*Chelonia mydas agassizi*) and leatherback (*Dermochelys coriacea*) nests on Playa Naranjo and Playa Grande, Costa Rica. We conducted critical thermal maximum (CTM) tests on hatchlings of all three species, as well as measured body temperatures of hatchlings at various stages of emergence from the sand.

The results of this study indicate that threshold temperature is the most likely of the three hypotheses to affect timing of hatchling emergence. The occurrence of negative temperature gradients in the sand above the nests prior to emergence was low, as was the rate of temperature change in the sand above the nests prior to hatchling emergence. The results suggest the inhibitory or threshold temperature for *D. coriacea* hatchling emergence is 36°C, while 37°C for the *L. olivacea* hatchlings. The predicted inhibitory sand temperatures are well below the CTMs for both *D. coriacea* and *L. olivacea* (40.2°C and 41.3°C, respectively).

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Asynchronous Emergence by Loggerhead Turtle (*Caretta caretta*) Hatchlings as a Result of In-nest Thermal Differences

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INTRODUCTION

In general, loggerhead turtle (*Caretta caretta*) hatchlings emerge from their nests en masse 50-80 days

after oviposition (Ackerman, 1996). Such events reflect a relatively uniform rate of development throughout the clutch, which leads to most of the eggs hatching around the same time.

However, at certain sites around the world, such as the Greek Island of Kefalonia (38°09'N, 20°33'E) a more asynchronous pattern of emergence occurs, with activity lasting up to 12 days or more. In light of previous studies focusing on the relationship between embryonic development rate and incubation temperature (Kaska *et al.*, 1998), it was decided to investigate whether asynchronous emergence was related to the thermal conditions within individual nests.

METHODS

Temperature data loggers (Tinytalk II, Gemini data loggers, Chichester, UK) were placed at the top and bottom of five loggerhead nests laid on Mounda beach Kefalonia, during June 1998. After a period of 45 days, all nests were nocturnally monitored to ascertain the duration of hatchling emergence activity from each. Once emergence activity had ceased, the temperature loggers were retrieved and data downloaded to spreadsheet format.

RESULTS AND DISCUSSION

Asynchrony - Evidence and Possible Causes

The mean duration of emergence activity from nests on Mounda beach during 1998 was five nights ($n = 33$) (Fig. 1). On a closer scale, Figure 2 shows the numbers of hatchlings emerging from the sand each night from individual nests, where night 1 is the night of first hatchling emergence. In these examples, hatchlings emerged over a total of: 12 nights (a and b), nine nights (c and d), seven nights (e and f) and three nights (g and h). From this evidence, it is clear that emergence activity on Kefalonia lasting more than one day, cannot simply be explained in terms of a mass emergence and subsequent 'stragglers'.

With regards to temperature, pronounced thermal variations were found to exist, not only between nests, but also within individual clutches (Fig. 3).

"In-nest" temperature range (i.e. the mean temperature at the top of the clutch during incubation - the mean temperature at the bottom of the clutch during incubation) was significantly related to the duration of hatchling emergence ($R^2 = 0.83$, $P < 0.05$). More precisely, nests displaying large thermal ranges emerged over a longer time scale than those characterized by more uniform temperatures. This implies that asynchronous emergence is caused by varying rates of development within clutches as a result of differences in incubation temperature. For, example, the first hatchlings to emerge from a nest may be those incubated towards the warmer top of the clutch, whilst the last hatchlings to emerge may be from the cooler base of the clutch and, as such, underwent a longer period of development (Fig. 4).

This suggests that when in-nest thermal conditions are uniform, synchronous development and emergence will

occur as described by Carr and Hirth (1961), with less fit 'stragglers' following over the next few days. However, if in-nest thermal conditions lead to asynchronous development, it would be energetically disadvantageous for the first animals to hatch to wait for their slower developing siblings, thus favoring asynchronous emergence as has been observed on Kefalonia.

Possible Implications of Asynchronous Development for Temperature Sex Determination

Pronounced 'in-nest' thermal variations have implications for the sex of offspring produced. For example, previous studies have successfully used the incubation duration as a proxy for the sex of hatchlings produced throughout the season (Mrosovsky, 1988; Mrosovsky, 1999; Godfrey *et al.*, 1999) with incubation durations of >55 days for loggerheads indicating cool male producing temperatures and vice versa (Mrosovsky, 1988).

On Kefalonia, sand temperatures were relatively cool at the start of the season, and incubation durations for both the first and last hatchlings to emerge from nests, were >55 days, indicating that predominantly males would be produced. However, by after about days 20 of the season, shorter incubation duration were found, in line with the seasonal warming of the sand (Fig. 5) and incubation duration suggested that the first hatchlings to emerge from nests would have been females (i.e., incubation duration <55 days) and the last hatchlings to emerge would have been predominantly males.

The observed within-nest thermal variations may also have implications of the sex ratios being produced from individual nests, with our calculations showing that more females would be expected from the tops of clutches and more males from the bottom (Fig. 6).

These observations reinforce the need for extensive measurement of both in-nest thermal variations and incubation durations, so that refined estimates can be made of the sex ratios being produced from different rookeries, which will allow demographic implications of TSD in sea turtles to be explored further.

ACKNOWLEDGMENTS

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travel fund whose generous donation enabled our participation in the Symposium.

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Fig. 1. Frequency distribution of the number of nights over which hatchlings emerged from individual nests.

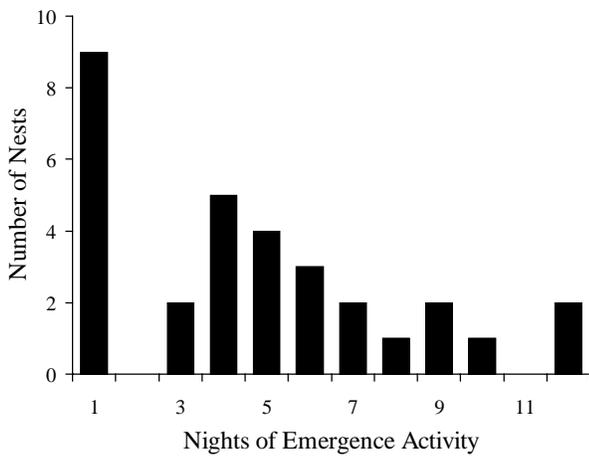


Fig. 3. Mean, maximum and minimum temperature at the top (open circles) and bottom (filled circles) of the five experimental clutches. Data represents the time from oviposition to last hatchling emergence.

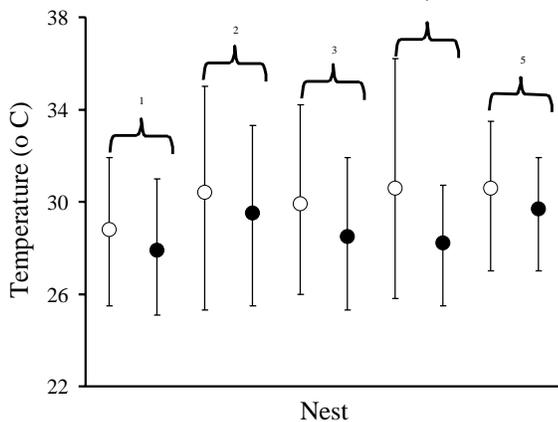


Fig. 2. Examples of the numbers of hatchlings emerging from the sand each night from individual nests, where night 1 is the night of first hatchling emergence. Hatchlings emerged over a total of: 12 nights (a and b), nine nights (c and d), seven nights (e and f) and three nights (g and h).

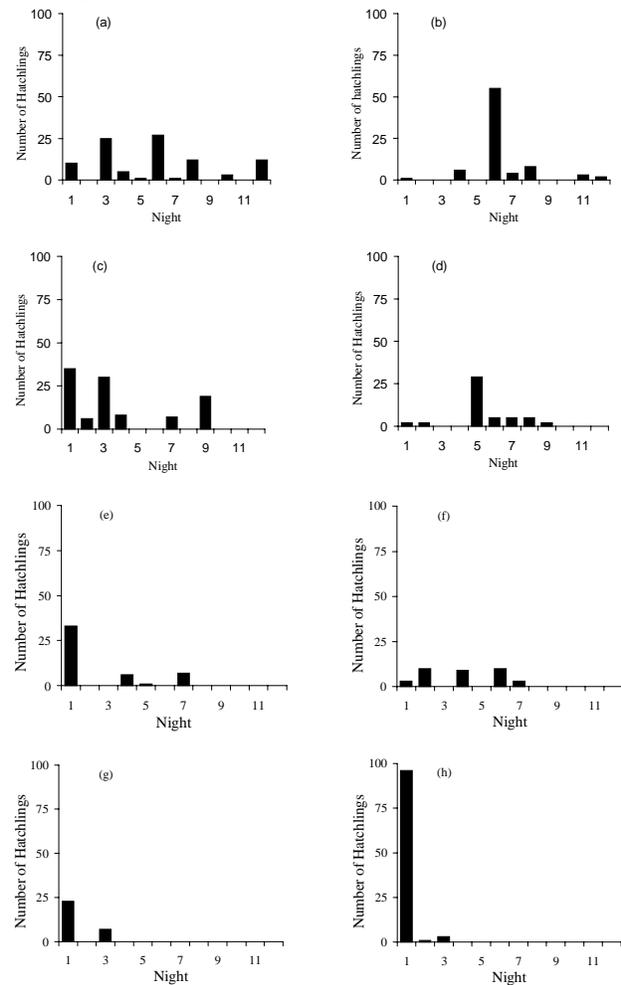


Fig. 4. (a) The incubation duration (i.e. the interval between oviposition and hatchling emergence) for the first (open circles) and last (filled circles) hatchlings to emerge from the sand versus the incubation temperature at the top and bottom of clutches respectively. (b) The relationship between incubation temperature and incubation duration on Kefalonia (solid points -see Fig. 5a for details) superimposed with the general relationship between these two parameters reported for loggerheads nesting elsewhere in the world (from Ackerman, 1996).

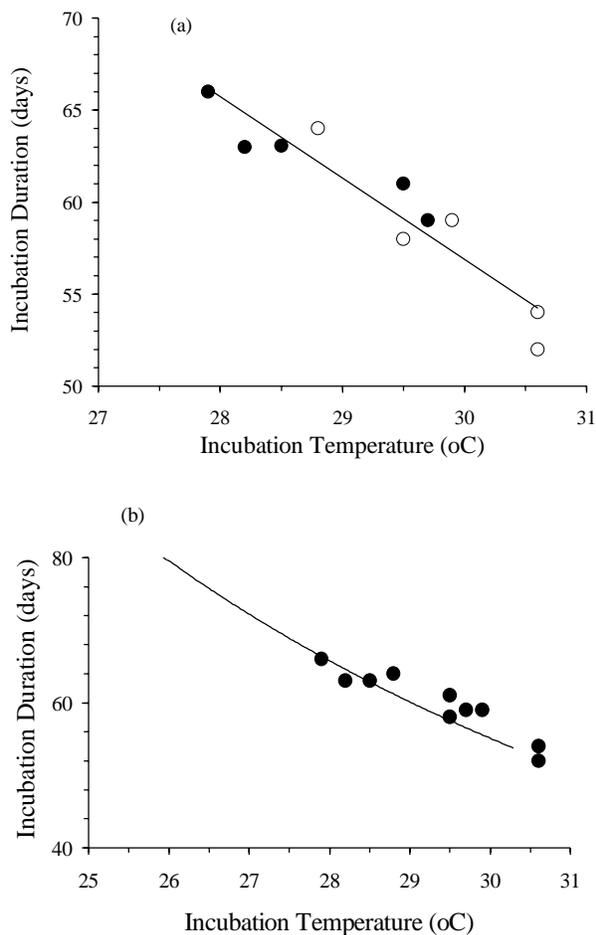
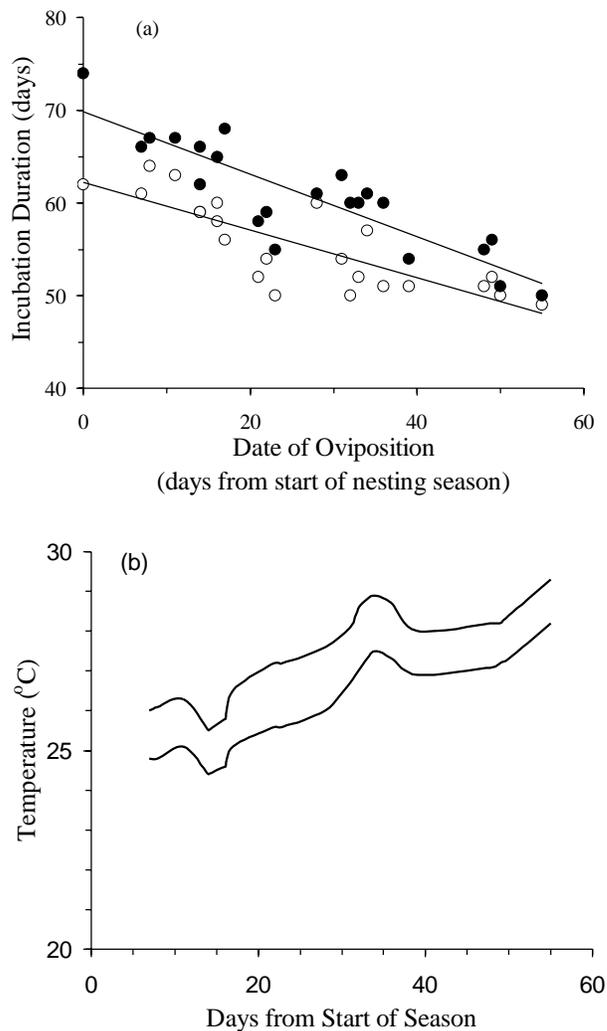


Fig. 5. (a). The incubation duration for the first (open circles) and last (filled circles) hatchlings to emerge from individuals clutches laid throughout the season. (b) The seasonal change in sand temperature at nest depths recorded at two control sites (i.e., not in nests) throughout the nesting season.



Ontogeny of Diving and Feeding Behavior in Leatherback Hatchlings

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INTRODUCTION

Leatherback hatchlings, like most sea turtles, migrate offshore to open ocean habitats. Where they go is unknown (Musick and Limpus, 1996). In addition, young leatherbacks do not return to “developmental” habitats in coastal waters, where their growth, ecology and behavior can be observed. As a consequence we know little about their behavior, or how it changes during development. Once they

reach large size, leatherbacks dive to great depths to feed upon gelatinous prey found in the deep scattering layer. But body size is one factor that limits dive depth, and so smaller turtles must feed upon different prey assemblages, found nearer to the ocean surface.

The purpose of this study was to determine how diving and feeding behavior developed in young leatherbacks during their first few weeks of life. The following questions were central to our study: When do hatchlings begin to

feed? Do hatchlings dive to locate food? How deeply, and for how long, can hatchlings dive? Does diving behavior change with age?

To obtain the answers, we raised hatchling in the laboratory for up to 10 weeks. At two week intervals, turtles were taken offshore, temporarily released in the ocean, and allowed to swim and feed upon prey (ctenophores, fishes, jellyfish, salps) present in the water column. Thus we were able to directly observe how their diving and feeding behavior changed over time.

METHODS

Leatherbacks are difficult to raise in captivity, but some workers (Deraniyagala, 1936; Witham, 1977; and Bels, 1988) have succeeded. We used circular plastic pools (1.5 m wide x 0.30 m deep), filled with 103 l of seawater, to house four turtles each at 23-27°C. Each turtle was confined by a short tether to one quarter of the pool. Tethering allowed the hatchlings to swim freely in any direction, but prevented them from contacting one another, the tank walls, or bottom.

We devised a diet consisting of prescription (Hills a/d™) cat food, French bread, vitamins (“Reptavite”™), and minerals (Miner-AI™) blended with water and flavorless gelatin. The diet was allowed to gel, then cut into strips. Turtles were hand-fed strips each day to satiation.

At one week intervals we measured each turtle’s weight (using an electronic balance accurate to 0.1 g) and carapace length (using vernier caliper, accurate to 0.01 mm).

All field observations were made in near-shore coastal waters (4-8 km offshore; depth: 70–200 m) adjacent to Palm Beach County, Florida. Once near the test site, two swimmers were towed eastward at 1-2 knots for 15 minutes to record the number and identity of all gelatinous prey within visual range (typically, ~20 m). Each turtle was then released for 30 minutes. Two swimmers followed behind each turtle at a distance of 4-7 m (depending upon visibility). A third observer, driving the boat, followed 10-15 m behind the swimmers.

Each turtle towed a sealed aluminum cigar tube (1998 season) or a Lotek miniature data tag (LTD 100; 1999 season) attached by a 1 m length of fine thread to its carapace. Both “packages” were rendered neutrally buoyant and did not impede diving though they slightly reduced swimming speed. A long (200 m) length of green (15 lb test) fishing line was attached to the tube or tag. When a turtle dove, one swimmer continuously released line so that downward movement was not impeded. Another swimmer signaled to an observer on the boat the beginning and end of each dive.

In 1998, dive profiles were recorded by the one surface swimmer, who aimed a sonar “gun” at the cigar tube during each dive. Depth was recorded continuously on a chart recorder on board the boat. During the 1999 season, dive profiles were tag-stored, then downloaded to a computer.

RESULTS

Hatchlings began feeding in the laboratory 5-8 days after capture. Over two years, we reared 35 turtles. Nine (~25%) survived for 10 weeks and, at that age, were released at sea in good condition. The remaining (26) turtles died at various ages, usually of internal or external infections. Infections were controlled until 2-3 days before the turtles stopped feeding and eventually died. Most of our hatchlings were “stragglers”, captured from the nest after the most vigorous (“first emergence”) turtles escaped. Many of these turtles had injuries before capture. Turtles living the longest were usually subjects (n = 12) captured in good condition. Six of the hatchlings we released at 10 weeks of age were members of this group.

While they were healthy and feeding, all subjects grew rapidly. Carapace length over the first seven weeks increased by ~76 % and mass more than doubled.

Only turtles that were eating and swimming normally were used for behavioral observations. The proportion of turtles diving in the field was correlated with their age. Two-week old hatchlings rarely dove (20%, n = 5). Diving was shown by 10 of 19 (53%) turtles, 3-6 weeks of age, and 10 of 13 (77%) hatchlings older, than six weeks of age.

Half of the diving turtles fed upon natural prey (moon jellies, *Aurelia* spp.; unidentified ctenophores) during their field trials. Turtles swam straight down to prey within 15 m of the surface. Several hatchlings made repeated dives to the same jellyfish to continue feeding. “Hunting” turtles swam at the surface with their head canted downward, as if they were searching for suitable targets.

The depth and duration of 79 dives were recorded. Dive depth ranged from 0.8-17.1 m, and dive duration from 10-440 seconds (7.3 minutes). Dive duration was significantly correlated with dive depth, but there was no correlation between dive duration and surface time before the next dive.

Turtles completed descents and ascents rapidly, resulting in “V-shaped” dive profiles. However hatchlings often “lingered” for a short time, usually at or near their maximum depth. There, they briefly swam a short distance horizontally, upward, or downward before continuing to ascend to the surface or descend to depth.

Most young turtles (≤6 weeks of age) usually made shallow dives (range: 0.5-9.0 m; 41 of 42 dives.). Older turtles (≥7-10 weeks of age) made both shallow (<9.0 m) and deeper (>9.0 m) dives.

Dive duration showed similar trends. Young turtles (≤6 weeks of age), with one exception, usually dove for less than three min. Older turtles (7-10 weeks of age), however, were equally likely to make dives of both short (<3 min) and longer (>3 min) duration.

DISCUSSION AND CONCLUSIONS

Hatchling leatherbacks probably do not feed during their first 5-8 days of offshore migration. Young turtles

grow rapidly, even before they begin feeding, probably using their yolk reserves. By the time they begin to forage, they have increased in mass by about 10% and in size by about 9%.

Hatchlings can dive toward, and capture, suitable prey (jellyfish and ctenophores) without previous visual experience. Feeding is confined to prey located at relatively shallow depths, and probably detected visually. These observations are consistent with the presence in leatherbacks of a circular area temporalis in the retina. This region of concentrated retinal ganglion cells is probably used to detect gelatinous prey below the turtle in the water column (Oliver *et al.*, submitted).

Dive profiles of the hatchlings are V-shaped, as are those of adults (Eckert *et al.*, 1986; Eckert *et al.*, 1989). However once hatchlings achieve a given depth, they may spend short periods of time swimming up and down in the water column. We hypothesize that these movements probably reflect a search for prey at dive depth.

Hatchlings, like adults, show a correlation between dive duration and depth, but no correlation between dive duration and surface time. These results suggest that hatchlings (like adults) probably depend upon aerobic metabolic pathways during diving.

As hatchlings increase in size and age, they dive more frequently. Our behavioral data suggest that with increasing size and age, they improve in ability to dive to greater depths (up to 17 m) for longer periods (up to 7 minutes). Since all of our animals were diving freely, maximum depths and durations we observed probably do not reflect physiological limits.

Routine dives of adult leatherbacks range in duration between 4-14 minutes (Lutcavage and Lutz, 1996). Our data suggest that young turtles can breath-hold for seven min at 9-10 weeks of age, at relatively shallow depths. These results indicate that reath-holding capacity probably increases more rapidly than ability to dive deeply, since the latter depends upon body size, blood volume and oxygen storage capacity, and swimming power and/or speed. The size and/or age that a young turtle can dive to the deep scattering layer remains a mystery because growth rates in nature are unknown.

We speculate that diving capacities of young leatherbacks probably exceed those of other sea turtle species at the same age and size. However no studies comparable to ours have been done with any hard-shelled species. We plan this coming summer to carry out similar field trials with green turtle hatchlings so that the appropriate behavioral comparisons can be made.

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Development of Serological Assays for Herpesvirus Infections in Chelonians

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Herpesviruses are associated with several diseases of chelonians (tortoises and turtles). Herpesviruses are responsible for mortality and morbidity associated with conjunctivitis, stomatitis, tracheitis, and pneumonia in *Testudo hermanni*, *Testudo graeca*, and *Testudo horsfieldii*. A herpesvirus has been identified in green turtles (*Chelonia mydas*) with experimentally-induced fibropapillomatosis (FP), and is associated with naturally occurring FP in green, loggerhead (*Caretta caretta*), and olive ridley (*Lepidochelys olivacea*). Herpesviruses have also been associated with two diseases of mariculture-reared green turtles, Gray Patch Disease (GPD), a necrotizing dermatitis of post-hatching green turtles and Lung-Eye-Trachea Disease (LETD), characterized by conjunctivitis, pharyngitis, tracheitis and pneumonia. The current studies have explored antibody detection methods and antigenic relationships among selected chelonian herpesviruses in order to develop specific serological tests to determine exposure of turtles and tortoises to specific

herpesviruses. Herpesviruses studied included LETV and FP-associated herpesvirus of green turtles and HV4295 and HV1976 from *Testudo hermanni*. Several synthetic peptide herpesvirus antigens were evaluated. Antibody detection methods included immunoperoxidase staining of infected cultures and sections, ELISA, and serum neutralization. Immunoperoxidase testing has previously been shown capable of distinguishing FP-positive and negative turtles from several widely separated geographic areas. For *Testudo graeca* there was good correlation between serum neutralization, ELISA, and immunoperoxidase tests. For *Chelonia mydas*, results were less consistent among the methods. There was a suggestion of cross-reactivity between several of the tortoise and green turtle herpesviruses. These results have revealed new levels of complexity that must be addressed before reliable serodiagnostic assays for herpesvirus infections of chelonians can be developed.

Program for the Rehabilitation and Conservation of Marine Turtles in the Northwest Mediterranean Sea

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The coastal regions of Spain in the NW Mediterranean sea have important feeding grounds for loggerhead turtles (*Caretta caretta*), originating from breeding populations in the eastern Mediterranean basin and the wider Atlantic ocean (Argano and Baldari, 1983; Argano *et al.*, 1992; Camiñas and Serna, 1994; Laurent, 1993; Carr, 1987). During summer, (June-September) (Fig. 1), it is thought that a great number of sea turtles feeding near the coast coincides with the period utilized by the local longline fishery. (Aguilar *et al.*, 1992; Argano and Baldari, 1983; De Metrio *et al.*, 1983; Laurent, 1990). These fisheries uses surface longlines with baited hooks in other to capture pelagic fish species and has been shown to have a large incidental catch of sea turtles (Camiñas, 1988; Mayol *et al.*, 1988; Mas and Garcia, 1990; Aguilar *et al.*, 1992). Turtles are usually returned to the sea with the hooks still in their digestive tract. These hooks can lead to severe injuries depending on their position inside the animal body, and can seriously affect the chances of survival.

Since 1995, the Marine Animals Rehabilitation Center has been running a program for the conservation of sea

turtles. Every summer rescue and rehabilitation of turtles that have been involved in incidental capture in fisheries or subject to other injuries is undertaken. This has involved a great deal of cooperation with the local fishermen. This has been facilitated by the organization of several meetings between the organizers of the campaign "Help Them" and fishermen, so that we can explain our work and demonstrate the significance of their cooperation. Fishermen who already cooperate are encouraged to convince new ships to join, so that our goal of recovering a greater number of sea turtles every year may be realized. To date, 10 vessels are involved.

Fishermen travel up to 20 mi from the coast to fish. As their ships are not big and fishermen usually come back from fishing every three or four days, they can not carry all turtles they capture, so they release them and only bring us the turtles they get on their last day before sailing back to the port. They put turtles in a small tank or cover them with a wet blanket to immobilize them and protect from the sun. When the boat is about two hours from fishing port the fishermen report the number of turtles and their size to

CRAM. A vet and an assistant move immediately to the port, in the Foundation's purpose designed vehicle, which is equipped with a pool and a stretcher designed for animal transport. Once the ship reaches the fishing port, the vet undertakes preliminary clinical examinations, while the assistant asks the fishermen about additional data (e.g. positions, the depth of the capture, water surface temperature, if any other sea turtle were seen nearby). By the time the turtles arrive at the Rehabilitation Center, the medical team is ready to undertake a complete examination of the animals and carry out a wide spectrum of clinical tests so as to assess the severity of any lesions present. After the examination the vet team proceeds with whatever surgical or medical treatment is necessary. However, the majority of turtles arrive with hooks in their esophagus or stomach, so they have to be anaesthetized and undergo surgery. Other common lesions are flipper and carapace trauma. Most limb lesions occur when turtles become entrapped in nets, leading to laceration of tissues and loss of the limb if constriction stops the blood supply. Carapace trauma is usually caused by the impact of propellers from small vessels.

After the surgery, turtles remain at the center for a period ranging from one week to a couple of month, depending on their health. The Rehabilitation Center has corralled an area at the seashore for the rehabilitation of the animals before returning them back to the sea. We also have individual pre and post operation pools in case any animal could need daily treatment. During the rehabilitation period vets and biologists of CRAM collect as much data as possible from animals (biometrics, radiographic and ultrasound images, hematology and blood biochemistry). We believe that the collection of all this information is fundamental when you are working with threatened an endangered species. These data are important for increasing the relevant clinical and biological knowledge. Necropsy is carried out on every turtle that does not survive or is found already dead.

Between 1995 and 1999, we have assisted and recovered more than 260 stranded-all alive turtles that are found near the shore. They are, most of the time, ill, injured, dehydrated or undernourished because most of them have a hook located in their esophagus or stomach for some months after the accidental capture by fisherman-and accidentally captured sea turtles. All individuals were loggerhead turtles except one green turtle (*Chelonia mydas*) found last year in the north of Spain (Catalonia). This turtle measured 55 cm in straight carapace length (SCL). This species is rarely found in the Noroccidental Mediterranean Sea, but is not unknown and has been recorded from Sardinia, Sicily and the Adriatic Sea (Knoepffler, 1961; Bruno, 1976). The last recorded of green turtles in Balear Islands for 125 years was in Mallorca in 1991 (Sebastià Pou *et al.*, 1991).

For *Caretta caretta* population we define juveniles as those of 21-40 cm SCL; subadults as 41-65 cm SCL and adults >65 cm SCL (Aguilar, 1999; Margaritoulis, 1985).

The great majority of sea turtles captured in longlines, captured in nets, subject to live stranding and stranded dead have been juveniles and sub-adults (Fig. 2). We rarely have adults brought to the Rehabilitation Center. However, fishermen have reported that although they catch some large turtles (about 70-80 cm SCL), it is difficult for them to approach them and load them onto the boats. Captures of turtles with a SCL of less than 25 cm are not usual in Catalan waters.

When sea turtle are totally recovered we release them back to the sea. Before release, all turtles are tagged with a subcutaneous microchip or Passive Integrated Transponder (PIT) in the nape of the neck and these are tested for function using a hand-held scanner (Indexil Blister BTRReader: Handi Reader Type 17). During the five years of the campaign we have dealt with more than 260 loggerhead turtles with more than 200 being released. To help increase awareness within the fishing communities, the children of the fisherman are invited to the release.

In addition, amongst other projects, CRAM has begun during this year a mitochondrial DNA study in order to determinate the origin of NW incoming turtles. Up to now, we have sequenced 60 blood and soft-tissue samples of *Caretta caretta*. All samples have been obtained from sea turtles accidentally captured by longline fisheries. CRAM and the Biochemistry Department of Autònoma University of Barcelona are carrying out this study. The results that up to now we have obtained are not enough to provide firm conclusions (Table 1). Therefore we will continue this study one-year more with approximately another 70 samples.

ACKNOWLEDGMENTS

I want to acknowledge the David and Lucille Packard Foundation and the Symposium Overseas Travel Fund that enabled me to attend the Symposium.

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Table 1. Results of mitochondrial DNA analyses from loggerhead turtles caught on longlines in the northwestern Mediterranean Sea. Not shown in this table are 44 B haplotypes that were also found. SCL is the straight carapace length (cm).

Code	Haplotype	SCL	Changes for new haplotypes
CC96/007	A	67	
CC99/002	A	46	
CC99/010	A	51.5	
CC99/029	A	62	
CC99/039	A	71	
CC99/30	C	26	
CC99/31	C	33	
CC99/38	C	33.5	
CC99/60	C	31	
CC99/73	C	31	
CC99/007	E	60.5	
CC99/054	J	36.5	
CC99/008	B*	40	Position 119: A → G; Position 313: G → A
CC99/022	B*	60.5	Position 318: T → C
CC96/007	A*	67	Position 78: G → A

*New haplotypes with position changes from most closely related haplotype given.

Fig. 1. The number of sea turtles admitted to the Recovery Center by month from 1994 - 1999.

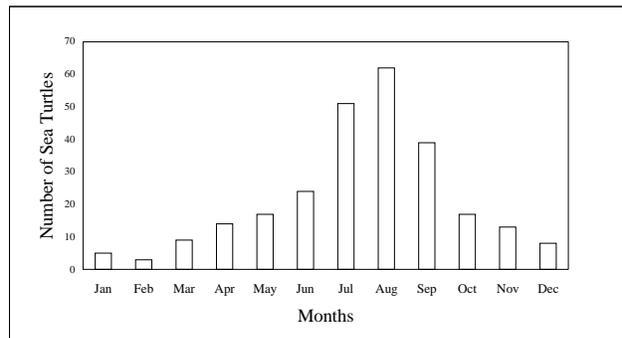
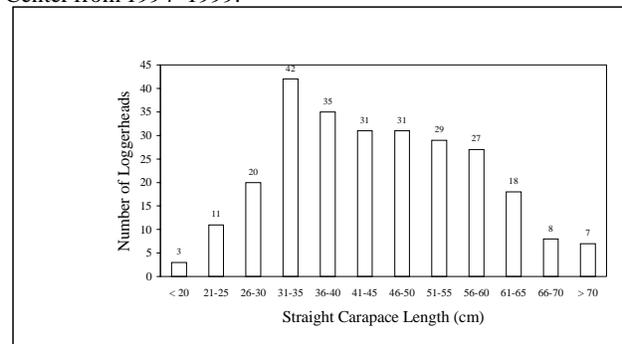


Fig. 2. Size classes of loggerhead turtles admitted to the Recovery Center from 1994 - 1999.



Studies on the Activity of Captive Sea Turtles Using New Logger Techniques: Rhythms in Aquaria and Potential for Determining Rhythms in the Wild

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Although a great deal is known about the nesting behaviour of sea turtles, little is known about activities at sea where these animals spent most of their time. In an attempt to rectify this, there has been increasing use of time-depth recorders (TDRs) on free-living turtles (e.g., Eckert *et al.*, 1986; Sakamoto *et al.*, 1990; Yano and Tanaka, 1991; Sato *et al.*, 1994; Dellinger, 1998; Eckert, 1998). However, although such units may elucidate the form of dive profiles, they have drawbacks with regard to precise determination of the function of dives. This is particularly pertinent in sea turtles because these animals have been described as “surfacers” [i.e., animals that essentially live at depth, only returning to the surface to allow gaseous exchange to occur (Kooyman, 1989)]. In an attempt to gain new insight into turtle activity underwater Hochscheid *et al.* (1998) and Storch *et al.* (1999) used an archival tag with a compass as an activity meter on turtles during their inter-nesting interval. The technique showed considerable promise in showing that turtles do engage in a variety of different activities underwater which could be determined as such by the unit. However, calibration of the system is urgently needed so that clearly-resolvable activity signals can be definitively ascribed to specific behaviors. The aim of this study was to test a modified and improved version of the new compass activity meter under conditions most closely approaching those encountered in the wild, but where the equipped animals could be observed at all times. Specific questions were, what recorded activity patterns correspond to which activities and how is the resolution of the activity dependent on sampling interval?

METHODS

Between 08/10/99 and 09/04/99, two sea turtles, a Kemp's ridley (*Lepidochelys kempii*) and a loggerhead (*Caretta caretta*), both female, were equipped with data recorders complete with a compass sensor at the New England Aquarium, Boston, MA and allowed to swim freely in their major exhibit, the “Giant Ocean Tank” (depth of 8 m and diameter of 12 m). The devices were developed by Driesen and Kern, D-24576 Bad Bramstedt, Germany. In a series of deployments, units were attached with velcro to metal base plates stuck with dental cement to the animals' shells (dorsal, midline between lateral scutes four and five) and left in place for periods of between 1 and 24 hours. The compass was similar to a miniature ship's compass, and was able to rotate in all dimensions. Compass output values

were stored by special sensors at sampling rates of between 0.5 and 30 Hz. Hall sensors attached to the outside of the compass changed magnetic field strength into electric voltage, this being stored in the unit until retrieved using a computer and appropriate interface. The resultant data were treated mathematically to calculate animal orientation, both with respect to magnetic north and gravity. Equipped animals were simultaneously watched continuously and notes made of their activities. These notes were compared to the compass output values afterwards.

RESULTS

Extremely Fine Resolution

Figure 1 shows an example of a compass output value at a sampling rate of 30 Hz. The individual flipper movements of the swimming animal can be seen as something approximating a sin curve at this sampling rate. The flipper beat frequency is approximately 0.2 Hz in this example.

Fine Resolution

Figure 2 shows an example of compass-derived data where the logger sampling rate was 0.5 Hz, and related to the observed behaviour of the turtle.

Medium Resolution

Figure 3 shows calculated activity indices for the Kemp's ridley sea turtle over one measuring period. The standard deviation, taken over a set number of readings, is a useful measure of activity (Hochscheid *et al.*, 1998) and Figure 3 shows these calculated activity indices for a turtle over about three hours highlighting the difference between active and inactive periods.

Determination of General Activity

The raw data on magnetic strength, transduced by the Hall sensors into voltage, do not provide a fully comprehensive index for activity since each sensor responds to movement in only one axis. When these data are integrated together, however, animal orientation (in the horizontal as well as the vertical plane) can be derived so that, by consideration of differences between adjacent points, animal angular velocity can be determined as a measure of activity. For a number of reasons, however, angular velocity will be a function of the measurement interval.

Operating at the most crude level, during device

deployment on turtles over a full 24 hour period, subdivided over a number of days, it was found, by examination of the loggers that the animals actively swam for 27% of the time. This accorded well with visual observations made simultaneously where it was determined that the animals actually swam 26% of the time.

DISCUSSION

Our results indicate that the compass logger used on the turtles in captivity usefully records data that can be assigned to various behaviours. Behaviour may be determined by direct consideration of the voltage output of Hall sensors placed around the compass body but seems to provide a better integrated output of movement, and thus behaviour, if values are mathematically treated to calculate animal orientation (horizontal and vertical). Animal orientation can subsequently be converted into changes in orientation as a function of time. In this the resolution of behaviours is critically dependent on the sampling interval. Recording frequencies in excess of 10 Hz are required to elucidate flipper beat frequencies but rates of 1 Hz and less give good detail on overall behaviours. As recording intervals increase so the likelihood that an animal will move in one particular direction and then, at least partially, back to the original position increases so that the overall angular velocity will tend to decrease with increasing recording interval. Note, also, that the maximum angle over which the animal may move over the recording interval is 180°, values in excess of this being recorded as a lesser angle moved since the compass is not able to resolve how the animal moves from one angle to another, having to assume that it takes the shortest route. Units placed on animals set to record at high frequencies will allow us to determine the maximum angular velocity of the various species and thus to set a minimum recording interval to ensure that this type of error does not occur. Ultimately, the utility of the compass as a recording system for activity of animals in the wild depends on the resolution of various behaviours, this being dependent on recording frequency (see above), and the length of time over which the animal is to be equipped. Limited memory in the logging unit will have to be considered in this although as larger memories become available on the market, this will be less of a problem. Onboard processing of information would also help in this regard.

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Fig. 1. Flipper beat frequency of the Kemp's ridley sea turtle at a logger sampling rate of 300 Hz.

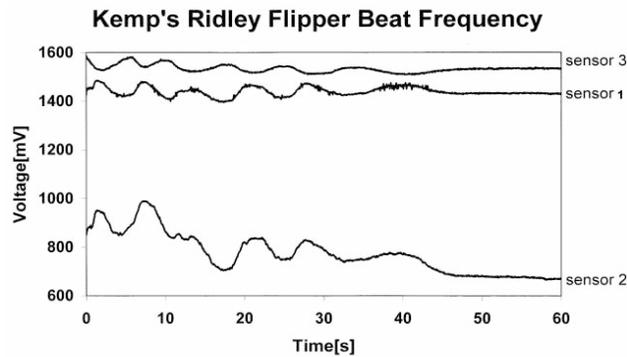


Fig. 3. Activity Index of the Kemp's ridley sea turtle during four periods of activity

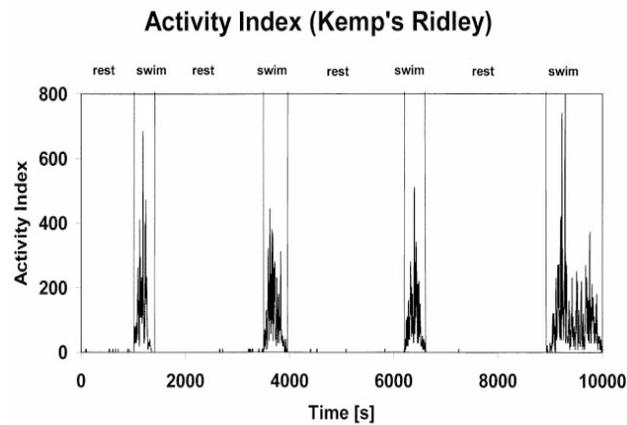


Fig. 2. Determination of behavior of the loggerhead

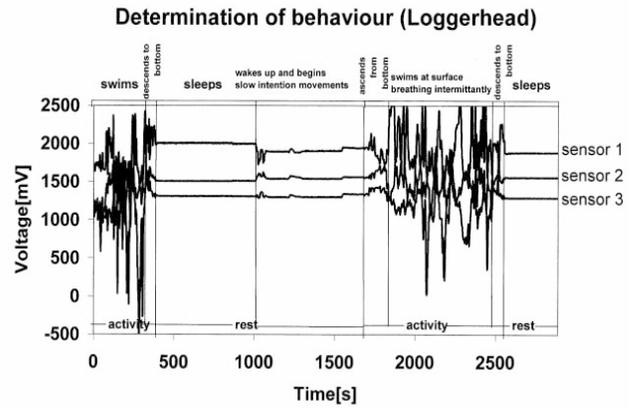
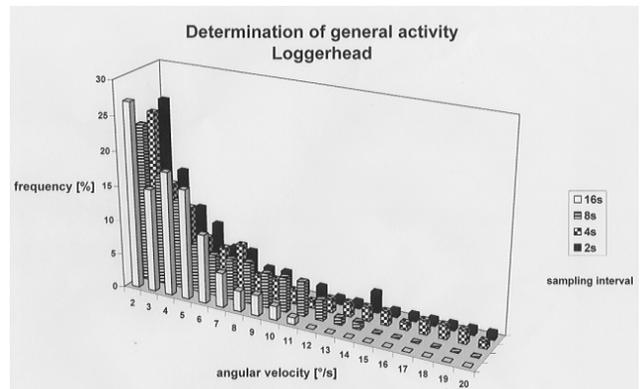


Fig. 4. Frequency of occurrence of various categories of the loggerhead sea turtle as a function of sampling interval.



Breeding of Hawksbill Turtle *Eretmochelys imbricata* with Artificial Food

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Two experimental designs were carried out at the turtle nursery with newborn and juveniles of hawksbill turtle *Eretmochelys imbricata* (mean initial weight 41.2 g and 188 g, during 60 and 72 days respectively) from nests in the wild, the aim was to know the effect on growth and survival of a diet alone and enriched with gelatine and two artificial diets with 35 and 44% protein alone and alternating with fresh food in newborn and juveniles hawksbill turtle respectively. The weight gain per day was higher using the enriched feed for both diets, survival was high, with a value of 96.9% the juveniles that consumed the 44% protein diet alternating with fish mince got a growth significantly higher ($P < 0.05$). However the survival was elevated for both artificial diets when they were supplied and combined. It is recommended to study nutritional requirements of hawksbill turtles for the purpose of finding effective

artificial diets considering the practical and economic advantages that the dry granulated offers.

INTRODUCTION

Food is one of the main problems to solve in any culture, representing up to 70% of the production cost. However there are difficulties with the fresh food: supplies, elaboration and conservation and high cost. Considering the difficulties when using fresh food (fish mince) the artificial diets are one of aspects of major interest to solve in the turtle nursery, bear in mind the characteristics of artificial diets: adaptability to the physiological conditions of the species, nutritionally complete, available all over the breeding cycle and

reasonable cost.

The aim was to know the effect on growth and survival of a diet alone and enriched with gelatine and two artificial diets with 35 and 44% protein alone and alternating with fresh food in newborn and juveniles hawksbill turtle respectively.

METHODS

At the turtle nursery, two experiments were carried out using newborn animals and juveniles (initial mean weight 41.2 g and 188.0 g, during 60 and 72 days respectively) from nests in the wild, at Doce Leguas Keys, Camaguey area of the greater abundance of this species (Moncada, 1995). The diets were provided twice a day, in 5% of the biomass (Witzell, 1980; Pérez, 1991) for this species.

The frequent use of gelatine is an agglutinant for the studies in nutritional requirements (De la Higuera, 1987) due to its high protein content (75%). Here it was used to enrich the diet of this nutrient. To obtain the enriched diet, 5.5 g of gelatine were diluted in the following proportion in 50 ml of hot water and 50 g of the pelletized feed were added.

In the composition of the diets fish meal and soy were mainly used as protein sources and wheat flour as binder and source of carbohydrates and beside premix of vitamins and minerals mainly. The treatments consisted of: I. diet 44% protein; II. diet 44% protein alternating with fresh food; III. diet 35% protein and IV. diet 35% protein alternating with fresh food.

Results from other authors were also considered (Wood, 1991; Márquez *et al.*, 1991; Pelegrín, 1994) in this study when supplying the diets.

Tests of standard distribution adjustment were carried out in final data and Student's T Distribution was applied. Survival between treatments was compared using Chi squared test (Sigarroat, 1985).

RESULTS AND DISCUSSION

Table 1 shows results for newborn animals. It can be seen that growth gain in animals that consumed enriched feed was significantly higher ($P < 0.05$) compared with those consuming feed without gelatine. The same can be observed for gain in weight/day.

There were no differences for the instant growth rate in length between treatments I and II. Values were different from those reported by Nuijta and Uchida (1982) for *Caretta caretta* juveniles (loggerhead turtle) where the best daily growth rate was 1.87% at a water temperature of 20EC.

The relative growth was between 182.5 and 201.4%, being better that corresponding to the enriched diet, as well as the Food Conversion Rate in which the best value corresponded with treatment II. However, Wood (1991)

has reported a Food Conversion Rate in a wider range, of 1.2 to 6.5 in turtles, more official in smaller turtles. Survival was high for both treatments with value of 96.9%. Buitrago (1987) and Pérez (1991) have reported similar survivals for the species in captivity.

The average temperature of water was 26.2 EC, within the range reported by Nuijta and Uchida (1982) for *Caretta caretta* the experimental period O_2 (average) was 6.5 mg/l, salinity was 36.5‰ and pH was 7.8.

No significant difference was found ($P < 0.05$) as to the growth in animals fed only with artificial diets, but there was a significant difference ($P < 0.05$) when they were given alternating with fish mince (Fig. 1).

Survival varied from 70 to 100%. The highest values were reached with treatments II and IV. Other authors have reported similar survivals in species fed with fresh fish mince (Fig. 2).

CONCLUSIONS

1. The enrichment of diets with gelatine contributes to a higher growth.
2. The higher the percent of protein in diet alternating with fresh food, the faster growth of animal.
3. The alternation of artificial and fresh food contributes to a higher survival.

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Table 1. Results for the artificial diet alone and enriched with gelatin. FCR is the food conversion rate.

	Initial mean weight (g)	Final mean weight (g)	Initial mean length (mm)	Final mean length (mm)	Instant growth rate in weight	Instant growth rate in length	FCR	Relative growth (%)	Protein efficiency	Survival (%)
Food without gelatin	41.2	116.39	59.30	89.42	125.31	50.2	1.75	182.49	1.27	96.9
Food with gelatin	41.2	124.19	59.30	90.75	138.32	52.4	1.68	201.44	1.22	96.9

Fig. 1. Growth in hawksbill turtle juveniles according to the different treatments.

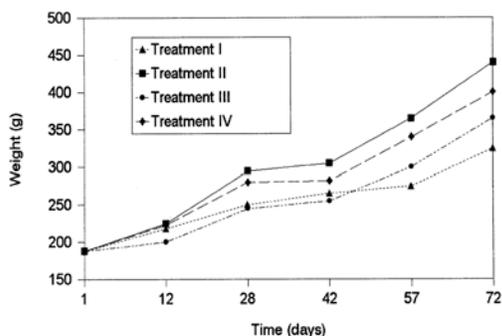
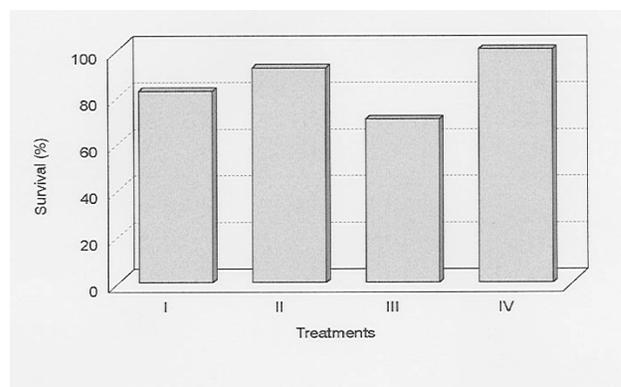


Fig. 2. Survival according to the treatments.



Adaptation of Captive-Reared Green Turtles Released into Hawaiian Coastal Foraging Habitats, 1990-99

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Green turtles obtained from Hawaiian waters by Sea Life Park on Oahu in the 1960's have nested and produced hatchlings on an artificial beach every year since 1976 (Bourke *et al.*, 1977). Most of these hatchlings were released into the wild shortly after emergence. However, starting in 1989, a few were retained each year for an educational loan program to facilitate the display of small turtles less than about 40 cm in straight carapace length (SCL) at qualifying aquaria in Hawaii, Canada, and the mainland USA. Steve Kaiser, the program's originator, called this novel outreach the "Hawaiian Sea Turtle

Ambassador Program." Steve's rationale, shared by many, was that live sea turtles, especially small ones, are their own best advocates for conservation when viewed up close by the public. The end-point of each carefully conducted loan occurred when the turtles reached the carrying capacity of their display tanks and were certified healthy for release into Hawaiian waters. "Head-starting" has not been the purpose of the program, although at times this aspect has been given inappropriate emphasis by the news media and others. The program's ongoing fundamental goals, currently being accomplished with distinction, are the

enhancement of public awareness and conservation education on behalf of sea turtles.

For the past decade, most of the turtles in the Sea Life Park program have been released as part of the July 4th "Turtle Independence Day" celebration at the Mauna Lani Bay Hotel on the South Kohala Coast of the island of Hawaii (20°N, 156°W). This coastline constitutes rich underwater foraging and resting habitats for an abundance of naturally occurring green turtles. Terrestrial basking also takes place along this lava rock shoreline. Investigations of the biology, ecology, and life history of these turtles have been underway since the 1980's by the National Marine Fisheries Service (NMFS), in partnership with the Hawaii Preparatory Academy (Balazs, 1996; Balazs *et al.*, 2000; Davis *et al.*, 2000; Harrington *et al.*, This volume; Rice *et al.*, This volume). These research activities have provided excellent opportunities to recapture and evaluate turtles originating from Sea Life Park. Since 1993, all turtles released at Mauna Lani have been measured, weighed, and positively identified by NMFS using Inconel flipper tags and PIT tags. Herein we provide a summary of the results of tag recoveries made to date.

RESULTS

From 1990-99, 102 captive-reared green turtles ranging from 25.5-68.0 cm SCL (mean-40.7 cm) were released at the Mauna Lani Bay Hotel (Fig. 1). Twelve turtles (11.7%) have been recaptured/resighted from 1-5 times by hand, net or (in one instance) a visual tag reading during in-water research (Fig. 2). Elapsed times from initial release to the most recent recapture ranged from 2.3-7.3 years. Eight of the 12 turtles were encountered within five kilometers of the Mauna Lani Bay Hotel. Three others were recaptured along the coastline 45-80 km to the south at Honokohau (1), and Honaunau (2). Another turtle was recaptured in the major foraging habitat of Kaneohe Bay on Oahu, a distance of 270 km (Fig.3).

Six other turtles (5.9% of 102) were found stranded 0.8-2.4 years after release (Fig. 2). Two were dead and four were alive. Necropsy of the former revealed that one was severely emaciated, and the other in good body condition with no indication of the cause of death. This turtle stranded 2.4 years after release along green turtle foraging habitat on the island of Lanai, 150 km from Mauna Lani. The four live strandings included three emaciated and/or excessively buoyant turtles, and one with a severe propeller injury to the carapace. This latter turtle also had two small fishing hooks externally and one internally as revealed by x-ray. All four live strandings required considerable veterinary treatment and captive rehabilitation by NMFS before being released a second time.

As shown in Figure 4, the SCL growth rates of the 11 turtles recaptured and remeasured during in-water research ranged from 0.7-3.2 cm/year (mean = 2.1 cm/year). The Kaneohe Bay recapture displayed the most rapid rate of

growth (3.2 cm/year). A small fibropapilloma was recorded on the eye of this turtle. Growth rates for the 11 turtles compare favorably and are consistent with data obtained over the past 25 years for naturally occurring green turtles in a wide array of foraging habitats throughout the Hawaiian Islands. However, three of the 11 turtles are known to have been fed pelleted fish food and lettuce by tourists and others during their post-release residency near the Mauna Lani Bay Hotel. The growth rates of the six stranded turtles ranged from only 0.5-0.9 cm/year (mean = 0.6 cm/year). These data suggest the failure of the turtles to adapt to the wild and thrive.

CONCLUSION

Nine of the 18 captive-reared turtles encountered have successfully adapted to natural Hawaiian marine habitats. The other nine did not adapt (six stranded and three being fed in the wild). Eighty-four turtles have thus far not been seen again. The two PIT tags used to identify each animal should help ensure longer term recognition if or when the turtles are recaptured during coming years or decades.

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Fig. 1. Captive-reared green turtles released annually at the Mauna Lani Bay Hotel. Gray indicates the number recaptured in each year-class during in-water research. Black indicates the number stranded.

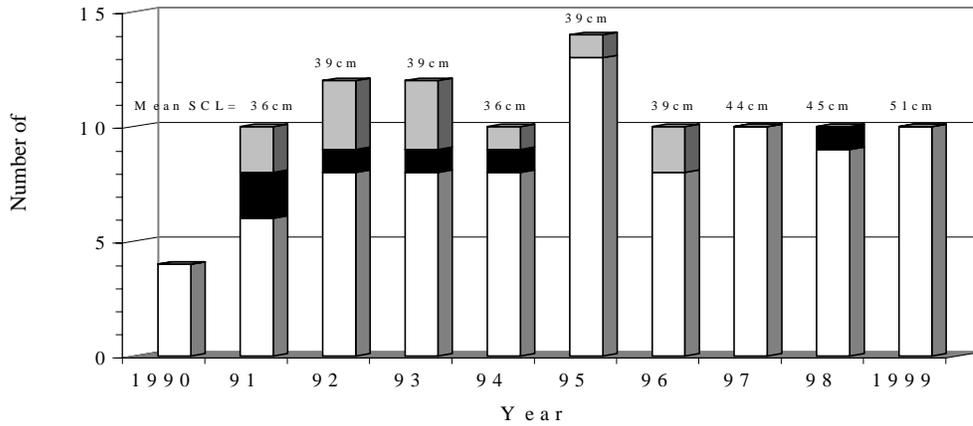


Fig. 2. a). Outcome of green turtles released into the wild at the Mauna Lani Bay Hotel (N = 102). b). Circumstances of recoveries of captive-reared green turtles (N = 18).

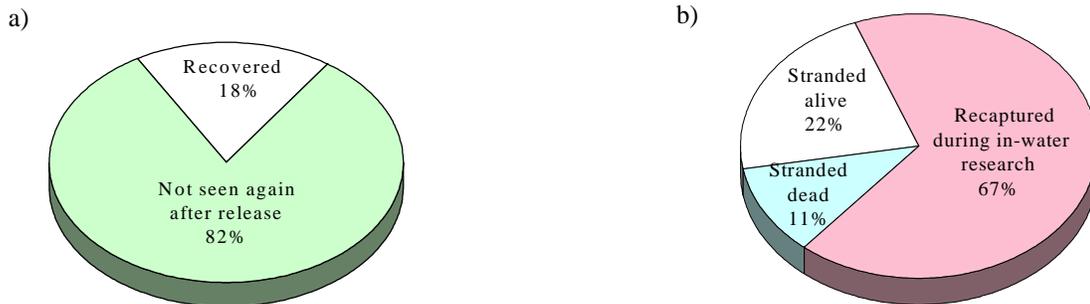


Fig. 3. The main Hawaiian Islands and the recapture locations and distances from the Mauna Lani release site.

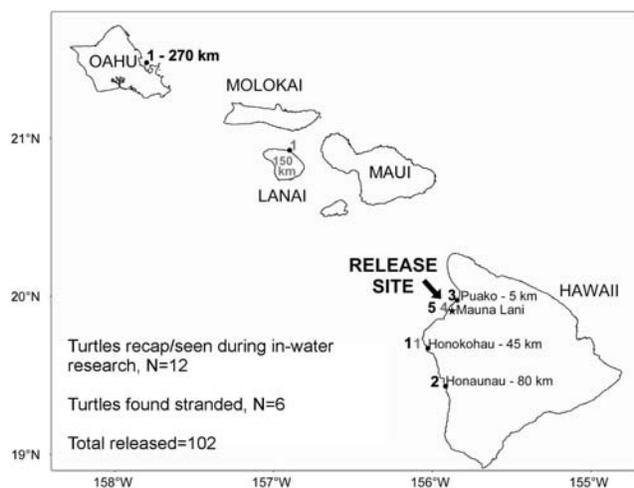
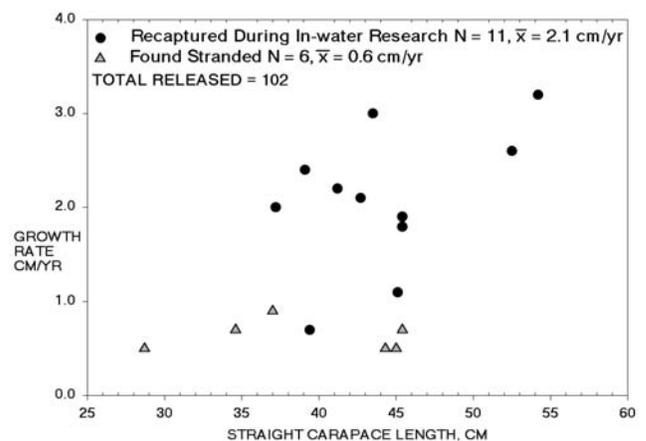


Fig. 4. Growth rates in the wild of recaptured turtles released at Mauna Lani.



Clinical Implications of Hematology and Plasma Biochemistry Values for Loggerhead Sea Turtles Undergoing Rehabilitation

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INTRODUCTION

There is little published information on the clinical pathology values of rehabilitating sea turtles. The Karen Beasley Sea Turtle Rescue and Rehabilitation Center currently maintains a revolving population of approximately ten sea turtles representing three species (*Caretta caretta*, *Lepidochelys kempii*, and *Chelonia mydas*). During the past three years, over thirty sea turtles have been maintained at the facility for a variety of medical and surgical problems including idiopathic anemia, limb paresis, blunt shell trauma, penetrating propeller wounds, necrotic shell disease, and fishing gear entanglement. The majority of the patients recover to be released, and each animal receives a thorough pre-release physical examination, including complete blood testing. In 1999, a program was started in which resident animals are bled quarterly for blood parameter monitoring.

METHODS

This retrospective study included 26 sea turtles (21 loggerheads, three Kemp's ridleys, and two green turtles). Because of insufficient numbers of green and ridley turtles, only loggerhead data were analyzed statistically. Ten loggerheads presented for trauma consistent with boat collisions, four for fishery interactions (fish hooks, line, or net entanglement), and 12 for other causes (including cold-stunning, prolapsed oviduct, paresis, stingray spine, lethargy). Three animals died, 14 were released, and nine are still in the rehabilitation facility. Hematology and plasma biochemistry values were determined at two different clinical pathology laboratories. Hematology and plasma biochemistry data were categorized by time of sample following presentation: 0-7 day, 1 week-1 month, 1-3 months, 3-6 months, 6-12 months, and >12 months.

Additional categories were pre-release, initial (0-7 day, or 1 week-1 month if no sample was obtained in the first week), and latest (pre-release, or the latest sample obtained following three months hospitalization for turtles that have stabilized, i.e., no active infections, shell lesions stable and healing, good appetite and weight gain). Not all turtles were sampled during each time period. Comparisons of initial and latest data for loggerheads are presented. Due to non-normal distribution of some data, statistical comparisons were made using non-parametric methods. Wilcoxon rank sum test was used for comparing initial and latest samples. Statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

A number of statistically significant differences were identified between initial and latest blood work in loggerhead turtles (Table 1). The increase in median hematocrit (PCV), blood urea nitrogen (BUN), total plasma protein (including albumin and globulin), and phosphorus can most likely be attributed to an appropriate plane of nutrition. The decrease in creatine phosphokinase (CPK) is probably a result of muscle healing and repair during the patients' recuperation. No statistically significant differences in initial blood work were identified by cause of presentation.

Future work in the area of clinical pathology will focus on increased frequency of sample collection and standardization of blood parameter profiles. As we accumulate more data and begin to understand blood work results in recuperating sea turtles, we will be in a better position to evaluate prognoses and prescribe appropriate treatment and rehabilitation protocols. We also hope to collect enough data to chart the clinical pathology progress of both green and Kemp's ridley turtles.

Table 1. Initial versus latest (including pre-release) hematology and plasma biochemistry values for loggerhead sea turtles undergoing rehabilitation. Columns show number of samples (n), 10th, 50th (median) and 90th percentiles, and p values obtained by Wilcoxon rank sum test (ns = not significant). Clinical pathology abbreviations: PCV = packed cell volume, WBC = white blood cell count, lymphs = lymphocytes, Hgb = hemoglobin, BUN = blood urea nitrogen, TP = total protein, AST = aspartate aminotransferase, ALT = alanine aminotransferase, Ca = calcium, P = phosphorus, Mg = magnesium, Na = sodium, K = potassium, Cl = chloride, CPK = creatine (phospho)kinase, ALP = alkaline phosphatase, Cr = creatinine, T CO₂ = total carbon dioxide, agap = anion gap, LDH = lactate dehydrogenase, chol = cholesterol, Osm = osmolality.

	Initial Values				Latest Values				p
	n	10%	Median	90%	n	10%	Median	90%	
PCV (%)	14	9.5	26	37.5	14	23	31.5	38	0.04
WBC (/ml)	14	4050	9500	32500	14	3800	11000	19000	ns
Heterophils (/ml)	14	1055	5102	20200	12	1628	4780	8898	ns
Lymphs (/ml)	14	845	2836	9020	12	921	5175	10696	ns
Monocytes (/ml)	14	0	92	1072	12	103	390	758	ns
Hgb (g/dl)	5	3.5	6.5	8.4	insufficient sample size				
Glucose (mg/dl)	14	68	108	348	13	76	107	145	ns
BUN (mg/dl)	13	23	50	164	13	45	122	183	0.007
TP (g/dl)	14	2.4	3.2	4.1	13	3.2	4.5	6.9	0.0003
Albumin (g/dl)	13	0.7	1.0	1.6	13	1.2	1.8	3.1	0.0003
Globulin (g/dl)	10	1.5	1.9	3.0	12	1.7	2.8	4.5	0.03
AST (IU/l)	14	112	165	330	13	47	178	1007	ns
ALT (IU/l)	insufficient sample size				7	5	6	66	
Ca (mg/dl)	14	4.7	6.3	7.4	13	5.1	6.3	10.0	ns
P (mg/dl)	14	4.4	5.9	8.4	13	5.1	8.6	11.8	0.002
Ca/P ratio	14	0.68	1.11	1.35	13	0.47	0.76	2.09	0.02
Mg (mEq/l)	7	2.6	4.5	6.8	8	1.6	4.0	6.4	ns
Na (mmol/l)	13	140	151	161	13	141	151	157	ns
K (mmol/l)	13	2.5	3.4	4.0	13	3.1	3.9	4.5	0.005
Cl (mmol/l)	13	100	113	128	13	108	116	128	ns
CPK (IU/l)	14	317	1843	7382	13	151	853	4163	0.03
uric acid (mg/dl)	12	0.5	0.8	2.9	6	0.7	0.9	1.4	ns
ALP (IU/l)	8	0	12	42	7	15	25	37	ns
Cr (mg/dl)	8	0.1	0.4	0.5	8	0.5	0.8	1.2	0.001
T CO ₂ (mmol/l)	6	22	29	40	insufficient sample size				
agap (mEq/l)	6	0.4	9.8	14.2	insufficient sample size				

High Accumulation of Cadmium and its Subcellular Distribution in the Kidney of the Green Turtle (*Chelonia mydas*)

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Cadmium (Cd) is well known as one of marine environmental pollutants. Chronic exposure of animals to Cd has been reported to cause various maladies including altered kidney function. These Cd toxicity were reduced by specific protein called as metallothionein (MT). This study aimed at elucidating the Cd accumulation and its relation to MT in the kidney of green turtle (*Chelonia mydas*) which accumulate higher renal Cd. MT in the renal cytosol was found in all the samples examined, where more than 70% of renal Cd was bound to MT. Significant positive relationship between concentrations of MT and Cd in the kidney was recorded. Molar ratios of MT/Cd in green turtle were lower than those in northern fur, minke whale and black-footed albatross. Furthermore, concentrations of MT in green

turtle were lower than those in marine animals, nevertheless Cd concentrations in green turtle were not so low. MT bound Zn (MT-Zn) concentrations in green turtle and other marine animals were significantly increased with Cd accumulation. However, the increasing rate of MT-Zn concentration in green turtle was lower than those in marine mammals and seabirds examined. Composition of Cd contents in MT fraction to sum of metal contents (Cd, Zn and Cu) in MT fraction was higher in green turtle than in marine mammals and seabirds. These results are likely to indicate the lower inducibility of renal MT by Cd in green turtles than marine mammal and seabird, implying that green turtles are susceptible to nephrotoxic effects of Cd.

Multicentric Lymphoblastic Lymphoma in a Stranded Loggerhead Sea Turtle (*Caretta caretta*) in the Canary Islands

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Since 1994 the College of Veterinary Medicine, University of Las Palmas de Gran Canaria, has been carrying out a survey of the pathologies and causes of mortality among sea turtles stranded on the coasts of the Canary Islands. This survey has included the pathological and histopathological study of 30-40 animals per year. We report here the preliminary results in a case of multicentric lymphoblastic lymphoma in a loggerhead sea turtle.

We received for necropsy a juvenile, 5 kg, female stranded loggerhead (*Caretta caretta*) sea turtle. The turtle exhibited anorexia and lethargy several weeks prior to its death. At necropsy the thymus weighed 25 g and appeared to be larger than that seen in other sea turtles necropsied by us. The thymus was formed by two white and firm nodules. White nodules similar to those described in thymus were observed in the thyroid gland. The ventral aspect of the plastron was also infiltrated with similar masses. Variably sized nodules were also observed in the serosa of the celomic cavity, thoracic wall, muscles of the front flippers, myocardium, liver, spleen, kidneys and left lung. We observed nodules infiltrating both serosa and mucosa of the stomach and small intestine. Histopathology revealed a neoplastic proliferation of round cells, with large nuclei

and scarce cytoplasm. These were identified as lymphoid cells. In all nodules the number of mitotic figures was moderate. Due to infiltrates of lymphoid cells, there was a loss of the normal architecture of many affected organs. By electron microscopy the neoplastic cells were consistent with lymphoblastic cells. The diagnosis was multicentric lymphoblastic lymphoma.

Lymphomas are more frequent in snakes, but they have been described even in terrestrial chelonians. Systemic lymphoblastic lymphoma was described in a male Greek land tortoise (*Testudo hermanni*) involving the liver, heart, kidneys, spleen, pancreas and intestinal serosa (Ippen, 1972). *Lymphoreticular neoplasia* was listed in a Florida soft-shelled turtle (*Trionyx ferox*) (Harshbarger, 1974). To our knowledge, this case is the first report of a multicentric lymphoblastic lymphoma in a sea turtle.

ACKNOWLEDGMENTS

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Six Years of Observations on the Maintenance in Captivity of Sea Turtles

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Marine turtles have lived at the Centro Mexicano de la Tortuga since the end of 1993. This has given us new challenges to provide the optimum habitat conditions to them. Day by day we learned more about hatchlings, juveniles and adults of different species. In a way that was not previously possible we have had the opportunity to understand more about their food, water and environment and to learn more about aspects of their biology such as etiology. We have recently implemented a system of tagging using chaquiras (plastic colored balls) and tattoo. The old system using steel tags was not liked by the turtles who would bite them and often eat them.

We have also adapted the lodgings of some species such as leatherback hatchlings. This species is very difficult to maintain in captivity; its strength often causing lacerations from the lodgings that sometimes resulted in death. In addition, we have had the opportunity to study the

feeding habits of several turtle species, carnivorous and herbivores, as the Kemp's and olive ridley and the black turtle. Particularly their young stage. As a result we have been able to formulate nutritious diets to suit their needs.

Table 1. Results in adaptation of sea turtles in captivity.

Species	Name	Common name	Range of adaptation to captivity
<i>Lepidochelys olivacea</i>	olive ridley	golfinas	Regular
<i>Lepidochelys kempii</i>	Kemp's ridley	lora	Good
<i>Caretta caretta gigas</i>	Pacific loggerhead	jabalina	Good
<i>Caretta caretta caretta</i>	loggerhead	cahuama	Very good
<i>Eretmochelys imbricata</i>	hawksbill	carey del golfo	Very good
<i>E. imbricata bisca</i>	Pacific hawksbill	carey Pacífico	Very good
<i>Chelonia mydas</i>	green turtle	blanca o verde	Excellent
<i>Chelonia agassizii</i>	black turtle	prieta	Excellent
<i>Dermochelys coriacea</i>	Leatherback	laúúd o siete filos	Unknown
<i>D. coriacea schlegelii</i>	Pacific leatherback	laud del Pacífico	No good
<i>Natator depressus</i>	flatback	kikila Australiana	Not reported

First Confirmed Case of Fibropapilloma in a Leatherback Turtle (*Dermochelys coriacea*)

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Fibropapillomatosis has been described as a major epizootic disease that affects several sea turtle species. So far, it has been reported for populations of green turtles (*Chelonia mydas*), olive ridleys (*Lepidochelys olivacea*), hawksbills (*Eretmochelys imbricata*) and flatbacks (*Natator depressus*), but cases of leatherbacks (*Dermochelys coriacea*) with fibropapillomas were unknown. On December 16, 1997, an adult female leatherback nested on Mexiquillo Beach, in the Pacific coast of Mexico. During the routine examination of the condition of the female, a tumor was found, which was

removed and fixed. The sample was sent to NMFSC-Honolulu Lab in Hawaii, for analysis. The diagnosis confirmed that it was a fibropapilloma in regression. This is the first documented observation of fibropapilloma in leatherback turtles. Given the current situation of the Eastern Pacific leatherback population, which is drastically depleted, the presence of fibropapillomas is cause of concern. Since the prevalence of fibropapillomas in the population is unknown, it is recommended to carefully examine the nesting females in order to evaluate the frequency of the disease and its possible impact.

Quantitative Fluorogenic Real-Time PCR Assessment of Herpesvirus Sequences from Normal Tissue and Fibropapillomas of Turtles Sampled at Different Geographic Locations

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INTRODUCTION

Fibropapillomatosis of sea turtles is a recently emerging disease and likely represents a new viral epizootic (Balazs, 1991; Herbst, 1994; Lackovich *et al.*, 1999; and Quackenbush *et al.*, 1998). We have used PCR to identify turtle herpesvirus (THV) DNA sequences associated with fibropapillomas from green, loggerhead and olive ridley turtles from Hawaii, Florida, Costa Rica and Australia, and more recently from Mexico and the West Indies (Quackenbush *et al.*, 1998). Standard PCR demonstrates a strong correlation (>93%) between the presence of the turtle herpesvirus DNA polymerase gene and of fibropapillomatosis, suggesting a role for this agent in the genesis of the disease. However, standard PCR does not provide a measure of the levels of THV DNA in tumors and infected tissue and thus leaves questions about the significance of the role of THV in tumorogenesis. The study of this virus has been further restricted by the failure of all attempts to date to culture it. We present here the quantitative fluorogenic (QF) PCR assessment of THV DNA load in both tumor and uninvolved tissues from green, loggerhead and olive ridley turtles sampled from widely different geographic locations. Levels of THV DNA are 2.5 to 4.5 logs higher in tumors than in uninvolved tissue from the same animal. Further, the presence of low levels of viral DNA in tissue other than the viral target, skin, may indicate early metastasis.

METHODS

Real-Time Quantitative PCR Analysis of Turtle DNA

The ABI 7700 PRISM Quantitative PCR instrument has

been used to process and quantify levels of THV DNA. The technology to accomplish this task is based upon TaqMan chemistry (PE Applied Biosystems). Briefly, the quantitation of PCR products is achieved by monitoring the amplification reaction during each cycle (Real-Time PCR). The amplification product is measured by fluorescence. During the extension phase of the PCR cycle, the 5'→3' exonuclease activity of Taq polymerase cleaves the hybridized reporter fluorogenic probe (FAM), releasing it from the 3' quencher (TAMRA) resulting in an increase of fluorescence emission of the reporter dye that is related to the amount of PCR product. The rate of accumulation of product is proportional to the concentration (copy number) of target. Thus, comparison to the simultaneous amplification of standard, serial dilutions of the THV pol plasmid allows a precise calculation of viral copy number in the experimental samples.

Primers and Probe

Turtle 5' pol-primer
Sequence: ACTGGCTGGCACTCAGGAAA
Turtle 3' pol-primer
Sequence: CAGCTGCTGCTTGCCAAA
Turtle pol-probe
Sequence: 6FAM -
CGATGAAAACCGCACCGAGCGA-TAMRA

Conditions

Amplifying serial 10-fold dilutions of a plasmid containing one to 10⁶ copies of the THV pol gene generated standard curves for the quantitation of this sequence in experimental samples. In addition, "no template" control reaction mixtures containing the appropriate probe and primer system without DNA were run on all plates. PCR

mixtures were subjected to two minutes at 50°C (reaction of AmpErase uracil-N-glycosylase), 10 minutes at 95°C (activation of AmpliTaq Gold), and 40 cycles of 15 seconds at 95°C and one minute at 62°C. For each reaction, real-time fluorescence values were measured as a function of the quantity of a reporter dye (6-carboxy-fluorescein [FAM]) released during amplification. A threshold cycle (Ct) value for each sample was determined as the number of the cycle at which the measured fluorescence first exceeded the threshold limit (10 times the standard deviation of the baseline). Ct values obtained for control DNA were used to calculate the viral genome copy number for each experimental sequence amplified. The limits of sensitivity of the QF PCRs were estimated as the lowest plasmid dilutions that yielded comparable Ct values in replicate samples: they were all <10 copies/100 ng of input DNA. All standard curves were fit by linear regression, with correlation coefficients of >0.95.

RESULTS

THV DNA levels in tumors and corresponding tissues of turtles with fibropapillomatosis.

A copy number of 10⁵ THV genomes is equivalent to five copies of THV/tumor cell under these assay conditions. The results obtained from tumors sampled in Hawaii or Florida ranged from one to 10 copies/tumor cell, a value in agreement with previous estimates by Southern blot analysis (Quackenbush *et al.*, 1998). Since THV's primary target appears to be skin, as with most alpha herpesviruses, the unexpected presence of THV DNA, albeit at low levels (10 to 100 copies), in tissues other than skin may represent either errant infections or metastases.

THV DNA levels in tumors and uninvolved skin samples from distinct geographical locations.

In all cases examined, THV DNA loads in tumors were 2.5 to 4.5 logs higher than in uninvolved skin from the same animal. A potentially informative pattern of viral DNA load variation appeared when Hawaiian and Florida tumor samples, obtained from stranded, moribund turtles, was compared to the viral DNA load in tumor samples obtained from biopsy of captured turtles in Australian, Costa Rica, and Mexico. Approximately half of the tumors obtained by biopsy from otherwise healthy turtles were as much as two logs lower than the viral load in tumors obtained from stranded, moribund turtles. The result suggests that viral load relates to the stage of tumor progression. Quantitation of viral DNA during tumor progression will allow this finding to be experimentally substantiated.

CONCLUSION

In this study we used quantitative fluorogenic real-time PCR to measure the viral DNA load in uninvolved and tumor tissues from turtles with fibropapillomatosis sampled from widely different geographical locations. To date, turtle herpesvirus sequences have been detected by PCR in essentially all green, loggerhead and olive ridley turtles with fibropapillomas suggesting that THV is the etiologic agent of the disease (Lackovich *et al.*, 1999; Quackenbush *et al.*, 1998). THV sequences are also found in some uninvolved skin and organ tissues from turtles with and without fibropapillomatosis. Because standard PCR analysis does not provide a quantitative measure of viral DNA load, the impact and relevance of THV infection on tumor induction has been somewhat blurred. We now extend these data to include a measure of THV DNA load in tumor and uninvolved tissues and further implicate THV as the cause of fibropapillomatosis.

We conclude that:

1. Viral DNA loads in tumor tissue are 2.5 to 4.5 logs greater than in uninvolved tissue regardless of geographical location, further substantiating THV as the causative agent of fibropapillomatosis.
2. Viral DNA loads in necropsied turtles, where matched tissues other than skin were available, may be indicative of sites of sub-clinical metastasis.

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Sea Turtles in Aquariums: A National Survey

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The Virginia Marine Science Museum (VMSM) has been holding sea turtles for research and public display since 1989. In 1996, VMSM conducted a comprehensive survey of aquarium and zoo facilities to determine a national sea turtle census. The survey posed questions designed to characterize the activities of facilities holding sea turtles and was distributed to more than 125 zoos and aquariums, including the entire membership of the American Zoo and Aquarium Association (AZA). Responses were received from 101 facilities and 25 reported holding sea turtles. There were 193 individual sea turtles reported in the survey: 85 *Chelonia mydas*, 74 *Caretta caretta*, 19 *Lepidochelys kempii*, 12 *Eretmochelys imbricata*, and three *Lepidochelys olivacea*. The number of individuals held by a facility ranged from one to 44. Other survey questions included the following: age and gender of sea turtles; were turtles on public display; how long had the facility been keeping sea turtles; were sea turtles part of any research activities; had the facility tagged and released any sea turtles in the last 30 years. The zoo and aquarium sea turtle survey was the first of its kind for these animals. VMSM is actively involved with other facilities and the AZA in establishing this survey as an annual census and information gathering tool for zoo and aquarium professionals beginning in 2000. Future plans include development of a sea turtle husbandry manual, establishment of guidelines for sea turtle holding facilities, development of medical care and rehabilitation guidelines, and increased support of field conservation projects.

INTRODUCTION

VMSM is a public aquarium facility located in Virginia Beach, Virginia. VMSM has been holding sea turtles for research and public display since 1989. In 1995, an idea for a national survey of zoo and aquarium facilities holding sea turtles was born. Preliminary research indicated that very little information existed about sea turtles as a group in zoos and aquariums. VMSM was interested in gathering and sharing information regarding sea turtle husbandry and holding facilities. In addition, the VMSM Stranding Program was working closely with the National Marine Fisheries Service (NMFS) Sea Turtle Stranding and Salvage Network in Virginia. As a result, information on medical care and rehabilitation of sick or injured sea turtles was also of great interest. It was decided that the first step should be a national survey to determine which species and how many sea turtles were being housed in zoo and aquarium facilities.

METHODS

The VMSM sea turtle survey was designed to generate a national census of turtles by species and also to describe the age and gender of the collections. Additional questions were designed to characterize the activities of the facilities holding sea turtles. The sea turtle survey was mailed to more than 125 zoos and aquariums throughout North America in October of 1995. The mailing list was created from the members of the AZA and from other known aquarium facilities. The survey was mailed to the attention of curators and collection managers at the various facilities. Responses were requested by mail or fax and had all been received by spring of 1996. Surveys were then processed by entering data into spreadsheets for later analysis.

RESULTS

Responses were received from 101 zoo and aquarium facilities. Twenty-five of the facilities reported holding sea turtles in their collections (Table 1). Twenty-four of the facilities were located in the USA and one was located in Canada. There were a total of 193 individual sea turtles from five different species represented in the survey results. Green sea turtles were the most common at 44% (85), followed by loggerheads at 38% (74), Kemp's ridleys at 10% (19), hawksbills at 6% (12) and olive ridleys at 2% (3). There were no reported individuals of the following species: leatherback, flatback, and black sea turtle. The number of individual sea turtles held by a facility ranged from one to 44, with a mean of 7.7. Twenty-three facilities reported the length of time they had been keeping sea turtles in their collections, with a range of 5 to 40 years and a mean of 17 years. All but one of the facilities reported that sea turtles were on public display. Ten of the facilities reported that sea turtles were part of research activities and 20 reported tagging and releasing sea turtles in the past 30 years.

The age and gender breakdowns by species are illustrated in Figures 1 and 2, respectively. The genders were not known or reported for most of the turtles. Gender was unknown for all of the turtles less than one year of age, young of the year (YOY). For the different species (male:female:unknown), loggerheads were reported as (6:12:56), greens as (19:22:44), hawksbills as (4:1:7), Kemp's ridleys as (6:8:5) and olive ridleys as (1:0:2). Most of the sea turtles reported were greater than one year of age (143, 74%) and the remainder were YOY (50, 26%).

SUMMARY

The 1996 VMSM sea turtle survey was the first of its kind for these animals. The survey was a first step towards organizing zoo and aquarium professionals to share information and technical expertise to benefit sea turtles. Today, VMSM is actively involved with other facilities and the AZA in a Sea Turtle Working Group (STWG). The goals of the STWG are very ambitious and include development of a sea turtle husbandry manual dealing with issues such as nutrition and turtle handling; establishment of guidelines for design and operation of sea turtle holding facilities; development of medical care and rehabilitation guidelines for sea turtles; and development of institutional support for field research and conservation projects with sea turtles. The first task of the STWG will be to establish an annual sea turtle survey as a census and information gathering tool for zoo and aquarium professionals beginning in 2000.

ACKNOWLEDGMENTS

Many thanks to the Virginia Marine Science Museum Foundation and Stranding Program for project support. Cecilia Hatton and Kim Goldman assisted in sending and compiling surveys and Susan Barco assisted in graphic design.

Table 1. Results of sea turtle survey. The species are abbreviated as follows: Cc = loggerhead, Cm = green turtle, Ei = hawksbill, Lk = Kemp's ridley, and Lo = olive ridley.

Location	Species					Total	Time	Display	Research	Tag/Rel
	Cc	Cm	Ei	Lk	Lo					
101	2	0	1	0	0	3	20	yes	no	no
102	1	1	1	9	0	12	5	yes	no	yes
103	0	1	0	0	0	1	10	yes	no	yes
104	0	1	1	0	0	2	25	no	yes	yes
105	3	0	0	0	0	3	12	yes	yes	yes
106	1	0	1	0	0	2	30	yes	no	yes
107	0	2	0	0	0	2	10	yes	yes	no
108	1	7	0	0	0	8	40	yes	yes	yes
109	12	13	0	2	1	28		yes	no	yes
110	1	0	1	0	0	2	15	yes	no	yes
111	1	1	0	1	0	3	20	yes	no	yes
112	1	1	0	0	0	2	20	yes	no	yes
113	5	0	0	0	0	5	20	yes	no	yes
114	14	1	0	0	0	15	19	yes		yes
115	3	1	0	0	0	4	15	yes	no	yes
116	0	1	0	0	0	1	8	yes	no	yes
117	9	0	0	0	0	9	7	yes	yes	yes
118	1	41	2	0	0	44		yes	yes	yes
119	2	3	3	6	2	16	6	yes	yes	yes
120	5	2	0	0	0	7	7	yes	no	no
121	5	4	2	1	0	12	40	yes	yes	yes
122	1	0	0	0	0	1	13	yes	no	no
123	0	4	0	0	0	4	40	yes	yes	yes
124	6	0	0	0	0	6	7	yes	yes	yes
125	0	1	0	0	0	1	10	yes	no	no
Totals	74	85	12	19	3	193				

Fig. 1. Age class of captive sea turtles in surveyed institutions.

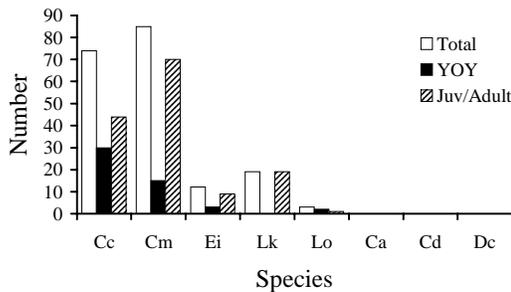
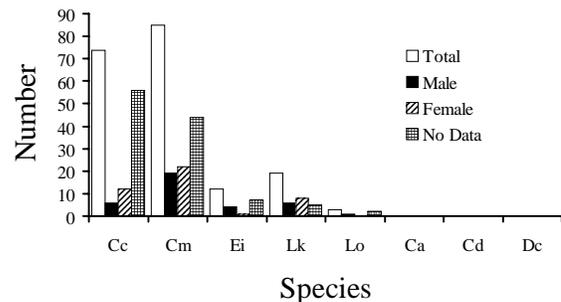


Fig. 2. Gender of captive sea turtles in surveyed institutions.



Tools of the Trade: Shifting Paradigms in Sea Turtle Rehabilitation

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INTRODUCTION

The rehabilitation of injured sea turtles presents unique challenges. The challenges become even greater when faced by a small facility with limited resources and an all-volunteer staff. Adapting inexpensive and readily available equipment to achieve similar results as that of costly items is a necessity. Using this approach, the staff of

the Karen Beasley Sea Turtle Rescue and Rehabilitation Center (KBSTRRC) has developed a number of innovations that have produced positive results.

The KBSTRRC is a small facility located on Topsail Island, North Carolina, and is dedicated solely to the treatment and care of sick and injured sea turtles. It began in late 1995 with one tank in a volunteer's back yard housing a juvenile loggerhead with a head injury. Historically, sea

turtles can recover from horrific injuries but the recovery is slow and requires long term and labor intensive care. Resources for sea turtle rehabilitation were very limited in North Carolina. This modest beginning drew attention to the need for such a facility. In the fall of 1997 the present facility was completed, financed totally from the private sector. Currently the center houses 17 recovering sea turtles, including eight Kemp's ridleys (*Lepidochelys kempii*), eight loggerheads (*Caretta caretta*), and one adult male Green (*Chelonia mydas*).

Over several years the volunteers at KBSTRRC have developed a number of techniques and ways of using equipment that have proved very successful in promoting the successful healing and recovery of the turtles in their care. A summary and description of some of these techniques and usage of equipment follows.

METHODS

Water Pik

Boat impact injuries and propeller cuts are the most common wounds seen at the KBSTRRC. Successful healing from this type of injury is greatly dependent on the ability to thoroughly clean and flush the injured area. The use of a Water Pik (or similar instrument used in cleaning human teeth) with a flexible catheter tip added has proved useful in cleaning fractures as well as under the ledges of broken carapace. Diluted Betadine, Nolvasan, or other product can be continuously added to the bowl of the Water Pik for uninterrupted flushing. The force of the solution can be regulated according to what is most desirable for the specific wound.

Dental Mirror

Thorough cleaning of the wound area is critical for successful healing. These wounds can be very deep and often the carapace forms ledges around the open wound, preventing a clear view of the extent of the injury. In these cases, a dental mirror works well.

Velcro

Many of these wounds are deep into the body cavity and require gauze packing: another technique has proved helpful here. A small piece of Velcro (with hooks) is placed alongside the wound area and secured with Super Glue to healthy shell. Gauze is then attached to the Velcro at one end, while the opposite end is inserted into the wound. Thus the gauze is anchored to prevent its migration into the wound area. Later, the gauze is easily removed.

Blow Dryer (Cold Air)

After a wound has been flushed, debrided and dressed, a sheet of Tegaderm is placed over the dressing to hold it and the medications in place. The Tegaderm is fixed to the carapace with Super Glue. The drying time can be greatly shortened by using a blow dryer. The dryer used must have

a cold air setting. No heat should be used. The drying facilitates a quicker return to the water thus reducing stress on the sea turtle.

Booties and Diapers

Having wounds cleaned, a dressing change, or even a routine examination can be very stressful for a sea turtle. As the turtle struggles, nails can be torn from the flippers. To prevent this, hospital booties, such as those worn in an operating room setting, can be slipped over the flippers preventing injury to the nails.

Stress can create other problems for the turtle and staff. At the other end, we have found clean up facilitated by frequent diaper changes. To be more specific, we use disposable pads such as those used in hospitals.

Physical Therapy

Wound care is not our only focus. Impaired use of flippers can be a problem with injured sea turtles. We have found that physical therapy is successful in restoring use of impaired limbs and in retaining range of motion in injured flippers. Great care must be taken to first observe the natural movements of a turtle without this problem. Physical therapy is administered twice daily, gently mimicking the natural movements of the turtle. "Tickling" the soft tissue in the neck area between the head and shoulder often stimulates and encourages the turtle to use the front flippers. Scratching along the posterior edges of the top of the carapace will bring about stretching and moving of the rear flippers. Physical therapy should be given while the turtle is in water if at all possible.

Tube Feeding Using Food Coloring

On occasion a turtle is admitted in such a weak condition that it is unable to eat. In these cases the standard tube feeding procedures are followed with a twist that we have added. After blending together the ingredients such as fish, vitamins, etc., into a "fish smoothie" a few drops of blue food coloring are added to the mix. As is standard procedure, the tube is inserted while the turtle is upright with the head extended. After administering the food, if there is no regurgitation after 15 minutes, the turtle is gently lowered about 15 degrees. If no blue fluid appears, the turtle is lowered a bit more each 15 minutes until eventually it is prone. The blue food coloring makes it easy to see any possible regurgitation at which time the turtle can be returned to the upright position. Blue was chosen because the turtle has no natural body fluids this color making it easy to track the success of the feeding.

Please Note: It is very important that none of these procedures be undertaken without the full knowledge and approval of the attending veterinarian.

RESULTS

Since June 1997 we have cared for 39 sea turtles,

including *Caretta caretta*, *Lepidochelys kempii* and *Chelonia mydas*. Of 12 turtles with carapace, plastron and cranial fractures, six have been released, two are in residence, and four have died. Of seven turtles with internal, viral, fungal or unknown problems, four have been released and three are in residence. Of five turtles with a hook or entanglement, four have been released and one is in residence. Of 15 cold-stunned turtles with other complications, four have been released and 11 are in residence (eight were from the 1999 mass stranding in New England). All sea turtles in residence are expected to be released.

ACKNOWLEDGMENTS

We gratefully acknowledge the efforts of all of the volunteers at KBSTRRC who continue to dedicate their

time, energy and money in the daily care of sick and injured sea turtles. Without their commitment there could be no success. We gratefully acknowledge the College of Veterinary Medicine at North Carolina State University, staff, students, and especially Drs. Greg Lewbart, Craig Harms, and Andy Stamper (currently New England Aquarium). Their confidence in us has given us confidence in ourselves. We gratefully acknowledge the town of Topsail Beach, NC, for sharing the vision and providing us with a location on beautiful Banks Channel for our facility, our many friends and supporters who provide supplies and funding so that we can carry out our work, and Ruth Boettcher of the North Carolina Wildlife Resources Commission for her encouragement, support and guidance. And finally, we gratefully acknowledge Howard Malpass, a founding member, whose backyard served as our first rehab center and whose wheelbarrow served as our first ambulance.

Preliminary Evaluation of the Capture of Sea Turtles by Artisanal Fisheries In Cipara Beach, Peninsula De Paria, Venezuela

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INTRODUCTION

The artisanal fishery in Venezuela has its origins in the prehispanic world, and nowadays it is one of the three more important fishery areas in the Peninsula of Paria (Novoa *et al.*, 1998). It is located in the northeastern area of the Venezuelan territory, formed by a succession of hills and rain forests that go as far as the Caribbean Sea.

Throughout the peninsula there are more than 25 villages that comprise approximately 43% of the artisanal fishermen that exist in the country (Suarez and Bethencourt, 1994).

This work was carried out in Cipara beach located to the east of Cabo Tres Puntas (62°42'W and 10°45'N) on the north coast of the Peninsula de Paria.

In Cipara four species of sea turtles nest, the leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), green (*Chelonia mydas*) and loggerhead (*Caretta caretta*). Cipara is the most important beach for nesting of the leatherback turtle in Venezuela (Guada *et al.*, 1994).

During the realization of the the "Sea Turtle Conservation Project" at Cipara (June 14-August 14, 1999) we could record the occurrence of interactions between the artisanal fisheries and the marine turtles. Cipara fishermen use wooden vessels which range from 4 to 10 m long, and have either one or two overboard motors (20, 40 HP). They practice coastal fishing with several fishing gears: seines, gill nets, longlines, hooks, lobsters traps and immersion. Due to that information we began to run an evaluation of the interactions.

METHODS

We went with the fishermen to lower and to raise the nets (July 31-August 13, 1999). We observed the type and position of the nets from the coast and the time in the water, the type of caught of each net. Additionally we asked for their opinions regarding the type of fishing gear which had more interactions with the sea turtles.

RESULTS

The gill net is done by using several pieces of nets, one along the other to form a single curtain set upright in the

water and the size and thickness of the mesh and thread are variable, approximately 800 m long and 10 m high, depending mainly on the kind of fish one is looking for.

The most common sizes and thickness of the mesh and thred used in Cipara and La Poza were: "Caritera" (for *Scomberomorus cavalla*; 5 cm), "Bagrera" (for catfish; 21 cm) and "Chuchera" (for Myliobatidae; 33 cm) as they were called by fishermen. According to the fishermen the sea turtles get caught more easily in the last two sizes: "Bagrera" and "Chuchera". Usually the gill nets are lowed at dusk and raised at dawn. The net was set for an average of 13 hours in the night.

Twelve trips with the fishermen were made at dawn when the nets were raised of which 58% were set parallel to the coast (Fig. 1) and opposite the nesting area (800 m long). The gill net sizes vary between 150-200 m long and 4.9-9 m high. We documented the capture of one juvenile female hawksbill turtle (straight curved carapace length, 54 cm; carapace width, 45 cm) on 31 July that got tangled in the net and was brought to the community to use its carapace to make spurs for cock fights. The skull and carapace were donated to us for educational purposes and we sent it to the collection of the Fauna Service (EBRG #3714).

These nets set in a parallel position don't allow the turtles to reach the shore to nest, causing their death by tangling and drowning in the nets (Fishermen, personal communication). However, during the period of this evaluation, the leatherback turtle (*D. coriacea*) nesting season was ending and we couldn't record any entanglement.

The fishermen of Cipara beach informed that the incidental capture of leatherback turtles occurred mainly in April and May, the peak of the nesting season. If the turtle was alive it was returned to the sea, but if it was dead it was taken to the village to be used as food.

In the Peninsula de Paria there is a tradition of consumption of sea turtles (Guada and Vernet, 1988; Guada and Vera, personal communication). Even though it is illegal, the killing continues.

The community of Cipara Beach is respected our work and they allowed us to be in the boats with them to carry out our studies. Informative talks about fisheries and sea turtles were made, where we found out the misinformation about Venezuelan fishery laws and the use of permits.

Fishermen get nervous when they capture protected species by the Venezuelan law, because they have been

imprisoned by the Guardia Nacional for that reason.

During the stay of our technicians in Paria four facts related to the interaction between the artisanal fisheries and sea turtles took place:

1) In Playa Negra (26 June 1999), a beach located to the west of Cipara, we found three fishermen of the Guarataro community slaughtering a female leatherback turtle (curved carapace length, 154 cm; curved carapace width, 110 cm). They had the eggs in development on the boat and were giving away its meat to other vessels. The turtle had a hole on each side of its head probably caused by knife stabs.

2) In a nesting survey (24 July 1999) carried out along the northern coast of the Peninsula de Paria, it was found a Spanish vessel carrying a juvenile *Chelonia mydas* (curved carapace length, 42.3 cm; curved carapace width, 37 cm) which came from a recent capture in a net by fishermen of the area, in the town of Uquire (within the boundaries of the Peninsula de Paria National Park).

3) In San Juan of Unare (5 km west of Cipara, Fig. 1) in the morning hours (4 August 1999) in front of the boats, within the rubbish, a plastron (length, 37 cm; width, 32.5 cm) and skull of a juvenile green turtle was found. These are the parts of the animal that are not edible and therefore the fishermen get rid of.

4) During midnight (7 August 1999) a group of fishermen of Guarataro community set a trawling boat on fire because they were fishing in forbidden areas.

Cipara fishermen rescued two trawling nets, that belonged to the burnt boat from the bottom of the sea. The nets had the TED (Turtle Excluder Devices) sewn instead of being open.

CONCLUSIONS

Scarce interactions between the artisanal fisheries and the sea turtles could be established, however, we could not work in 1999 during the peak of the nesting season and, the evaluation period was very short.

According to the fishermen the nesting season is the period when most of the sea turtle incidental catches occur and the position of the nets has a significant influence in the incidental capture.

There is consumption of the meat of drowned or of alive turtles entangled in the nets.

RECOMMENDATIONS

- To carry out detailed investigations to estimate the number of turtles that get entangled in the nets and how many of them die.
- To train to the fishermen about sea turtle resuscitation techniques.
- To continue fostering a fluent communication with the fishermen in order to find solutions to problems as the position of the nets in the feeding areas and during the

nesting season.

- To develop specific educational materials for the fishermen regarding sea turtle legislation and fisheries regulations.

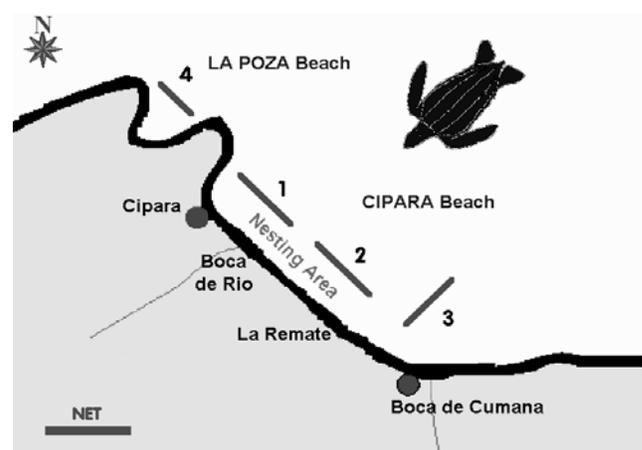
ACKNOWLEDGMENTS

This project has been auspiced by WIDECAS, the BP Conservation Program, the Universidad Simon Bolivar and the Government of the Sucre State. It has been done under scientific permits #1536, 1537 and 1538 from PROFAUNA-Ministry of the Environment and Natural Renewable Resources. The first author has received support from David and Lucille Packard Foundation to attend to the Twentieth Annual Symposium. Special thanks to the Community of Cipara for their help.

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Fig. 1. The locations (1-4) of gill net sets along the beach at LaPoza and Cipara and the areas of sea turtle nesting.



Ghost Crab Predation of Loggerhead Turtle Hatchlings in the Sinai Region of Egypt

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INTRODUCTION

The Sinai Peninsula hosts the only sea turtle nesting sites on the Mediterranean coast of Egypt (Clarke *et al.*, 2000). The few turtles found are predominately loggerheads (*Caretta caretta*), but there are also a few green turtles (*Chelonia mydas*), (Sella, 1982; Clarke *et al.*, 2000). The major non-human threat in the Sinai region is the ghost crab (*Ocepode* spp.), which can predate both eggs and hatchlings (Fowler, 1979; Stanyck, 1982). Ghost crabs can move twenty times as fast as hatchlings, and those with burrow diameters of 3.2 cm or greater are capable of successfully catching hatchlings and dragging them to/down their burrows (Smith *et al.*, 1996).

The Egyptian coastline is severely polluted with non-biodegradable debris such as plastics, rubber and oil tar, (Clarke *et al.*, 2000). Sea turtles are especially susceptible to injury by ingesting tar or plastics and by entanglement in nets and cordage, (Carr, 1987), so it presents a potential danger to adults and hatchlings but little is known about indirect effects pollution might have upon turtles.

Ghost crabs forage at the high tide mark and at accumulations of debris (Hughes, 1966), so it is possible that there would be higher densities of crabs where there are higher concentrations of pollution. The objectives of this study were therefore to gain quantitative estimates of the level of beach pollution, density of ghost crabs and to estimate the proportions of hatchlings being predated on each beach and along the whole coastline by ghost crabs.

METHODS

The study was carried out between 6 July and 6 September upon eight beaches along a 135 km stretch from the town of Rhafa on the border with Israel to the first inlet of Lake Bardawil. These were the only beaches on the Egyptian coast where turtles nested this year (Clarke *et al.*, 2000). 10 m x 10 m grids were marked in the sand and all burrows within this area were counted and their widest diameter measured. For the pollution survey, 50 cm x 50 cm quadrats were used and the percentage coverage of sand by the various pollutants was recorded.

To calculate the proportions of hatchlings predated, the number of crabs in the area through which the hatchlings pass when migrating to the sea is needed. The area can be represented as a triangle, the nest being the apex, the height being the average distance from the sea (30 m), and the width being the distance the hatchlings have spread apart by the time they reach the sea (a conservative 3 m). As ghost crabs will travel 3 m from their burrows to catch a hatchling (Smith *et al.*, 1996), a 3 m band must be added onto the

sides of this triangle. This gives an area of 225.9 m².

The maximum predation by ghost crabs was the mean number of burrows ≥ 3.2 cm encountered by hatchlings, divided by the mean clutch size (64.68) multiplied by the mean hatching success (0.6839) (after Smith *et al.*, 1996).

RESULTS AND DISCUSSION

Plastics and polythene were the dominating pollutants and beach surface area covered by pollutants ranged from 5.3 to 9.3%. Beaches were ranked from most to least polluted: 9 > 2 > 8 > 4 > 7 > 1 > 3. There was a significant correlation between pollution and ghost crabs ($R = 0.88$). High levels of predation by ghost crabs were discovered (Table 1), estimates of proportions of hatchlings being taken varying from 45% to 99%. Predation of hatchlings by ghost crabs presents a massive threat to the turtle population, the mean of the different estimates being 66.6%, which can be taken as the level of predation along the entire Mediterranean coast of Egypt, because every beach, which had turtles nesting upon it, was surveyed.

Losses of this magnitude could contribute to the demise of this small loggerhead turtle population in the not too distant future if further conservational measures are not taken.

Because of the relationship between ghost crabs and pollution, (assumed to be causal due to the fact that ghost crabs feed on the encrusting biota found on these drift materials) a possible conservational method that could be initialized would be cleaning of the beaches. If the levels of pollution are reduced, the densities of ghost crabs should follow suit, enabling more hatchlings to reach the sea safely because predation is reduced.

ACKNOWLEDGMENTS

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Table 1. Estimates of the percentages of hatchlings predated by ghost crabs on each beach.

Beach name and number	Mean number of crabs with burrows 3.2 cm in 225.9 m ²	Estimate of the percentage of hatchlings taken
Rhafa 1	20.14	45.53
Sheik Zwayed 2	31.38	70.93
El Shalak 3	20.58	46.53
El Kharruba 4	43.86	99.15
El Msagad 6	24.60	55.61
Abo Flifel 7	29.12	65.82
Zaranik 8	43.42	98.16
Bardawil 9	22.59	51.07

Anthropogenic Effects Affecting the Sea Turtle Conservation Project in Humacao, Puerto Rico

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Sea turtles are species that are in a constant battle against anthropogenic effects. Humacao beaches present three main causes of these effects: development, pollution by garbage, and illegal capture. The development causes loss habitat and beachfront lighting. Pollution by garbage causes death by ingestion or entanglement. Illegal capture and poaching are the main threats for the sea turtles in the area. This research presents an example of each anthropogenic effect that is affecting the sea turtle population in the Humacao area and the management solutions to help turtle population survives.

INTRODUCTION

Marine turtles represent a primitive group that hasn't change too much for the past 100 million years. They were abundant around the globe in tropical and subtropical seas in the 18th and 19th Century. Many populations used to have thousands of individuals, but now population numbers have declined very drastically in the past hundred years. Most of this decline is cause by the anthropogenic effects that the human has caused and keeps causing to the environment. Factors like commercial fishing traps, destruction of habitat that is critical for feeding and nesting, and the poaching of eggs and turtles for meat, are the ones that are affecting the sea turtle populations around the world.

The biology of these species is an interesting one, they spend most or all of their lives in the sea and during the

reproduction season they come to the beaches to nest. This occurs several times during the reproduction season. The eggs incubate from 50 to 60 days. When hatching occurs the hatchlings go to the sea were they will remain for several decades until they complete their development to the adult stage. This type of life cycle makes efforts to study and save these species difficult.

This research presents examples of the anthropogenic effects that are affecting the sea turtles in a Turtle Conservation Project in the town of Humacao and the management strategies that are implemented to help the turtles survive.

METHODS

Data were collected from the sea turtle activity and incident reports from beaches that are in the Sea Turtle Conservation Project in Humacao Puerto Rico from 1997 to 1999. These beaches were Balneario, Palmas del Mar, Refugio, Villa Palmira and Buena Vista. The collected data included number of nests, stolen nests, number of disoriented hatchlings, illegal capture and the factors that affect each area.

Anthropogenic damages are all of the damages that are cause by humans. Sea turtles are not free of these damages. In the area of the Sea Turtle Conservation Project (STCP) in Humacao we found three main anthropogenic effects that have a direct effect on the turtle population. These effects are pollution, development and poaching.

POLLUTION - MARINE DEBRIS

Marine debris pollutes all of our oceans today. Almost 80% of the debris are washed down or dumped from shore (Cintrón and Cintrón, 1987). The debris composition includes plastics, rubber, metal etc. The biological impacts from this debris are entanglement and ingestion. Entanglement is caused mainly by fishing nets, fishing tackle (lines, hooks). Ingestion is mainly by accident, it occurs when turtles mistake floating debris like plastic bags with medusae (jellyfish), which is the principal food on their diet (Eisenberg and Frazier, 1983). The debris does not stay in the water forever, it will be carried to shore by the waves where it will accumulate and affect the turtle reproduction. The debris will act like a barrier when the turtles come to shore to nest. Studies have demonstrated that when turtles come to shore to nest and find barriers, obstacles and human presence they may lay their eggs; they can have problems making the nest but some times the turtle will retrieve back to the water and try another beach that the condition will not be the best for nesting (Murphy, 1985).

As a result of the marine debris in 1996, a loggerhead died when it got entangled with fishing net. One juvenile of *Eretmochelys imbricata* also died when it got entangled with a fishing net in 1997 (Montero, 1997).

The cleaning of the debris causes another problem. The method that is employed for cleaning the beaches in an area of the Sea Turtle Conservation Project is very dangerous for the turtles. The area is near a hotel complex and the method that is used is a mechanical rake pulled by a tractor. This can penetrate the surface of the nest and disturb the nest (Mann 1977), and the compactation of the sand and the track marks from vehicles and pedestrians can interfere with the ability or chances of the hatchlings to reach the ocean (Hosier *et al.*, 1981).

Management Options

1. Try to clean the beaches without using mechanical cleaning equipment.
2. Prohibit the use of motor vehicles on the nesting beaches.
3. Educate the public by brochures and announcements about the efforts to preserve the sea turtles in order to create an awareness and motivate them to avoid littering in the beaches.
4. Develop a beach cleaning campaign involving the community.

COASTAL DEVELOPMENT

The development is a big problem on an island like Puerto Rico that is 100 mi long and 35 mi wide and with a population of four million. Due to the big population and small territory available development will be an intense one. An example of this is that the (STCP) area is surrounded by a resort, communities and recreational

facilities. The expansion of past development projects will even threaten or reach nesting areas. This development will create other problems just like the ones already mentioned in the pollution by debris and others like the pollution that we will be presenting now, the beach-front lighting.

Expansion of developments have increased the amount of illumination or brought illumination to places that in the past there were none. This will affect the sea turtle population. Adult turtles and hatchlings tend to find their way to the sea by a visual response to light (Witherington *et al.*, 1991a). Artificial beachfront light from buildings, street lights have been documented to disorient hatchlings and adults (Witherington *et al.*, 1991b) (McFarlane, 1963). There have been thirteen incidents that were caused by light pollution problems between the 1997 and 1998. Some of the hatchlings died when they went in the direction of the light source of a nearby building because they got stranded with obstacles and desiccated, were attacked by predators like dogs and birds or were killed by motor vehicles in the nearby road (Montero, 1997 and 1998).

Management Options

1. Reduce the lamp wattage and use low-pressure sodium lamps.
2. Install shields to prevent direct light to be seen from the beach.
3. Use the light management suggestions made by Witherington and Martin (1996).
4. Maintain existing vegetation and plant more in other areas, vegetation plays an important role in reducing the beachfront light that gets to the beach. The height of the vegetation should be kept for at least four feet.

ILLEGAL CAPTURE/POACHING

Theft of eggs and illegal capture for meat has been one of the main threats for the sea turtles in Puerto Rico (Cintrón and Cintrón, 1987). The theft of eggs for consumption is a problem that hasn't been controlled in the Humacao area. This practice continues today because of the black-market that promotes and maintains this practice. The hawksbill turtle seems to be the most affected species of the turtles that nest in the beaches of the Sea Turtle Conservation Project (STCP). There have been four incidents of turtles killed in 1997. Most of the killings were to obtain the meat.

Management Options

1. Night patrol along the nesting sites.
2. Nest relocation to more secure beaches.
3. Education plan to the public to create awareness about the turtle conservation and include facts and fines to violators.

ACCOMPLISHMENTS

Pollution-Marine Debris

1. Beach cleaning methods were changed.
2. Municipal ordinance prohibiting motor vehicles in the beach was enforced.
3. Educational campaign involving the community (beach cleaning activities).

Coastal Development

1. Light problems were reduced by replacing high-pressure sodium with low-pressure sodium lamps and by changing the types of lighting.
2. Installation of protection shields to lamps.
3. Decrease of disorientation's in the area.

Illegal Capture/Poaching

1. Nest relocation has reduced the egg theft in some areas.
2. Night patrols have reduced the poaching for meat, but the egg thefts have increased. These results have occur because is a large area to patrol and egg theft has been a part of most of the poachers for all their lives an that gives them the advantage in this type of situation.
3. Education program has been successful; community informs when they see turtle hatchlings or stranding.

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A Record Cold Stun Season in Cape Cod Bay, Massachusetts, USA

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A record number of cold-stunned sea turtles stranded on Cape Cod Bay beaches during the 1999-2000 season. The strandings occurred from 8 November 1999–7 January 2000. A total of 277 turtles stranded including: 218 Kemp's ridleys (*Lepidochelys kempii*), 54 loggerheads

(*Caretta caretta*), and five green turtles (*Chelonia mydas*). Stranding events usually followed abrupt declines in air temperature accompanied by strong sustained winds. The Massachusetts Audubon Society's Wellfleet Bay Wildlife Sanctuary coordinates a volunteer network for patrolling

Cape Cod beaches. Beaches were surveyed systematically after each high tide to minimize the turtles' exposure to chilling winds. This method of beach coverage increased the proportion of turtles recovered alive from the beach. One-hundred thirty-three Kemp's ridleys (61%), 19 loggerheads (37%), and four green turtles (80%) were initially retrieved from the beach alive. Of 127 live turtles transported to the New England Aquarium for treatment and rehabilitation, 89 Kemp's ridleys (82%), 16 loggerheads (100%), and two green turtles (66%) survived. All findings

presented here are preliminary. Further analysis of this event will be conducted and placed in the context of the past 20 years of cold stun data from Cape Cod Bay. Available data suggest that Cape Cod Bay is an important developmental habitat for juvenile Kemp's ridleys. It is our belief that studies of marine turtles in Cape Cod Bay will provide an opportunity to learn more about their behavior and ecology in northern waters and to gain a better understanding of cold stun response and rehabilitation.

Impact of Six Hurricanes Within Three Years on Loggerhead Turtle Nesting Success on Topsail Island, North Carolina, USA

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INTRODUCTION

Hurricanes may impact sea turtle nests in a variety of ways. Nests may be (1) entirely washed away (total nest loss), (2) flooded long enough to reduce hatching success, (3) partially eroded exposing eggs to heat, dessication, or predation, or (4) covered with enough sand to impact hatching success. Between 12 July 1996 and 17 October 1999, six hurricanes made landfall in coastal North Carolina during the loggerhead turtle (*Caretta caretta*) nesting season. Redfearn *et. al.* (1998) previously addressed the impacts of Hurricanes Bertha and Fran on loggerhead turtle nesting success in 1996 on Topsail Island, North Carolina. In this paper we examine the impact of these six storms on survival of loggerhead turtle nests.

METHODS

The Topsail Turtle Project enlists the aid of numerous volunteers to report daily nesting activities of turtles along the 42 km beach of Topsail Island, North Carolina. Nesting activities have been monitored systematically since 1990 on Topsail Island. Nests surviving the storms were analyzed 3+ days post-emerging. Only nests totally lost to erosion events are treated here. Clearly, this underestimates losses as many nests in which some young emerge suffered decreased hatching success.

RESULTS AND DISCUSSION

Total nest losses (entire contents lost during erosion events) during the nesting season has varied from 0 (0%) to 114 (93.4%) between 1990 and 1999 (Table 1). Significant

nest losses occurred in 1996 (Fig. 1) from Hurricane Bertha (12 July) and Hurricane Fran (5 September). The timing of these two events was such (Fig. 2) that most early nests were destroyed by Bertha and nests laid afterwards did not have enough time (six weeks between Bertha and Fran) to emerge (Redfearn *et al.*, 1998). The eyes of these two hurricanes struck the coast just south of Topsail Island. Strongest winds and maximal storm surge damage occurred just north of where the eyes made landfall. Lowest nest survival rates along the entire North Carolina coast occurred in this high impact zone.

On 26 August 1998 Hurricane Bonnie struck the southeastern coast of North Carolina destroying 53 of the remaining nests (Table 1) on Topsail Island. Only about 10 nests hatched some young after passage of this hurricane. During an average nesting season young from nearly half of all nests emerge by the first of September (Fig. 2).

In 1999 three hurricanes made landfall in North Carolina. Hurricane Dennis remained near or over coastal North Carolina from 30 August to 4 September. However, the bulk of its energy remained north of Topsail and thus only two nests were lost. Hurricane Floyd made landfall on 16 September and destroyed 64 nests. Only 36.6% of loggerhead nests were lost to Floyd and Dennis. Because of Floyd's late season arrival, most nests had already hatched (Fig. 2). A weakened Hurricane Irene made landfall on 17 October, destroying no nests.

Clearly, hurricanes may have devastating impacts on the nesting success of sea turtles. Timing is critical (Fig. 2). Late season storms occur after significant numbers of turtles have emerged from nests. Very early season storms may destroy all nests laid prior to storm arrival. If an adequate beach remains, late-season nesting by turtles may produce young. Particularly devastating are storms that arrive back to back-early enough to destroy nests before

hatching begins and the second storm arriving before later nests have had time to hatch.

ACKNOWLEDGMENTS

We are grateful to the many volunteers working with the Topsail Turtle Project for gathering the data presented here. In addition, we thank Ruth Boettcher (N.C. Wildlife Resources Commission) for allowing us to use the 1996 data for all of the nesting beaches in North Carolina.

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Table 1. Losses of loggerhead turtle nests on Topsail Island, North Carolina, due to erosion events (entire nest washed away).

	Year										
	90	91	92	93	94	95	96	97	98	99	
Total number laid	107	140	100	66	104	99	122	65	100	183	
Total number lost	2	8	7	4	2	9	114	0	53	67	
Percent lost	1.9	5.7	7.0	6.1	1.9	9.1	93.4	0	53.0	36.6	

Fig. 1. Loggerhead turtle nests lost to erosion events on Topsail Island, North Carolina.

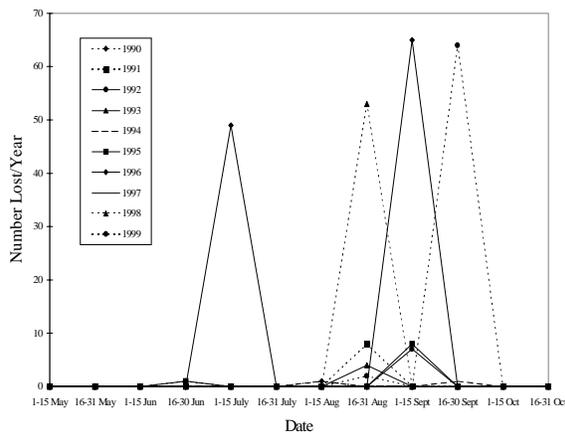
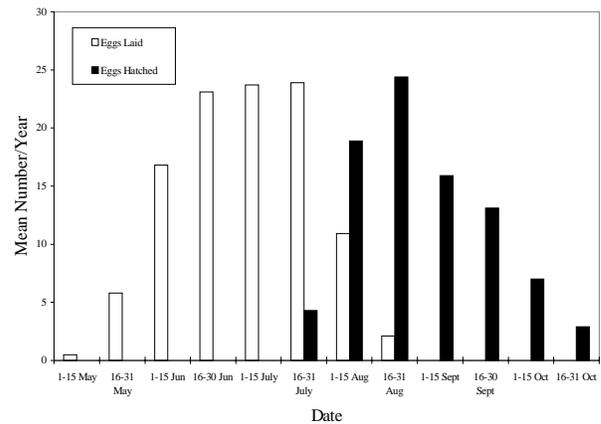


Fig. 2. Temporal pattern of egg laying and hatching by loggerhead turtles on Topsail Island, North Carolina and arrival times of recent hurricanes.



What Marine Turtle Strandings Can Tell Us

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INTRODUCTION

In Greece, a country with 16,000 km of coastline and over 3,000 islands, the life of a great percentage of the population is directly related to the sea and its resources for income via the domestic fishing industry. Loggerhead (*Caretta caretta*), green (*Chelonia mydas*) and, occasion-

ally, leatherback (*Dermochelys coriacea*) sea turtles inhabit the Greek seas. Despite the existence of both national and international legislation protecting sea turtles (Groombridge, 1982) little action has been taken to ensure the survival of these endangered species at sea. Many sea turtles are found stranded nation-wide, with injuries primarily resulting from fishing activity. Lack of

awareness, combined with the decrease in fish stock and accidental damage in the fishermen's fishing gear, result in fishermen inflicting intentional injuries to a significant percentage of sea turtles. ARCHELON (the Sea Turtle Protection Society of Greece) has conducted conservation projects, since 1983, in the most important nesting areas of Greece: Zakynthos, Crete and the Peloponnese. In 1992, ARCHELON formed the Sea Turtle Rescue Network (STRN) in co-operation with the Ministry of Mercantile Marine. As a result, the Greek Port Authorities became directly involved in the collection of stranding information for the STRN. The objectives of the STRN include collecting information on live and dead strandings throughout Greece. This information revealed the large number of turtles requiring rehabilitation treatment, which resulted in the establishment of the Sea Turtle Rescue Centre (STRC) in 1994. The STRN and STRC are closely inter-linked. This has occurred as the publicity obtained at the STRC via media coverage (turtle admissions, release or death), has caught the attention of the Greek general public, encouraging them to become more involved in the plight of sea turtles. The stranding data collected in the period 1997-1999 are discussed in this report.

METHODS

Port Police Stations, Fishery Agencies, ARCHELON personnel, environmental organisations, fishermen and concerned individuals report strandings to the STRN. For each turtle found a "stranding sheet" is completed. Photographs, thus enabling a fairly accurate evaluation of the cause of stranding, usually accompany records. For this report the strandings have been sorted into five categories as per their possible cause. These are:

1. Bycatch-in cases where the cause of stranding was hook ingestion and entanglement in fishing gear
2. Boat and propeller strike
3. Intentional injuries- primarily head trauma cases, weighted animals, decapitated animals
4. Other-cases of healthy, basking, weak, lethargic or cold-stun turtles or turtles with buoyancy problems, pathogenic infections or turtles that have ingested tar or plastic
5. Unknown-in cases where the cause of stranding could not be identified such as decomposition; possible entanglement; no apparent injuries; drowning; cases of suspected illegal fishing methods (i.e. dynamite fishing) that cannot be proven

Often these categories were found in combination (i.e. an intentional injury resulting after entanglement in fishing gear). Additionally, the data have been sorted into three size categories, according to the CCL (curved carapace length): 5-40 cm (hatchlings, post hatchlings and small juveniles); 41-60 cm (juveniles); 61-150 cm (sub adult and adult turtles).

RESULTS AND DISCUSSION

Sea turtle Species Observed

In the period 1997-1999, 524 marine turtle strandings were recorded along the Greek coastline. Of these 471 (89.9%) were *Caretta caretta*, 43 (8.2%) were *Chelonia mydas* and four (0.76%) were *Dermochelys coriacea*. In six cases (1.14%) identification of the species was not possible. The loggerhead turtle is the most common sea turtle species in the Mediterranean. Considering the occurrence of the green turtle, it is interesting to note that all the stranded *Chelonia mydas* (with the exception of one adult and one post hatchling turtle) were juveniles. Sixty-five percent of them were stranded in Peloponnese; 58% in Lakonikos Bay, which is a feeding ground for juvenile green turtles (Margaritoulis *et al.*, 1992, Margaritoulis *et al.*, 1999). Nine and a half percent were located around Attica and 7% were found on the island of Crete, possibly indicating small feeding grounds for this species. Another 11.6% were located in the East Aegean, near the Turkish coastline where green turtles are known to reproduce. Reproduction of *Chelonia mydas* has never been recorded in Greece, therefore green turtles observed in Greek waters could originate from populations nesting in Cyprus and Turkey. However, further research needs to be carried out to support the above hypotheses.

Cause of Stranding

Identifying the cause of stranding, especially when it comes to dead individuals, posed many problems to the processing of the data. The absence of experienced personnel to conduct a necropsy, decomposition or the lack of apparent injuries seriously interfered with the identification of the cause stranding. Such records have been included in the "unknown" category, which contains a considerable percentage (36%) of the reports. According to the data, bycatch was the most common cause for stranding, with a percentage of 26%. The second most important threat to the Greek sea turtle populations was trauma inflicted deliberately by fishermen. Twenty-three percent of the stranded turtles had been intentionally killed or injured. However, in the last five years only one such incident was witnessed and officially reported. Boat strikes were a seasonal phenomenon, occurring during the summer, with the intense use of the beaches and the sea by people (speedboats, jet skis, etc).

Live and Dead Strandings

There is a correlation between the fluctuation of live and dead strandings. From the 524 strandings reported, 31% were alive. Of these, 74% were admitted to the STRC for rehabilitation, 6% were treated by others and 20% were released or observed only, regardless of their condition.

Spatial Distribution of Strandings

Fifty-one percent of the reported strandings, referring to individuals of various sizes, were located near the major

nesting areas. On the island of Crete there was an increase of over 50% in reported strandings during 1998-1999, as a result of the obtained publicity by ARCHELON. In the north-east Aegean stranding reports were over double in 1999 as a result of the closer co-operation with the regional Fishery Agency and the Port Authorities.

Seasonal Stranding Information

The data suggest that loggerhead and green sea turtles inhabit Greek waters throughout the year. About 50% of all stranded individuals were located during summer; 72% of the reported *Chelonia mydas* were stranded between May and September. Three out of the four stranded leatherback sea turtles were found in September and one in August, concurring with a previous study (Margaritoulis, 1986).

Size Based Evaluation

Of all the stranded individuals; 26.5% had a CCL ranging from 5 to 40 cm; 26.3% had a CCL between 41-60 cm; 47.2% were adult and sub adult (CCL 61-150 cm). In this size category the four stranded leatherback turtles have been included. These percentages have remained consistent over the last three years even when there was an increase in stranding reports. Due to the absence of experienced personnel on site, some of the records might have contained false or incomplete information (e.g., measurements, cause of death). Therefore there is a possible error factor that may have biased current data analysis. However, an attempt was made to estimate possible mistakes and minimise the error factor through the authors' personal experience, collection of photos concerning stranded individuals and communication with those reporting the strandings. During the period of 1997-1999 there was a considerable increase of the stranding reports in comparison to previous years. However, this may represent not an actual increase in stranded sea turtles, but can be attributed to the following: the more efficient operation of the STRN, closely co-ordinated by the STRC; public awareness raised through ARCHELON's projects; and publicity promoted by ARCHELON through the media. Thanks to the direct involvement of relevant governmental bodies, the general public and fishermen, as well as the achieved publicity, an increase of live stranding reports was also observed. One hundred and nineteen (23%) of the located sea turtles were admitted to the STRC for rehabilitation. Of these, 60% were released to the wild. This is an encouraging step forward for the conservation of sea turtles, as the life of each individual is significant for the survival of the population. The STRN should continue to expand through closer co-operation with the fishermen via workshops, meetings and in situ presence of ARCHELON observers on the fishing boats. The first steps towards this direction have already been taken with encouraging results. The expansion of ARCHELON's work beyond the nesting areas should provide a more accurate view of the situation

and further publicity about sea turtle conservation. As a result a further increase of stranding reports should be expected. Research on beach strandings indicated that turtles found washed up on the beach may represent only 7 to 13% (Epperly *et al.*, 1996) of actual at-sea mortalities, due to the drag effects of differential surface and bottom sea currents. This statistic indicates that the 524 reported strandings might have actually been between 4000 and 7500. Involving people whose survival depends on the coastal zone, the sea and its resources, as well as the general public, in the conservation of sea turtles should lead to a significant decrease in mortalities. To this respect the STRN proves to be a valuable conservation tool and its continuation is essential to provide sea turtles with a more secure future.

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Effects of the Endangered Red Wolf (*Canis rufus*) on Raccoon Populations and Sea Turtle Nest Depredation on a Florida Barrier Island

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The Apalachicola National Estuarine Research Reserve (ANERR) has monitored the gulf beaches of Cape St. George Island, a barrier island in northwest Florida, for sea turtle nesting and subsequent depredation since 1990. Depredation pressure from two species, raccoons (*Procyon lotor*) and feral hogs (*Sus scrofa*) has been a constant threat to sea turtle nests on the Cape. Efforts at controlling raccoons and hogs were initiated by ANERR staff in 1992. (Bailey *et al.*, 1998). In January of 1998 a joint project between ANERR staff and U.S. Fish and Wildlife (USFWS) biologists placed two red wolves (*Canis rufus*) on the Cape as part of the Red Wolf Recovery Program. The red wolf historically inhabited the southeastern U.S.; however, aggressive predator control measures along with land development decimated the wild red wolf population. In 1980 red wolves were considered extinct in the wild with populations existing only in captive breeding programs (U.S. Fish and Wildlife Service, 1989). It was anticipated that in addition to finding suitable habitat on the Cape, these two wolves would serve to control the raccoon and feral hog population, thereby significantly reducing sea turtle nest depredation. Prey surveys performed before and after red wolf placement indicated at least a 78% reduction in the number of raccoons inhabiting the Cape. Unfortunately it became apparent during the 1998 sea turtle nesting season that the red wolves were also skilled in the depredation of sea turtle nests. Due to a dwindling prey base and depredation on sea turtle nests, the red wolves were removed from the Cape prior to and during the 1999 turtle-nesting season.

INTRODUCTION

Cape St. George Island is an undeveloped barrier island contained within the boundaries of the ANERR in Franklin County, which is located in the Florida panhandle (Fig. 1). ANERR is a cooperative program between the Florida Department of Environmental Protection, and the National Oceanic and Atmospheric Administration, and Franklin County.

The beaches of Cape St. George provide some of the most important nesting habitat for the threatened Atlantic loggerhead (*Caretta caretta*) in the Florida panhandle (Bailey *et al.*, 1998). In 1997 a cooperative effort was initiated between USFWS and ANERR that would place a pair of red wolves on Cape St. George to test the suitability of the island for use by red wolves and to serve as predator

control. Cape St. George is the fourth barrier island to participate in the Red Wolf Recovery Program (RWRP) and was not intended to provide a permanent home for the red wolf pair (St. Vincent National Wildlife Refuge, 1997).

St. Vincent National Wildlife Refuge (NWR) is a barrier island just west of Cape St. George and is managed by the USFWS. St. Vincent NWR is also within the boundaries of the ANERR and has been a participant in the RWRP since 1990.

METHODS

In June of 1997 a sterilized red wolf pair was shipped to St. Vincent NWR for acclimation prior to release on Cape St. George. The wolf pair was released wearing radio collars. Their locations were logged 1-3 times each week. A coyote that had occupied Cape St. George for six months in 1997 was no longer present after the release of the red wolves on the Cape in January of 1998.

Since Cape St. George is accessible only by boat, nests are monitored 1-3 times per week. An all terrain vehicle is used to patrol the nine-mile length of Cape St. George beach. Nests are marked and covered with a flat self-releasing screen to deter raccoon depredation. During periods of heavy raccoon depredation many nests are disturbed before the beach is patrolled and the nests are protected. Adult feral hogs are able to dislodge the screens and continued to depredate the nests. Removal of feral hogs by ANERR staff has been the only effective method of limiting depredation due to this species. Prior to placement of red wolves on Cape St. George raccoon control methods had been instituted but required a great deal of time and effort (Fig. 2) (Edmiston *et al.*, 1998).

Raccoon populations on Cape St. George have been surveyed three times. The first survey in 1996 was done prior to release of the red wolves. A second survey was performed in 1999, one year after release of the red wolves. The third survey, performed in January of 2000, occurred five months after removal of the last red wolf from Cape St. George. Prey survey results are calculated as captures per trap per night. Surveys are conducted by placing 25 live traps in pre-determined locations on Cape St. George. Traps are checked each morning and any captured raccoons are tagged and released. GPS coordinates of the trap locations are taken to ensure placement of the live traps at the same site with each prey survey.

RESULTS

The number of sea turtle nests surveyed has increased since 1992, but this may be due to an increase in monitoring rather than an increase in the actual nesting frequency on Cape St. George (Edmiston *et al.*, 1998). From 1992 through 1999 a total of 127 nests were found depredated by raccoons. Feral hogs depredated 55 nests during this period. The coyote that resided on Cape St. George in 1997 depredated 27 nests. After release of the red wolves turtle nest depredation attributable to raccoons dropped to one nest in 1998 and no nests in 1999 (Fig. 3).

Raccoon population surveys determining the number of raccoons available as a prey base show the impact of the red wolves on the raccoon population. The first survey conducted in September of 1996 resulted in 0.272 captures/trap/night. The January 1999 and January 2000 surveys produced 0.020 and 0.060 captures/trap/night, respectively. Comparison of capture data from these three surveys indicates an overall 78% reduction in the raccoon population during the 40 month period beginning with the first raccoon population survey in September of 1996 and ending with the third survey in January of 2000. Red wolves occupied Cape St. George for 18 of these 40 months. No other raccoon population control methods were employed during this 40-month period.

Unfortunately, during the 1998 turtle-nesting season, the red wolves began to prey upon the turtle nests. The wolves dug under the screens then dislodged the screen to obtain access to the clutch. In addition adult feral hogs depredated a significant number of nests during the 1999 turtle nest season, sometimes in conjunction with wolf depredation of the same nest. In 1998, 30 nests were documented as depredated by red wolves. In 1999, 20 depredated nests were attributed to red wolf activity, 15 nests were depredated by feral hogs, and another 11 nests were depredated by a combination of red wolves and feral hogs.

Efforts to capture both red wolves began in 1999 prior to the beginning of the 1999 turtle-nesting season. The male wolf was successfully captured in April of 1999 and was removed from Cape St. George. Extensive efforts to capture the female continued into summer of 1999. This animal proved highly skilled at evading all capture and trapping attempts until August of 1999 when she was trapped. Unfortunately the female succumbed to heat stress during capture.

DISCUSSION

The red wolves proved to be successful at reducing the number of sea turtle nest predators on Cape St. George. In addition to lowering the raccoon population the wolves displaced a coyote responsible for significant nest depredation during the 1997 nesting season. There was also evidence that the wolves preyed upon some of the smaller

feral hogs. The only other large prey species for the red wolf found on the Cape is the cotton rat. A lowered raccoon population reduces one of the most frequent sources of depredation pressure on turtle nests. However, wolf depredation on the turtle nests was at an unacceptably high rate on Cape St. George.

St. Vincent NWR has hosted red wolves since 1990 and during that time has documented four cases of wolves depredating turtle nests, one case only in which the red wolf was the primary predator. St. Vincent NWR is a much larger barrier island than Cape St. George (12,358 acres versus 2,300 acres, respectively). Over one half of the total acreage of St. Vincent NWR consists of upland and freshwater habitat suitable for maintaining a prey base of raccoons and small mammals (Apalachicola National Estuarine Research Reserve, 1998).

Unfortunately staff was unaware that the female wolf had a prior history of turtle nest depredation at a former coastal release site in South Carolina. Regrettably this information did not surface until after the wolf pair was placed on Cape St. George in January of 1998. Complete prior history of any wolf being considered for potential release is vital information for all agencies concerned in any future red wolf program on Cape St. George.

Future placement of red wolves on Cape St. George is dependent upon having available controls to exert upon the red wolves. An adequate prey base and efficient capture methods of red wolves prior to turtle nesting season are baseline criteria to be considered in any future release of red wolves on Cape St. George.

ACKNOWLEDGMENTS

The authors would like to thank the USFWS and the National Fish and Wildlife Foundation for providing ANERR staff with equipment and training necessary to maintain the red wolf program on Cape St. George.

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Fig. 1. Location of Cape St. George Island.

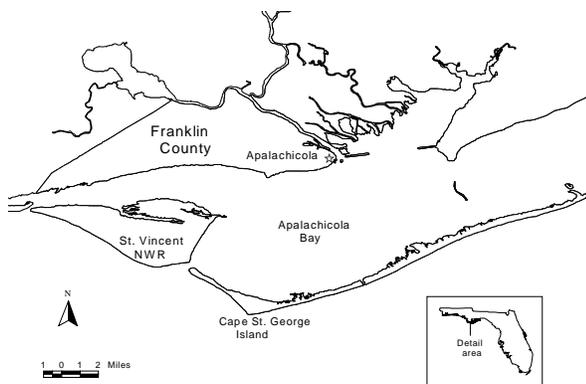


Fig. 2. History of predator removal vs. percent of nests depredated for years 1992 through 1999.

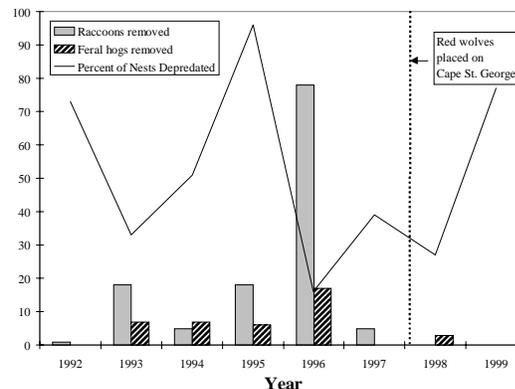
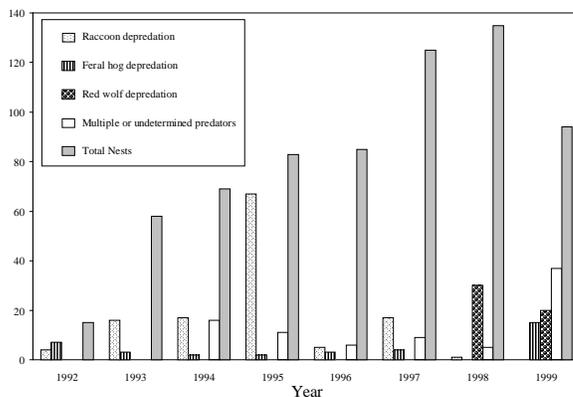


Fig. 3. Numbers of depredated nests by predator types and total number of nests 1992 through 1999.



Scavenging of Turtle Carcasses by American Alligators, *Alligator mississippiensis*, in Georgia, USA

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American alligators (*Alligator mississippiensis*) have been documented to feed on a wide variety of organisms, including the remains of deceased and relatively decomposed animals (Delany and Abercrombie, 1986). However, marine turtles are unknown from their diet. Moreover, scavenging the carcasses of dead sea turtles has not been documented. Here, we report observations of *A. mississippiensis* scavenging loggerhead sea turtle (*Caretta caretta*) carcasses on three Georgia barrier islands.

On 10 May 1999 at 2011 hour Caretta Research Project (CRP) personnel found the remains of a moderately decomposed subadult *Caretta* (SCL = 55.0 cm,

SCW = 45.9 cm, SPL = 32.3, SPW = 37.9 cm, Georgia Department of Natural Resources (GADNR) biopsy/specimen #GA99051001-WASI) on the north end of Wassaw Island (31°54.3'N 80°56.2'W). The carcass was pulled further up the beach, towards the dunes, so that it would not wash out later that night with the approach of high tide. Later that night, at 2300 hour, as patrols were being conducted for nesting sea turtles a large American alligator (~2.7-3.0 m long, TL) was found investigating the aforementioned turtle carcass. When the patrol vehicle approached the alligator it began to raise its body up and hiss vigorously. However, it did not flee towards the ocean as

most alligators do when surprised on the beach (personal observation). The alligator was left with the turtle carcass at 2330 hour.

On 11 May 1999 at 1200 hour, CRP personnel traveled back to GA99051001-WASI to take photographs of the specimen for GADNR documentation purposes. Upon arrival at the stranding site, we could see alligator tracks where the alligator was spotted the previous night. The tracks lead westward towards the dunes. However, the only remaining evidence of the turtle carcass was a depression where the turtle was placed, two costal scutes, and the right front flipper. *A. mississippiensis* tracks crossed the locality where the stranded turtle had rested. Following the alligator tracks into the dunes, we began to find pieces of the decomposing turtle along the alligator's route. Collectively, we relocated three scutes (with epibiota still attached), five ribs, two hyoplastra, the upper and lower tomia, marginal and pygal bones, horseshoe crab claws (presumably stomach contents), and portions of the esophagus with visible papillae. Turtle parts and alligator tracks lead directly to an alligator hole located on the eastern edge of Beach Pond (31°54.3'N 80°56.4'W) approximately 150 m away from where the stranding was originally located.

The wind of the previous night was blowing relatively hard out of the east (~20 knots). It is our belief that the prevailing winds carried the turtle carcass smell directly westward towards Beach Pond where the observed alligator apparently resides. Since the alligator's tracks lead directly from the 'gator hole' to the turtle carcass, we also believe that the alligator ventured to the beach to investigate the smell of the decomposing turtle.

Researchers on other Georgia barrier islands have observed similar instances. An *A. mississippiensis* was seen scavenging a loggerhead carcass on Blackbeard Island (31°28.4'N 81°13.1'W) in 1998 (Deb Keineth, personal communication). Additionally, two instances in 1995 and 1996 occurred on Little St. Simons Island (31°15.4'N 81°25.5'W) where alligators were observed carrying decomposing loggerhead carcasses down the beach and to fresh water ponds located behind the dunes (Michael Robinson, personal communication).

Strandings are often times used to estimate the annual

mortality of certain sea turtle species even though several studies have questioned the practice (Epperly *et al.*, 1996; Shoop *et al.*, 1998; Shoop *et al.*, 1999). Since many factors attribute to the likelihood of a dead sea turtle washing ashore, the possibility exists that strandings only represent a fraction of the overall annual mortality actually occurring. Additionally, the number of dead turtles reported each year might actually be higher than currently believed since alligators do scavenge the small percentage of turtles that actually wash up on the beach. More information is needed to determine the commonness of these scavenging events before we can accurately assess the effect of alligator scavenging on the real number of dead turtles washing ashore annually in Georgia.

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Sea Turtle Mortality in North Carolina (USA): A Summary of 1999 Stranding Events

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INTRODUCTION

Strandings are one of the few indices available to measure sea turtle mortality in state and adjacent federal waters (Murphy and Hopkins-Murphy, 1989; Magnuson *et al.*, 1990; Caillouet *et al.*, 1991). In 1999, sea turtle strandings in North Carolina reached their highest level

since the inception of the state's Sea Turtle Stranding and Salvage Network (NCSTSSN) in 1980. Moreover, they comprised approximately 19% of the total number of strandings reported in the United States last year (Wendy Teas, NMFS, personal communication). This information, along with other unique events, is summarized below.

METHODS

The NCSTSSN is largely composed of volunteers along with staff from various federal, state and private agencies. All trained NCSTSSN followed data collection methods outlined in Schroeder (1989) and in Henson and Boettcher (1998). In 1999, 97% (501 km) of North Carolina's 515 km of ocean-facing coastline was monitored for strandings by the NCSTSSN. Monitoring effort. During the sea turtle nesting season (May-August), all 501 km were patrolled daily for turtle crawls and strandings. Outside of the nesting season, the majority of state and federally owned beaches, which comprise approximately 50% of the coastline, were patrolled a minimum of two times per week by agency staff. On the remaining 47% of the coastline, which is largely composed of well-populated municipal and county-owned beaches, NCSTSSN volunteers relied on the public and local government employees to notify them of stranding events.

North Carolina's vast coastal rivers, sounds and estuaries encompass approximately 6,440 km of shoreline, most of which is accessible only by boat and therefore receives little to no coverage by the NCSTSSN. As such, the majority of inshore strandings reported in 1999 were discovered incidentally rather than by way of regular, systematic surveys.

RESULTS AND DISCUSSION

Statewide Summary

In 1999, 605 true strandings (strandings that did not involve direct observation of incidental capture) were reported by the NCSTSSN (Fig. 1). The majority of strandings were found along the ocean-facing beaches and inshore shorelines between Oregon Inlet and Cape Lookout (Fig. 2). The 1999 strandings were comprised of 383 loggerheads, 122 Kemp's ridleys, 85 green turtles, 11 leatherbacks and four unidentified species. Last year's Kemp's ridley and green turtle totals set new state records (Fig. 3) and comprised 17% and 20% of the total number reported in the United States, respectively (Wendy Teas, NMFS, personal communication). The majority of stranded loggerheads, Kemp's ridleys and green turtles were juveniles (Table 1). The largest percentage (42%) of inshore strandings was reported last year, despite limited coverage. The highest concentration of inshore strandings was found on the eastern shores of Core and Pamlico Sounds (Fig. 2), including 65% (n = 79) of all Kemp's ridley and 74% (n = 62) of all green turtle strandings reported last year.

Summary of Mass Stranding Events

In 1999, the NCSTSSN reported seven mass stranding events (events involving ten or more turtle carcasses found in near proximity of one another over a period of several days) between the Virginia/North Carolina border and Cape

Lookout (Fig. 2). The first five occurred on ocean-facing beaches and the last two were inshore events. The first event took place on April 7-10 and involved 11 immature (52.4-80.6 cm SCL) loggerheads and one severely decomposed juvenile (27.3 cm SCL) Kemp's ridley found along 20 km of beach. The condition of the loggerheads ranged from very fresh to moderately decomposed with no external anomalies. Field necropsies conducted on nine of the loggerheads revealed that all were in sound nutritional condition (full GI tract and good fat reserves) prior to death. The second event took place on May 11-15 and involved 42 immature (49.1-81.1 cm SCL) loggerheads, the majority of which were found along 22 km of beach. Most of the carcasses were severely decomposed which precluded any attempts to necropsy them. Several had missing appendages, but most were intact with few external anomalies. The third event, which occurred on May 26-29, involved 13 immature (59.6-83.0 cm SCL) loggerheads found along 32 km of beach. All but three were severely decomposed. Many of the turtles had missing appendages and other post-mortem anomalies. The fourth event, which took place on June 6-9 along 56 km of beach, involved 23 immature (55.1-91.9 cm SCL) loggerheads and as in the previous two events, most of the carcasses were severely decomposed with missing appendages and other post-mortem anomalies. The fifth event involving 19 loggerheads and one fresh dead juvenile (53.2 cm SCL) green turtle, took place on June 20-24 along 54 km of beach. Most of the loggerhead carcasses were fresh to moderately decomposed. Three of the loggerheads were adults (two males and one female) and the rest were immature (50.1-80.2 cm SCL) animals.

The sixth event spanned the entire month of November and took place along the southeastern shore of Pamlico Sound. It involved 39 immature Kemp's ridleys (32.9-56.9 cm SCL), 21 juvenile loggerheads (51.1-65.0 cm SCL) and 9 juvenile green turtles (26.3-30.5 cm SCL). Over half of the carcasses were severely decomposed. Field necropsies performed on 42 animals revealed that most were in good nutritional condition prior to death. A number of Kemp's ridleys and loggerheads had fish parts in their GI tract indicating that they may have fed on discarded bycatch or fish captured in nets. Several turtles exhibited signs of trauma around the neck and/or flippers suggesting they may have been incidentally captured a net. This event along with a similar one that occurred in November of 1998, led NMFS to enact a temporary emergency closure of a large-mesh, deepwater gill net flounder fishery that operates in Pamlico Sound during the fall sea turtle migration period (September-December). The seventh event also occurred inshore along 2 km of beach inside Cape Lookout Bight, an area that rarely gets covered by the NCSTSSN. This event involved 21 juvenile green turtles (25.2-38.0 cm SCL), two juvenile loggerheads (48.6 cm SCL, other measurement unknown) and one juvenile Kemp's ridley (36.2 cm SCL) found on December 16-18. The uniform condition of the carcasses (i.e., dried, body cavity contents missing)

suggested that they stranded several weeks prior to being discovered by the NCSTSSN.

year round (Epperly *et al.*, 1995). This has serious implications with regard to the numerous commercial fisheries that operate in state waters throughout the annual cycle (Cunningham *et al.*, 1992). Furthermore, little is

Additional Discussion

North Carolina's nearshore and inshore waters provide important developmental habitat for sea turtles virtually

Table 1. Mean straight carapace lengths among loggerheads, Kemp's ridleys and green turtles that stranded in North Carolina in 1999.

Species	N	Straight carapace length in cm (SD)
Loggerhead	244	68.4 (13.02)
Kemp's ridley	112	32.8 (7.47)
Green turtle	74	30.97 (10.03)

Fig. 1. Annual sea turtle stranding totals in North Carolina, 1980 - 1999.

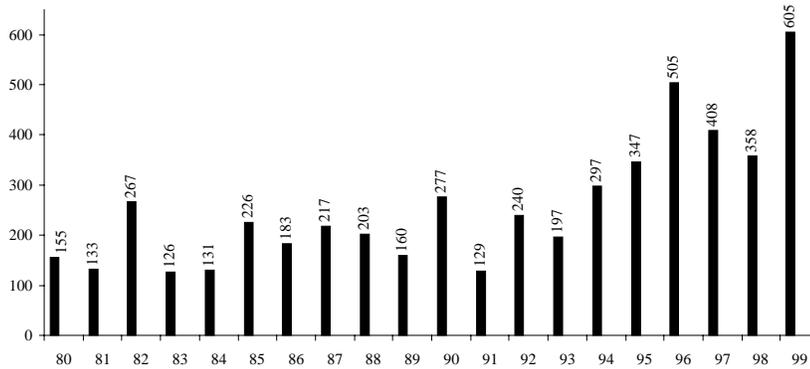
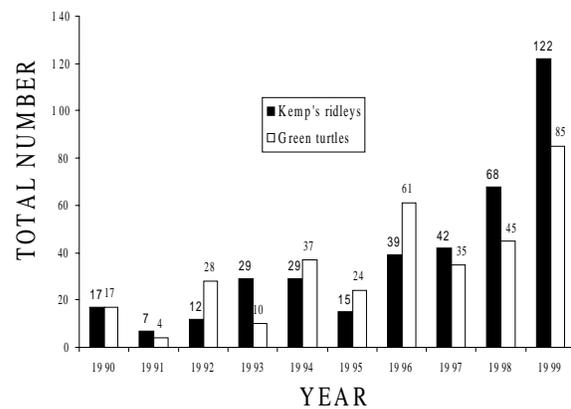


Fig. 2. Map of North Carolina. The area within the box is where 73% (n = 444) of the sea turtle strandings reported in 1999 were found.



Fig. 3. Total number of Kemp's ridley and green turtle strandings in North Carolina, 1990 - 1999. Prior to 1990, 20 or fewer Kemp's ridleys and green turtles were reported annually.



Marine Turtle Strandings in the Northeast U.S. Atlantic

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BACKGROUND

The Sea Turtle Stranding and Salvage Network (STSSN) documents dead or injured sea turtles along the coasts of the eastern United States (Schroeder, 1989). The STSSN relies on a group of trained volunteers, including state and federal employees and private individuals, to collect basic biological data on each turtle located. Each animal is identified to species, the condition or state of decomposition is determined, standard carapace measurements are taken, and any obvious wounds, injuries, or abnormalities are noted and described. Volunteers who have received additional training may also perform necropsies, or internal exams, on a carcass to determine the general state of health of the animal prior to death, determine sex, and locate any obvious internal abnormalities. Data are recorded on standardized report forms which are submitted first to a state coordinator and then to the national STSSN coordinator at the National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida.

Marine turtle stranding data have been collected by the STSSN since 1980 with data collection efforts being most consistent since 1986. Data are frequently summarized by regions and zones utilizing reporting areas originally designed by the Bureau of Commercial Fisheries (now NMFS) for shrimp catch and effort data collection.

DISCUSSION

Looking at long-term stranding trends can often provide clues as to potential causes of mortality. In this analysis, the mean number of strandings from 1986-1990 were used as a baseline with which to compare subsequent years. Cold-stunned turtles or any turtles known to be captive-reared (i.e., 'headstarted' turtles) were excluded from this analysis.

Loggerheads

Loggerheads (*Caretta caretta*) are the most commonly stranded species and the number of strandings in the northeast U.S. Atlantic region has consistently increased since 1991, with the 1998 total being 150% greater than the baseline 1986-1990 stranding average. This strong increasing stranding trend does not hold true for the Gulf of Mexico or southeast U.S. Atlantic regions. Based on nesting data, at best, the healthiest loggerhead sub-

population is increasing at a rate of only 4-7% per year (TEWG, 1998). Thus, the ever-increasing number of strandings in the northeast is likely due to increased mortality rates in the region. There have been observed takes of sea turtles in gillnet fisheries and offshore trawl fisheries in this region. In the U.S. Atlantic there is limited shrimping effort north of zone 34, and that is mostly concentrated in the inshore waters of North Carolina (zone 35). Loggerheads stranding in the northeast are mostly juveniles with a distinct subadult and adult component and are stranding predominately in zones 35-37 in May-June.

Kemp's Ridleys

The population of Kemp's ridley, as measured by nesting activity, is increasing exponentially (TEWG, 1998). Concomitantly, strandings are increasing in all regions, but relative to other regions strandings in the northeast, excluding cold stuns, are relatively rare. In the northeast, Kemp's ridleys are stranding mainly in zones 35-36 during the fall and early winter.

Leatherbacks

Leatherbacks strand in the northeast predominately in zones 39-41 with strandings of this species being highly variable from year to year.

ACKNOWLEDGMENTS

We thank the state coordinators of the Sea Turtle Stranding and Salvage Network and its innumerable volunteers, past and present, for providing the numbers and size distributions of stranded sea turtles.

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An Unfortunate Encounter with a Concrete and Rock Composite Groin

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During the night of July 13th or the predawn hours of July 14, 1999 a female loggerhead (*Caretta caretta*) came ashore on Coquina Beach, Manatee County, Florida (USA) in an apparent attempt to nest. The turtle crawled over a partially submerged concrete groin and fell into the adjacent rock revetment where she became entrapped. A volunteer with the Anna Maria Island Turtle Watch found the 273 lb (124 kg) loggerhead at 0545 hours. The turtle was found upside down with her left side wedged into the rocks. A blood covered fracture (10.24 in or 26 cm) was immediately obvious on the left lateral portion of the plastron. Following extrication the turtle was transported to the Marine Mammal and Sea Turtle Hospital at Mote Marine Laboratory in Sarasota.

ACKNOWLEDGMENTS

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How a Very Small Caribbean Island Creates Biologists at an Early Age

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The assistance of students is of much support to field work, as well as in the prevention of poaching of sea turtles and their eggs. While volunteering, the students learn field techniques such as tagging and hatching success evaluation. Youth and sea turtles alike have benefited from volunteer participation of the Antonio R. Barcelo School of Culebra. A large sector of the student participants have obtained a consciousness of the natural sciences and consider pursuing biological studies, while others have developed the knowledge necessary for the conservation and preservation of our natural resources. This presentation is intended to demonstrate how essential it is to directly involve student residents to guarantee sea turtle conservation since they are the future caretakers responsible for conservation of the planet. The secret to conservation and protection of endangered species is the integration of the student community into the program.

INTRODUCTION

Culebra is a small Caribbean island in the Puerto Rico archipelago with a population of nearly 3000 residents. Despite its small size, the island possesses a unique and natural beauty when compared to other islands of the Caribbean and its community feels a sincere respect and pride for its natural resources. A leatherback sea turtle nesting monitoring program commenced on Culebra in 1984. Leatherbacks nest on various beaches in the Culebra archipelago with the vast majority of nesting taking place on Playas Brava and Resaca. The project began under the direction of the U.S. Fish and Wildlife Service (FWS) and was later contracted to various groups with FWS administration of project design. Various project leaders have realized the importance of involving the Culebra community, in particular the local students. Their participation is of utmost importance since they are the ones who will determine the future of this beautiful island and, at the same time, serve as important tools in sea turtle conservation in the Culebra archipelago.

METHODS

During the nesting season March through July the student community participates as volunteers in nightly beach surveys. Students patrol the beaches and perform work almost identical to that of the biological technicians including obtaining body measurements, counting eggs, obtaining tag data, nest site triangulation, and insuring that other volunteers understand proper conduct while near the

turtles. All students have data books, flashlights, and measuring tapes, and assure that equipment is ready when needed. Upon termination of the nesting season, students continue monitoring the beaches to prevent egg poaching and document hatching activity.

RESULTS AND DISCUSSION

The sea turtle project has stimulated students' involvement in the project and has developed their interest in sea turtle conservation. Overall, due to active participation, students have matured with an appreciation of endangered species conservation and have helped insure higher levels of nesting success on Culebra beaches.

Information obtained from annual reports indicates that students have participated throughout the project history (Tucker, 1987; Tallevast *et al.*, 1990; Soler, 1999). This active participation has augmented the entire Culebrense community's interest in conservation of sea turtles. In addition, thanks to students' participation, tourists that volunteer for the project see the island's youth as caretakers with the skills necessary to work as technicians with nesting and hatching turtles. This helps raise the visitors' awareness of endangered species.

The sale of private land near Culebra's leatherback nesting beaches is threatening the future of this important nesting habitat. It is important that agencies find ways to acquire these lands to insure the habitat quality. Also, the frequent change of technicians over the years affects interaction between students and the technicians. We suggest that in order to achieve the best results, the project take into consideration the Culebrense community and student community. Culebrense involvement in the project is essential and we hope that the new directors of the project, The Puerto Rico Department of Natural and Environmental Resources, will continue involving the local community, especially the students.

ACKNOWLEDGMENTS

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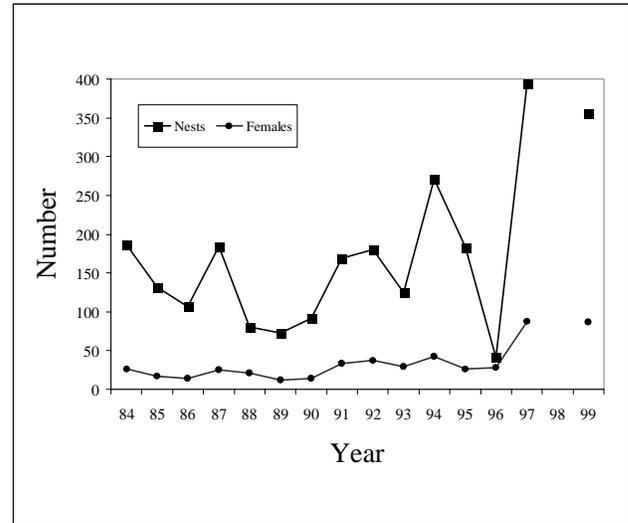
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Fig. 1. Annual numbers of females and nests, Culebra, P.R., 1984-1999 (Tucker 1988; Tallevast 1990; Soler 1999). There is no data for 1998.



Extension Programs for Conservation Measures to the Nesting Olive Ridley Sea Turtles at East Coast of Andhra Pradesh, India

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For the Conservation and Management of Olive Ridelys Sea Turtle Campaign Programme were conducted in the coastal areas of districts of Srikakulam, Vizianagaram, Visakhapatnam and East Godavari of North Andhra Pradesh, India (Fig. 1). Human inhabitation is a marked feature of this area. As a result, the presence of domestic dogs, pigs etc., is very high, whereas the human activity is meager. The presence of predators like foxes, jackals and hyaenas is also noticeable. These animals often prey upon the eggs of the olive ridley and nesting hatchling turtles. The major threat to the survival of the olive ridley and other species of sea turtles can be traced to the ignorance as well as subsistence pattern of the fishermen.

A pilot extension programme has been organized to create awareness among the fishermen with regard to the importance of sea turtles. The aim of this program is to avoid or at least to reduce the decimating impact of the human factor on the sea turtles. Extension programs are conducted at the village level to educate the importance of sea turtle conservation, with the cooperation of the Andhra

Pradesh State Forest Department (Wildlife Wing). Several posters and slides on the sea turtle conservation are displayed. Several extension lectures have been delivered in local ‘Telugu’ language at 28 colonies of fishermen to furnish them with sufficient information about the Sea turtles and their value and usefulness. They were educated on the various stages of the hatchlings of the sea turtle eggs in the nests and about their conservation. From those villages of the fishermen, some persons have been selected and placed in charge of guarding the nests on the coastline area during the breeding season of the Sea turtles. This aspect has also been explained to them through Audio–Visual aids, Pamphlets, TV, All India Radio and Press media.

The Coastline of Andhra Pradesh has 980 km and provides a major migratory route or pathway for the Olive ridelys to approach ‘Gahirmatha’ island in the adjoining Orissa state. It is here, that the largest ‘Arribada’ was reported by Bustard, 1976. It is more likely to locate a good number of turtles sporadically nesting along the coastline

of Northern Andhra Pradesh. 'Hope Island' near Kakinada, Andhra Pradesh is an important region to locate sea turtles, still exists in this region. Our extensive study of the Northern Andhra Pradesh coastline reveals that the Olive ridleys have been subjected to severe exploitation (Table 1). As a result, their nesting grounds are fast deteriorating. This makes their management for conservation purpose.

Frazier, 1980 has revealed that the different ways in which the marine turtles in the Indian Ocean are being exploited. He marked that the main motive behind their exploitation in the subsistence problem of the hunters who mainly live upon the gains of exporting the Sea turtles and their eggs which are traditionally exploited along the entire Indian coast. The same is supported by Kurian, 1950. The ever increasing trend of the turtle trade not only destroys them but also severely limits their reproduction.

In this context, an extension program, 'Save Sea turtles', was launched for turtle trade, turtle hunting and destruction of their nests has been reduced considerable from the first year to the last year of our study. This gradual decrease can be attributed to the awareness created in the minds of the people, greater protection given by hired people mostly fishermen which are also responsible for the above said programmes proved to be a success in protecting the sea turtles resources.

Based on the present study, the following recommendations are considered to be very important in conservation and management of the olive ridley sea turtles.

Stop subsistence hunting. Subsistence hunting can be avoided through intensive extension programmes in all 53 villages of our study area.

Establish beach hatcheries. Beach hatcheries can be started in all the zones with the technically trained

personnel supported by several poor fishermen and tribals.

Create a Central Sea Turtle Farm. This organisation will be fed with the newly born hatchlings from various beaches. Hatcheries should be setup to rear the hatchlings until they are one year old when they cross the most crucial period of their life cycle.

Strictly implement the Indian Wildlife (Protection) Act, 1972. Severe punishment should be imposed on the commercial exploitation of the sea turtles.

ACKNOWLEDGMENTS

We would like to take this opportunity to acknowledge Dr. P.S. Raja Sekhar and Dr. V.V. Subba Rao for their help in conducting field survey and awareness campaign in the coastal villages. We would also like to express our sincere gratitude to the organizers especially Dr. Blair Witherington, President of the Twentieth Sea Turtle Symposium during our stay at Orlando, Florida, USA for the hospitality and the travel grant.

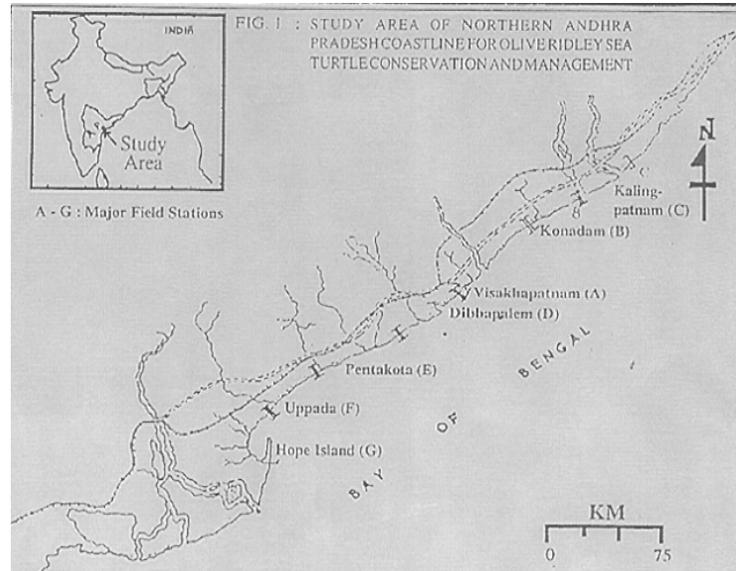
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 Frazier, J. 1980. Sea turtle faces extinction in India: crying wolf or saving sea turtles? Environment Conservation 7(3):239-240.
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Table 1. Factors threatening the survival of olive ridley sea turtles at different zones and divisions of the study area.

Zone	No. of Zones divided	False Crawls	Identified Nests	Human Disturbed nests	Turtle trade	Caught in fishing gear	Trapped in Drying nets	Turtles released into the Bay of Bengal	Caught while nesting	Turtles killed by Predators	Nests disturbed by Predators
A	5	47	27	78	25	128	3	19	32	0	49
B	4	32	12	54	32	68	2	12	23	1	42
C	3	40	14	51	30	92	1	10	20	1	56
D	3	51	18	75	78	101	4	23	36	1	28
E	5	51	16	53	37	93	2	11	18	1	65
F	3	78	12	52	53	55	1	17	25	1	58
G	2	68	25	79	63	111	2	11	16	4	65
TOTAL:	25	367	124	442	318	648	15	103	170	9	363

Fig. 1. Study area of Northern Andhra Pradesh Coastline for Oliver ridley Sea Turtle Conservation and Management.



Contributions by the South Carolina Department of Natural Resources to the History and Growth of the Sea Turtle Symposium

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INTRODUCTION

The South Carolina Department of Natural Resources (formerly the South Carolina Wildlife and Marine Resources Department) has hosted four of the 20 workshops/symposia. As the host agency for one-fifth of the meetings, we feel we have had an enduring influence on the direction the symposium has taken over the years. We present descriptions of the 3rd, 6th, 10th and 13th workshops/symposia, including events that were unique to each and innovations that are now an integral part of the meetings.

The Third - 1983

Place: The Marine Resources Center,
Charleston, South Carolina

Date: April 7-8

Co-Sponsors: SC Wildlife & Marine Resources Dept.
NMFS/Southeast Fisheries Center
Center for Environmental Education

Organizer: Sally Hopkins

Number attending: 108

Firsts: Invited, oral slide presentations
Poster presentations
Nighttime social - Oyster roast
Tours of the NMFS and Marine Resources Laboratories

The meeting consisted of two sessions on Thursday and one session on Friday. The oyster roast was on Thursday evening at the picnic grounds overlooking Charleston Harbor and the city.

The first session was a "Species update". The following invited presentations were given:

1. Leatherbacks-Peter C.H. Pritchard (Florida Audubon Society)
2. Green turtles-Ross Witham (Florida DNR)
3. Hawksbills-Larry Ogren (NMFS)
4. Kemp's ridley-David Bowman (FWS)

The second session was an "Agencies update". The presenters and topics were:

1. Chuck Oravetz (NMFS)-"TED Design and Usage"
2. Dan Odell (University of Miami)-"Stranding Network"
3. Jim Richardson (University of Georgia)-"Projects on National Parks"
4. Larry Ogren-"Research Projects under the Southeast Fisheries Center"
5. Bo Bricklemeyer and David McCollum-"Activities of Private Groups and Universities"

The session on Friday included talks on "Reproductive Strategies" by Whit Gibbons (Savannah River Ecology Laboratory) and Nat Frazer (University of Georgia), "Hatchling Behavior" by Sally Hopkins, and "Remote Sensing" by Richard Byles and Jack Musick. There was a Summary Session chaired by Tom Murphy and Llew Ehrhart

The poster sessions were displayed both days and included topics on the “Western Atlantic Turtle Symposium (WATS I)”, “Types of turtle tags”, “Identification of turtle products”, “Pelagic and nesting surveys” and “Public Information and Education”.

This workshop was more formal than the previous two, which consisted of round-table discussions. This format became the standard for all future meetings.

The Sixth - 1986

Place: The Georgia Episcopal Center,
Waverly, Georgia
Date: March 19-21
Co-Sponsors: SC Wildlife & Marine Resources Dept.
US Fish and Wildlife Service
Organizers: Sally Murphy and Earl Possardt
Number attending: 240
Firsts: Panel discussions after each session
Attendees from the northeast and
Gulf coast

The Sixth Workshop was held at the same location as the Fifth. The Georgia Episcopal Center overlooked the salt marshes of south Georgia and was tucked under the moss-draped live oaks. The Conference Center had a cafeteria and provided three meals a day. This was a great opportunity for discussions among the attendees. Most of the lodging was also at the Center.

The format was slightly different from the previous workshop in that in addition to papers presented on recent work, half-hour blocks of time were scheduled for discussion sessions. These sessions were intended to help answer the question, “Where are we and where do we need to be going”?

There was a barbecue and keg party the first evening to renew old friendships and adjust attitudes. Posters were set up at this time so that attendees could talk with those who brought displays. Since the tee shirt had now become a regular part of the meetings, the design for the Sixth was a black and white photo of a Kemp’s ridley with lettering in a circle around the turtle giving the workshop number, date and location.

There is not enough space to include the entire agenda, so the following is a list of the session titles and the members of the panel discussion groups.

Session I: Nesting Beach Management - Earl Possardt, Ross Witham, Llew Ehrhart and Sally Murphy.

Session II: Beach Nourishment - Ross Witham, Nora Murdock, Richard Wolf, Dave Nelson, Paul Raymond and Ed Standora.

Session III: Kemp’s Ridley - Peter Pritchard, Charles Caillouet, Rene Marquez, Jack Woody and Larry Ogren.

Session IV: TED Implementation-Tom Murphy, Jack Woody, Chuck Oravetz, Joe Webster, David Harrington and Michael Weber.

Session V: Strandings and Sitings-Douglas Beach, Robert Prescott, Fred Berry, Bob Schoelkopf, Jack Musick and Walter Conley.

Session VI: Telemetry-George Balazs, Tom Murphy, Richard Byles, John Keinath and Ed Standora.

Session VII: Population Biology-Nat Frazer, Ralf Boulon, Karen Bjorndal, Llew Ehrhart, Terry Henwood and George Balazs.

The use of 30-minute panel discussions after the presentations in each session is what set this workshop apart from previous ones. This format was dropped in later years as the size of the meetings increased.

The Tenth - 1990

Place: Hilton Head Beach & Tennis Resort,
Hilton Head Island, South Carolina
Date: February 20-24
Co-Sponsors: SC Wildlife & Marine Resources Dept.
The Museum of Hilton Head
Organizers: Sally Murphy and Ed Drane
Number attending: 480
Firsts: Keynote Address
Student Award for Best Paper
Gala Banquet
Concurrent Workshops
Abstracts required in the Call for
Papers
Questionnaire on the future organ-
ization of the workshop

The Tenth Workshop was very special and new traditions were begun. The motto on the program read, “a decade of knowledge, dedication and friendship”. The agendas, tee shirts and nametags all had a hawksbill drawing and the memento was a brass hawksbill lapel pin. At registration, individuals that had attended all 10 workshops had a blue ribbon attached to their nametag. Those who had attended at least eight meetings had a red ribbon.

The meeting began with the first, and very thought-provoking, keynote address by Nat Frazer (Mercer University). The title was “Sea Turtle Conservation and Halfway Technology: Confessions of an Academic Parasite.”

There were 80 oral presentations divided into 12 technical sessions. The following contains the titles of the sessions and the person that was the Session Chair: Aspects of Nesting, 1 and 2-Karen Bjorndal and Jack Woody; Conservation and Management-Terry Henwood; Potpourri, 1 and 2-Earl Possardt and Colin Limpus; Physiology-George Balazs; Disease and Strandings-Barbara Schroeder; Orientation and Movements - Ed Standora; Turtles at Sea, 1 and 2-Ken Stansell and Karen Eckert; International Conservation - Rod Mast; Leatherbacks-Peter Pritchard There were only five oral presentations considered for the Best Paper by a Student Award. The individuals were A.

Tucker, B. Witherington, W. Booker and B. Bowen for two papers. The winner, who was announced at the banquet, was Tony Tucker.

There were 41 poster presentations, a special evening program by Colin Limpus entitled “An illustrated lecture on the flatback turtle”, and evening movies and slides programs after the auction.

The three concurrent workshops were: “How do we measure and monitor sea turtle populations?” by Colin Limpus and Nat Frazer, “Stranded turtles and turtle parts” by Bob Shoop and Carol Ruckdeschel and “International conservation Issues” by Rod Mast and Jeanne Mortimer.

The highlight of the meeting was the Gala Banquet. Chuck Oravetz was Master of Ceremonies. Sally Murphy introduced those seated at the head table. They were: Ken Stansell (U.S. Fish and Wildlife Service), Tom Murphy, David Chamberlain (representing Congressman Arthur Ravenel), Ed Drane, Dr. Jay Hair (National Wildlife Federation), Dr. Jim Timmerman (Executive Director of SCWMRD), Fred Berry (NMFS) and Joan Logothetis and husband Bill.

Joan Logothetis gave the invocation, Jim Richardson presented the Best Student Paper Award to Tony Tucker and Llew Ehrhart announced the trivia quiz winner, Ken Dodd. “Doc” also presented the B.M. Stool Award to George Balazs for his paper, “Some aspects of the green turtle fecal wash-up phenomenon on Hawaiian beaches”. Fred Berry gave a brief history of the workshop by introducing all of the past organizers. And Marydele Donnelley presented an award on behalf of the Center for Marine Conservation to Capt. Joe Webster, a Georgia shrimper, for his conservation efforts with TEDs. Dr. Jay Hair, President of the National Wildlife Federation was the guest speaker and he presented an award to Sally Murphy on behalf of his organization.

In the middle of the banquet, “Tony the Turtle” appeared and was interviewed by Chuck Oravetz. Tony was really Jeff Brown (NMFS).

Although a “fine time was had by all”, there were several problems with how the workshop was organized. First, the social events, coffee breaks and nighttime gatherings were held in a private hospitality room to keep the cost down. If we used the facilities of the convention center, it would have raised the registration fee from \$10.00 to \$50.00. Second, there were many decisions, such as what papers to accept, funding for foreign travel, etc. that were too important to be made by just one or two individuals. And third, the workshop was just too big for one person to handle. A questionnaire, included in the registration packet, was intended to obtain the thoughts and feelings of everyone on “where do we go from here” The rest is history.

The Thirteenth - 1993

Place: Villas-by-the-Sea, Jekyll Island,
Georgia
Date: February 23-27

Co-Sponsors: South Carolina Wildlife and Marine Resources Dept.
Georgia Department of Natural Resources
Organizers: Sally Murphy and Mike Harris
Number attending: 565 from 29 nations and territories
First: Symposium
Copulating flatback turtles for logo
Use of tents and Japanese lanterns

The thirteenth meeting, now called a symposium, was held at Villas-by-the-Sea for the third consecutive year. But by now, we were bursting at the seams. A large tent was set up to house the vendors and a smaller one to extend the “Tippling Turtler Bar” was decorated with Japanese lanterns. The program and tee shirt design was of copulating flatback turtles and the memento, a refrigerator magnet, also depicted a flatback turtle.

There were thirteen sessions containing 86 oral presentations. The technical sessions and session chairs were: Threats and Solutions-Barbara Schroeder; Movements and Migrations - Ken Dodd; Gulf of Mexico - Pamela Plotkin; Indo-Pacific Stew-Roldan Valverde; Feeding Behavior-Anne Meylan; Nests, Eggs, Hatchlings- Llew Ehrhart; Conservation I, II and III-Jack Musick, Richard Byles and Javier Alvarado; Legislation-Blair Witherington; Anatomy and Physiology-David Owens; Genetics and Population Biology-Vincent Burke; Saturday Special-Karen Bjorndal

There were 15 oral presentations competing for Best Student Paper Award. The winner was Mary Rybitski (Virginia Institute of Marine Science, College of William and Mary) with Honorable Mention to Selina Heppel (North Carolina State University) and Tigerin Peare (Ohio State University). There were 50 poster presentations. Best Student Poster was by Sarah Fangman (North Carolina Maritime Museum).

The opening night mixer at the “Tippling Turtler Bar” happen to fall on Mardi Gras, and someone produced plastic beads for everyone to wear. It was very festive. There were evening video presentations, a symposium plenary session to elect officers and members of the Board of Directors and the auction, with our master auctioneer, Rod Mast. More than \$4,000 was raised to support travel grants for next year’s foreign participants and students.

At the banquet, a special slide show tribute was made to honor Jack Woody (U.S. Fish and Wildlife Service National Sea Turtle Coordinator) for his long term and dedicated work on behalf of sea turtle conservation as he retires from the USFWS.

Many were sad to be leaving Villas-by-the-Sea since there were many happy times here, but alas, we had out grown the facilities. More happy times were ahead at Hilton Head Island, Orlando, Mexico and Texas and we all looked forward to the Twentieth in the new Millennium.

Sea Turtles In The World Wide Web

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INTRODUCTION

At the world level, internet or the world wide web is an electronic medium to divulgate information, which involves the different areas of knowledge. Into that virtual world, also it is possible to find sea turtles. However, in the present time there is no data or references related to the global panorama about sea turtle web pages.

This work tries to present a preliminary view of the current situation and to influence the beginning of investigations and more specific works on this topic.

METHODS

Primarily, in this analysis a good known search engine was selected. This search engine corresponds to the web page more visited in the world: <http://www.yahoo.com>. Afterwards, it was performed the search through two key words: "sea turtles". This search revealed approximately 20,000 web pages.

Obviously it was not possible to analyze that great quantity of web sites, and it was decided to select as sample the first 220 web pages. However, it was necessary to discriminate the sample because there were web sites absolutely commercial and some in which sea turtles were not the main subject. Then 132 abstracts were analyzed. In some cases to clarify the information it was performed the connection with the respective web page.

RESULTS

Species comparisons

On other hand, it is possible to advise that a great number of web pages (85% approximately) focus the topic sea turtles without to consider a species in particular. In the rest of the sample analyzed (15%), the web pages dedicate their attention to one or two species. *Chelonia mydas* is the species with highest number of web pages, with a minimum difference in relation to *Caretta caretta*.

Geographical Comparisons

In the first analysis, it is possible to observe clearly at the level of continents, the major preponderance of the American continent, considering that more of 90% of the total are web pages from that continent. The main contribution to that percentage belongs to the United States of America. Obviously this could be attributed to the use of a search engine of the U.S.

In the opposite sense it is necessary to make special mention about the corresponding panorama of the African

and Asian continent (see graphic N°1). On the other hand, it is difficult to understand the Asian situation: they have several projects in this area and no information in web pages. Similarly, the Australian case does not correspond with the work made in that nation, taking in account there are only 3 web pages in the sample selected.

Participation of the GOs and NGOs

When it was compared the participation or presence of the private sector and the governmental sector in the generation of web sites, the private initiatives comprise 91% of the total. It is a faithful reflect of the situation respect sea turtle conservation programs and projects.

Moreover, with respect to the preponderance of the web pages from private sector, it must be said that is facilitated for current opportunities to elaborate and to include a page in the world wide web.

The majority of the web pages that have educational orientation (15.2%) correspond to the U.S. Practically the rest of nations identified in the analysis practically don't have this kind of examples.

Among the different aspects that comprise the sea turtle biology and conservation, it could be verified that topics like ADN mitochondrial analysis, legislation for sea turtle protection to national and international level and, evolution of these species are scarcely developed or simply ignored.

Analysis Limitations

At first, the limited time available and the expenses related to the internet connection in Venezuela, avoided the possibility to analyze a sample with a higher number of web pages. In addition, often the web pages evaluated are extremely reduced. This became a difficulty to get a complete understanding about the respective subject of each page, which could induce to some wrong concepts.

Finally, sometimes the search engine used does not give enough information about the extension and standing of the web pages that could avoid to arrive to new conclusions and to perform complementary comparisons.

CONCLUSIONS

United States of America has established an enormous difference with respect to other nations and also with respect whole continents, considering the number and variety of web pages included in internet for this country.

The private area as generator of web pages about sea turtles has an evident control and great responsibility in their orientation and characteristics. In consequence, this area is also involved in the defects and weakness of them.

More complete analysis and investigations are required at the level of regions or countries, in order to get results more specific that contribute to take decisions to improve the use of this powerful tool.

RECOMMENDATIONS

It is necessary that the summaries of the web pages in the search engines be specific, to avoid waste time in the search of the required information.

To increase the presence in internet of the web pages generated by other countries than U.S., it is suggested to send summaries of them to the highest number of search engines local and foreign.

Web pages included in internet must be always updated and must eliminate the use of the words “under construction” in current and new web pages.

It is important to improve the presentation and text of the web page and it is proposed to establish an annual award in the Sea Turtle Symposium to the best web page.

ACKNOWLEDGMENTS

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Education Program: Sea Turtles in Puerto Rico

LESBIA L. MONTERO-ACEVEDO

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This project is part of an education program in the Sea Grant Program of the University of Puerto Rico and is sponsored by the Fish and Wildlife Service and WIDECAS. This is a traveling exhibition about sea turtle conservation in Puerto Rico. This exhibition is a panel (8 ft x 6 ft) with photos and information (in Spanish and English)

about sea turtle biology, threats to survival and how we can help to protect the species. This exhibition includes an activity box for teachers. This activity box has sea turtle models, sea turtle curriculum guides for teachers, games, slide shows, videos, and other educational materials necessary to learn about sea turtles.

Evaluation of the Current Status and Exploitation of Sea Turtle Populations on Margarita Island, Nueva Esparta State, Venezuela

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The insular ecosystems, in islands inhabited by man, are the most effected by the overexploitation of the natural resources and overutilization of the habitats. This is due mainly to the limited existence of resources that substitute their needs. The Nueva Esparta state is not the exception of this premise. Additionally in the last decades we have had a tourist and commercial explosion of anarchical growth that has precipitated the degradation of several existent habitats, on Margarita Island.

The program toward the sustainable development of Nueva Esparta (subprogram - conservation of the species of Nueva Esparta State through the investigation handling and environmental education, the current evaluation and pursuit of the sea turtle population on Margarita Island) has as a principal objective, to know the current situation of the

different sea turtles species and their habitats through the pursuit of the populations in order to identify the most susceptible areas and generate or support the elaboration of educational and sensitization plans and handling for it recuperation beside, like others it reaches:

- Determine the distribution of the nesting population in the beaches by species.
- Establish the bases in order to sep up the dynamic of the population of the nesting species.
- Evaluate the success of the exploitation of the nest.
- Evaluate and actualize the knowledge about the conservation problems for the human pressure to which is confronted several species.
- Know the environmental problems that come up in the principal nesting beaches.

Current Status of the Bekko Industry in Japan

HIDEO ISHIKAWA AND KENGO OSAWA

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Japan is a range state of the hawksbill turtles (*Eretmochelys imbricata*) and located in the northernmost part of its distribution. Since the population in Japanese water is very small, the tortoiseshell (bekko in Japanese) industry has relied on raw materials imported from foreign countries. It is believed that the history of the bekko industry in Japan dates back to 1,000 years ago. Since the bekko industry became flourished after bekko crafting technique was reintroduced by Potuguese 400 years ago, the technique has been improved and was established as one of the Japanese traditional heritage. When Japan joined CITES in 1980, it entered a reservation with regard to the

hawksbill turtles and continued to import bekko. In 1992, Japan decided to withdraw the reservation. Currently, the industry is using the stocks which were imported before 1992. The industry has since met a lot of restructuring. Since its inception, Japan Bekko Association (JBA) has convened many international workshops on the conservation and management of the species. Also, JBA has funded the projects within and outside of Japan. JBA is discussing on how the proceeds derived from the industry could benefit the conservation of the species. These activities will be presented at a poster session.

Sea Turtle Conservation and the Assessment of the Demand and Supply of Sea Turtles in Bahia Magdalena, Baja California Sur, Mexico

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INTRODUCTION

Sea turtles have historically been a primary resource for many of the coastal inhabitants of Bahia Magdalena,

Baja California Sur, Mexico. In the Bay's region, the East Pacific green turtle, commonly known as the black turtle (*Chelonia mydas agassizi*) and the Pacific loggerhead (*Caretta caretta gigas*) are the species most commonly

seen. Turtles have long been used for such things as food, medicine, decoration, and household items (Ernst and Barbour, 1989). Still considered part of tradition today, the sea turtle is served at weddings, Christmas, Mother's Day, Sundays, and most commonly for Easter. Other uses include extracting the oil from the fat to aid children suffering from respiratory problems (Caldwell, 1962; Felger, 1987). In the 1960's humans had basically destroyed all reproductive efforts of this species by consuming large numbers of mature turtles as well as their eggs. In the early 1970's, the sea turtle population began to crash due to the fact that they were unable to reproduce fast enough to keep up with the demand (Cliffon *et al.*, 1979). Due to this situation the Mexican government implemented a recovery program in 1978 and closed nesting beaches prohibiting the harvest of sea turtle eggs. In 1980, a quota limiting the number of sea turtles that could be taken per month was introduced as a way to control the exploitation of the sea turtles (Instituto Nacional de la Pesca, 1990). The legal framework to protect sea turtles includes an executive order issued by the Mexican Ministry of Fisheries and the Mexican Ministry of Urban Development and Ecology on May 31, 1990. Under this scheme, the Mexican Federal Government strictly prohibits the extraction, capture, and pursuit of all species of sea turtle in federal waters or from beaches within national territory. In addition, the specimen of any species of sea turtle incidentally captured during the operations of any commercial fishery shall be returned to the sea, independently of its physical state, dead or alive (Diario Oficial de la Federación 1996, 1992, 1990, 1988). Nevertheless, before a plan can be outlined to conserve sea turtles in the region, it is necessary to gain a better understanding of the extent of turtle harvest. Only upon characterizing the problem and identifying its sources can an effective management plan be implemented. To date demand and supply levels are presently lower than they were during the peak of the sea turtle trade. For example, in the 1960's there was a sea turtle slaughterhouse in Puerto Magdalena, which processed between 150 and 250 turtles per week. Despite their endangered status (Instituto Nacional de la Pesca, 1990; National Marine Fisheries Service, 1985) and the implementation of the ban the demand for and the supply of these animals has persisted to some degree. Therefore, the objective of this study was to estimate the demand and supply of sea turtles in the Bahia Magdalena region in order to gain a better understanding of the socioeconomic factors that influence the consumption and the harvesting of these organisms.

METHODS

To assess the demand and the supply for sea turtles in the region surveys and interviews were performed in order to determine the demand and supply functions for sea turtles. From June 12 to June 30, 1999, 122 surveys and 56 interviews related to the demand for sea turtles were

randomly conducted in Puerto San Carlos and Magdalena Island. From July 24 to August 1, 1999, and in order to assess the supply of sea turtles 95 surveys and 70 interviews were conducted randomly in the town of Puerto Magdalena, Puerto San Carlos, and at Punta Arenas. The demand and supply functions were determined through a generalized least squares, GLS, method (Bohrstedt and Knoke, 1991; Menz and Mullen, 1981) to assess the socioeconomic factors that influence these functions. For the purposes of this study demand for sea turtles was defined as the number of sea turtles the respondents were willing to consume while supply was defined as the number of sea turtles captured by an individual.

RESULTS AND DISCUSSION

It was found that 35.7% of the variation in demand could be explained by six independent variables that were used to assess the demand. The occupation of the respondents had a significant negative effect on demand. As expected, if a person's occupation was anything but a fisher, then the demand decreased. It stands to reason that fishers have greater access to sea turtles than the average person does. Income negatively affected the demand because the more money a person earns the less their demand for sea turtle while the larger the family the greater the demand. Eighty-two percent of families in Puerto San Carlos earn less than 5,000 pesos (US \$500) per month and 62% have an average family size of four to six members. Therefore, when these factors are combined the demand for sea turtles increases significantly. The predominant religion of the people of Puerto San Carlos is Catholicism and Easter was found to be the occasion when most people consume sea turtle because these organisms have become a good substitute for red meat. This occurs because sea turtles are available to fishers in the bay and the majority of the respondents indicated that they like its taste more than fish, chicken, or shellfish. The 1990 ban was the most significant factor that decreased the demand of sea turtles despite the occasional lack of enforcement. In addition, the lower numbers (or availability) of sea turtles in the Bahia Magdalena region negatively influenced demand. Twenty eight percent of the variation of supply was explained by eleven independent variables. It was determined that age has a significant positive effect on the supply of sea turtles harvested because older fisherman have been catching sea turtles for much longer than younger fisherman and are less likely to alter their practices even when facing a declining sea turtle population. The low level of education of the respondents surveyed increased significantly the supply of sea turtles. The majority of people in this area have only a basic level of education and it is expected that with a higher level of completed education there is a lower incidence of sea turtle harvest. It was also determined that finfishing practices increased significantly the supply because fishermen typically use gill nets that are known to catch

non-target species such as sea turtles. In addition, the number of economic dependents increased the supply of sea turtles significantly. Thus, the more economic dependents an individual has, the more probable it is that he will supply sea turtle to his family. Culture increased significantly the supply of sea turtles because the people who perceive sea turtles as an important part of their culture may consume turtle occasionally. Low availability of turtles per week also had a significant negative impact on supply. Because those more interested in conservation are less likely to harvest sea turtles there was a significant negative influence on their supply. However, proclaiming an interest in conservation is not equivalent with a willingness to stop harvesting them. For instance, it was found that if the government allowed the harvest of sea turtles the majority of respondents would capture them and thus increase the supply.

CONCLUSIONS

Sea turtles have proved to be a sufficient, and sometimes necessary, meal for many families in the Bahia Magdalena region. The opportunity cost of a fisher to return a sea turtle to the sea is too great because it's more valuable for him to feed his family than to preserve biodiversity. Focusing management efforts on the enforcement of the law is not enough to conserve sea turtles. As long as people are unaware of the global and local consequences of lack of protection of the sea turtle populations, they will not assume conservation culturally, and no law can change this. By working with the community in devising a co-management strategy, involving the input of local fishers as well as the government, laws would be better understood and therefore people would follow them. With respect and better enforcement, turtle conservation strategies would be highly successful. However, it is evident that there is no happy medium between cultural needs and conservation. People are concerned that sea turtles may not exist forever in Bahia Magdalena, but also many families hope for a future where sea turtles could be legally caught in order to assist themselves, whether to use them for personal consumption or to sell them.

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Marine Turtles in the Egyptian Red Sea: Results of a Preliminary Coastal Survey

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We examined sea turtle nesting activity along Sinai and Egypt coasts in the present (June 1999), and compared it with past records. The last survey in the Egyptian Red Sea was carried out 16 years ago, and new surveys are badly needed in this area. The present survey was carried out by foot and by driving a 4WD vehicle along approximately 450 km of coastline, documenting crawl tracks, nests and stranded turtles. A total of 23 crawl tracks, four complete subadult carcasses, two hatchling carcasses found in their nest, and 11 incomplete skeletons were located scattered on five different beaches. All carcasses and tracks were measured and identified as those of the hawksbill turtle (*Eretmochelys imbricata*). Most of the nesting activity was observed on an island rather than on the mainland shoreline. An additional brief survey along Nabq National Park shores (Sinai) revealed another subadult hawksbill carcass (October 1999). The single concentrated green turtle (*Chelonia mydas*) nesting colony known from Sinai (in Ras Shartib, last documented 31 years ago), no longer

exists, apparently due to the development of an adjacent oil refinery. The existence of massive amounts of debris and tar that were observed on various parts of the surveyed coastline may possess a severe threat to nesting females and emerging hatchlings. This preliminary survey is a part of an ecological and genetic research on hawksbill turtle populations in the Red Sea that we initiated in the northern Gulf of Aqaba.

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Diagnosis of the Sea Turtles in the Beaches of Caimare Chico and Paraguaipoa, Venezuela

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INTRODUCTION

The sea turtles are reptiles that have had much evolutionary success through the times, adapting to all the changes from the days of the dinosaurs to our days. In existence today are a total of eight species of sea turtles. Venezuela contains five of these species: the cabezona turtle or caguama (*Caretta caretta*), the green or white turtle (*Chelonia mydas*), the carey turtle (*Eretmochelys imbricata*), the lora turtle (*Lepidochelys olivacea*), and the cardon turtle or seven keels (*Dermochelys coriacea*).

The populations of these turtles have been continually diminishing everywhere in the world. In population studies about the number of individuals done in the last year, only one species, the Kemp's turtle (*Lepidochelys kempii*), was reported to have increased in number. All other studies have maintained the same low numbers for the last three years. The principal dangers that threaten the survival of the sea turtles lie in the modification and destruction of their essential habitats (feeding areas, nesting areas, and migratory routes), commercial fishing, and the looting of their nests.

It is necessary to make use of the information of the number of individuals that actually exist in the zone of study, and the causes for the population decreases in that space, due to the great importance of the sea turtles in maintaining the ecological equilibrium of their ecosystem.

The realization of this type of investigation will contribute to the conservation of these animals in the zone, not only by giving us information on the dangerous situations that threaten the sea turtles' survival, but also by creating bases for the realization of future investigations.

The general objectives of the research are to determine the frequency of their capture by the fisherman of the zone, and, through the use of simple questions, to classify the levels of human activity in terms of tourist uses, and the presence of solid wastes and hydrocarbon remains. The problematic environment of the zone will also be analyzed in terms of its effect on the turtles. Once the area of study is identified, the species of sea turtles present in the area will be determined. The numbers of individuals of each species will then be counted, taking also into account their presence during the different seasons.

METHODS

Field trips were carried out in the zone of study that consisted of two activities: interviewing the fisherman of the zone and touring the coastline. The interviews were conducted in the form of dialogues, asking the fisherman about new discoveries; where they were found, what species was found, and the frequency of capture, there by determining the most abundant species found in the zone. In the tour of the coastline, a GPS (Geo-Positioning Satellite) was used to find the exact points of capture by the fisherman. The length of the coastline was also measured by recording the odometer of the craft. The help of a fisherman and resident of the zone was relied upon for the tour, not only in terms of knowledge of the zone and for communication with the inhabitants, but also for the security of the research team. In the event of the finding of some type of remains, a metric measuring tape was used to measure the shell or found specimen. For the collection of said remains, a plastic bag, large enough for the protection of the specimen, was used. Work gloves were also used in the collection of substances in advanced states of decomposition.

The steps for the collection of the specimens are the following. When a site is found where there is a possibility for their existence, a search is performed. Once remains are located, they are identified according to species (when possible in the field) and the visible characteristics are recorded and the state in which it is found is described. These observations are then recorded in a field book, whose contents are afterwards transferred into a data table in which the exact locations of findings made during the tour are proportioned by the GPS. At the time of the collection, photographs were taken of the most important specimens, after which all specimens were put into the plastic bags to protect them during transport to the laboratory.

RESULTS AND DISCUSSION

The study was carried out in the beaches located between Caimare Chico and Caño Sagua (Páez Municipality, State of Zulia), approximately 38 km in the direction south-east, north-west. This zone was chosen due to its easy access from the city of Maracaibo and for its high incidence of reports of the presence of sea turtles. Furthermore, the University of Zulia has a research team currently developing studies in the area.

The specimens of turtles collected were mostly from around the homes of the fisherman, due to the fact that when the animals are captured, they are prepared for sale in the referred places, while they could have been found in other places.

The green turtle was the species that turned out to be the most abundant in the zone, as they comprised 24 of the specimens found (58.14% of all the specimens collected). This abundance over other species is due to the fact that the

Gulf of Venezuela is a very important area of feeding and migration for a very large part of the population of *C. mydas* in the world. This is because it is the nesting population from the beach of Tortugero in Costa Rica. This turtle is the most exploited for its meat due to the large demand for it in the nearby markets (Los Filuos and Maicao). Another reason for their high rate of capture is their use by the inhabitants of the zone, as adornments and as domestic utensils (food dishes for animals, household storage, etc.). The animals' skulls are also used by the indigenous peoples of the zone, who believe that by placing them on fruit bearing plants will cause the plants to produce more rapidly.

The majority of the individuals collected in the zone, were adults (40%), and juveniles (36%), which confirms that the zone is a feeding area for the nesting population of the beaches of Tortugero, Costa Rica. After the nesting season they reach the zone of study to feed and gather with all the individuals of the referred population.

The caguama turtle was the next most numerous species collected after the Green turtle, with 14 specimens collected, representing 32.55% of all individuals. This number, relatively high, is due to the large distribution of the caguama turtle in both the Pacific and the Caribbean. It should also be kept in mind that in the Golfete of Coro, the National Park Archipelago of Los Roques, National Park of Morrocoy and Los Testigos, the population density of this turtle is much higher because of the abundance of hard shell mollusks, a principal food source, and that these locations are very close to the zone of study. It should be taken into account that the inhabitants of the area do not exploit this species for sale because of its having an unappetising look and smell. It is used only for consumption by local fisherman.

The majority of the individuals registered for the zone are juveniles (57.14%), which indicates that the zone is used by the turtles as a main feeding area within Venezuelan territory. It feeds such an important part of the population that once the turtles reach sexual maturity, they disperse to other beaches to carry out their reproductive activities.

Of the carey turtle, only a total of three individuals were found, or 6.98% of the total number of specimens collected. This low number doesn't coincide with the reports of the fisherman that were interviewed in the project. According to them, this turtle is much more frequently encountered, and is also important to the beliefs of the local inhabitants of the zone. It is believed that this species of turtle has the same magic-religious powers as the rest, only much more powerful. The beliefs are that the skulls of this species are the most effective in causing plants to bear fruit, that the consumption of their meat increases a person's life-span, and that the turtle's penis and blood are the best aphrodisiacs that exist. There are so many uses for this species by the local people that almost no part of the animal goes to waste; even the plastron is used to feed to the fishermen's dogs.

The Gulf of Venezuela provides that habitats in which the carey turtle feeds because it contains small banks of

coral reefs and sponges, which are principal food sources for this turtle. The most important feeding zone for this species in Venezuela is found in the State of Falcon, specifically in the Gulf of Coro.

Due to the small number of individuals collected, it is impossible to determine the specific state of this species in the zone. It should be taken into account that the skull that was collected was found without plates, and was most likely not identified by the fisherman. The two large shells were being prepared for sale.

Of the cardón turtle, the only reported individual was located on the coastline in the Zulia Sea Sector N (11°10.31)/W(71°49.32), in an advanced state of decomposition with visible cuts on the plastron, head, and extremities. According to the interviews this type of occurrence is very rare in the area, and the death of this species is mostly attributed to the shrimp boats and other large boats that pass through.

The information about this turtle indicates that they are the most frequently encountered, especially in the first months of the year. But due to the consistency of its hide, to its pillaging by birds and dogs, and to decomposition, it is difficult to find their remains. Another reason for the low number of reports is the appearance of this turtle's skin. It is barely perceptible, and it is believed that the marks on it can be transmitted to humans who eat them.

This turtle is one that has colonized on a much wider scale in the oceans. They have been observed in Alaska, Nova Scotia, and the Silver Sea; in Venezuela they are found along all of the coastal and island regions. The presence of this animal is associated with the presence of invertebrates such as jellyfish and squid. In the Gulf of Venezuela these types of animals are found in great quantities, which permits the development of the species in this area.

There were no reports of the lora turtle in the zone, but there have been recent reports about their presence in the Gulf of Venezuela. This suggests that this species of turtle is not common, and it is suggested that in many occasions it can be confused by the fishermen for the green turtle. It has a similar coloration, and none of the interviews were any turtles mentioned by name or other such distinguishing characteristic.

CONCLUSIONS

Sea turtles are animals that have adapted to the environmental changes that have occurred from the dinosaur days to the present day.

The study takes place in an area 38 km long, and the relative abundance of turtles in that area is high.

The green turtle is the most abundant species in the zone, with a total of 25 individuals comprising 58.14% of all collected. And the prevailing number of them were in their adult and juvenile states.

The caguama turtle turned out to be the second most abundant species, with there being a very small demand for their meat. A total of 14 individuals were collected, comprising 32.55% of the find, with a clear majority of juvenile animals.

Of the Carey turtle, only three individuals were found, all in their adult stages, representing 6.98% of the individuals collected. This emphasizes the large importance of this species and its high rate of exploitation by the inhabitants of the zone.

Only one cardón turtle was found, but in the form in which it was discovered it is very common to observe it in the mentioned zone of study. This is taking into account also that their greatest levels of appearance are during the months of January and February.

The lora turtle was not found in the zone of study, while there are recent reports of their sightings in the Gulf of Venezuela. At the same time, it is suggested that this turtle could possibly be confused with the *C. mydas* for their similarities in color and size.

The sea turtles are widely exploited as a food source in the region, and there is no type of control on their hunting by the entities in charge of the defense of wild fauna.

The Gulf of Venezuela, especially in the zone of study (Caimare Chico-Paraguaipoa), presents a wide variety of habitats that encourage the development of all species of sea turtles that reside in Venezuela.

The beaches of the zone of study are very wide, and are in very good condition to be nesting grounds for these sea turtles.

Tourism is the human aspect that has the greatest effect on the turtles in the zone, especially in the area of Caimare Chico. It is the main vacation area for the State of Zulia, and its sea and beach environments become even more altered during the heavy tourist seasons. Hydrocarbon waste is also affecting the zone more and more every day, as a result of oil spills in the

The sea turtles play a very important role in the culture of the Wuayúú, an indigenous people, and it is necessary to employ an environmental education program in the zone.

Marine Turtle Nesting Activity on Playa Naranjo, Santa Rosa National Park, Costa Rica 1998-99

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INTRODUCTION

Playa Naranjo is an important nesting beach for leatherback (*Dermochelys coriacea*), olive ridley (*Lepidochelys olivacea*), and Pacific green (*Chelonia mydas agassizi*) marine turtles on the Pacific coast of Costa Rica. Located to the south of Playa Nancite, an arribada beach, Playa Naranjo is second only to Playa Grande and Playa Langosta for leatherback nesting on the Pacific Coast of Costa Rica (Reina and Spotila, 1999; Chaves *et al.*, 1996).

Marine turtle populations worldwide are declining (Spotila *et al.*, 1996; Chan and Liew, 1996; Steyermark *et al.*, 1996; Limpus, 1995; Girondot and Fretey, 1996). The causes of these declines include predation at all life stages on beaches, mortality from fishing bycatch, and human encroachment on nesting beaches in the form of development (Spotila *et al.*, 1996). This study was undertaken to contribute to the assessment of the status of the nesting sea turtles on Playa Naranjo. The precipitous decline at Playa Grande (Steyermark *et al.*, 1996), and the fact that Playa Naranjo is the second most important nesting beach on the Pacific coast of Costa Rica for *D. coriacea* underlines the importance of assessing this beach, as it may be the last refuge for *D. coriacea* in Guanacaste.

METHODS

Between October 11, 1998 and February 28, 1999, we conducted night-time and early morning beach surveys on the 4.5 km stretch south of Estero Naranjo to monitor *D. coriacea*, *L. olivacea*, and *C. m. agassizi* nesting activity. At night we relocated fresh nests to a central location and covered them with wire mesh to protect them from high tides and coyote predation. In addition, we examined, measured and PIT tagged adult *D. coriacea* according to the protocol established and utilized at Playa Grande in Las Baulas National Park, Guanacaste Province, Costa Rica (Steyermark *et al.*, 1996). During the daily surveys, we recorded the location and fate of crawls, in situ, and protected nests. For each of the study nests, we recorded the temperatures every three days to later estimate the sex ratio of the hatchlings. We excavated the study nests approximately two days after the initial emergence, or within two days of the calculated emergence date if no emergence occurred. We opened the remaining eggs and classified development according to Leslie (1993). We calculated emergence and hatch success for each nest and released live hatchlings that night.

RESULTS

During the 140-day season, we encountered a total of 48 *D. coriacea* 292 *L. olivacea*, and 24 *C. m. agassizi* crawls (Table 1) that resulted in 25, 215, and 11 nests, respectively. We relocated five *D. coriacea*, 26 *L. olivacea*, and one *C. m. agassizi* nests to our central hatchery location. We PIT tagged seven individual *D. coriacea*. Coyotes predated 4.0% of *D. coriacea*, 80.0% of *L. olivacea*, and 63.6% of *C. m. agassizi* *in situ* nests and killed 14 of the 18 dead adult *L. olivacea*, we encountered. Nine of the *L. olivacea* study nests were either partially or completely predated by coyotes. The hatching(h) and emergence(e) success varied between species: *D. coriacea* n = 4 h:16-57%, e:12-44%; *L. olivacea* n = 20, h:31-99%, e:3-95%; *C. m. agassizi* n = 1, h and e: 100%. We released 74 *D. coriacea*, 1409 *L. olivacea*, and 43 *C. m. agassizi* hatchlings. Incubation temperatures of relocated study nests for the middle third of incubation were *D. coriacea*, n = 5, 30.8-31.9°C; *L. olivacea*, n = 23, 31-32.1°C; *C. m. agassizi*, n = 1, 31°C.

DISCUSSION

There was a general trend of decline in the number of nesting turtles from season to season. However, it was not possible to quantify the decline due to methodological differences in data collection.

The four *D. coriacea* study nests exhibited hatching and emergence successes below 50%, and 80% of the unhatched *D. coriacea* eggs were classified as "stage undetermined". Although we have no explanation for these low results, we eliminated egg mishandling as a possible cause for poor hatch success because no *in situ* *D. coriacea* nests were observed hatching.

The 20 *L. olivacea* study nests and the *C. m. agassizi* nest exhibited high hatching and emergence success. Eighty percent of *in situ* *L. olivacea* nests (n = 215) and 63.6% of *in situ* *C. m. agassizi* nests (n = 11) were predated by coyotes prior to hatching during the study period. If the *L. olivacea* and *C. m. agassizi* nests were not predated by coyotes, they could have had a higher chance of survival. Spotila *et al.* (1996) concluded that if there is no change in the rate of adult mortality, a population can increase if nest protection is greatly increased. Therefore, it is imperative to protect future *L. olivacea* and *C. m. agassizi* nests from predation at Playa Naranjo.

All of the study nests had mid-third temperatures above the pivotal temperature for the production of 50:50

male:female ratios, indicating that the majority of the 74 *D. coriacea*, 1409 *L. olivacea*, and 43 *C. m. agassizi* hatchlings we released were female. Pivotal nest temperatures are 29.4-29.5°C for *D. coriacea* (Mrosofsky *et al.*, 1984; Binckley *et al.*, 1998), 28.5-30.5°C for *L. olivacea* (Standora and Spotila, 1985; McCoy *et al.*, 1983) and 28.5-30.0°C for *C. m. agassizi* (Standora and Spotila, 1985). We observed an increase in the mean nest temperatures as our nesting season progressed, due to the change from rainy to dry season. Since *L. olivacea* and *C. m. agassizi* nest during both rainy and dry seasons, it is possible that nests that incubated completely during the rainy season produced mostly males, countering the high female production of the dry season. In contrast, *D. coriacea* nest at this location mainly during the dry season, which indicated a potential for an unbalanced sex ratio in the eastern Pacific population.

The distribution of *D. coriacea* and *C. m. agassizi* on Playa Naranjo in 1998-99 was similar to what Cornelius (1976) observed in 1971-72. Cornelius (1976) reported *L. olivacea* concentrated their activity on the northern end of the beach; the end closest to Playa Nancite. In contrast, *L. olivacea* activity from the 1998-99 season was dispersed along the entire beach. The introduction of a campsite behind section seven after Cornelius' study did not seem to affect the distribution of any species of turtle.

RECOMMENDATIONS

- Implement a standard and consistent method of data collection on the nesting activity of turtles at Playa Naranjo.
- Protect nests and adult turtles from predation.
- Deter additional development on Playa Naranjo.
- Provide tourists visiting the beach with information on the biology of sea turtles, the importance of this nesting beach, and proper etiquette on the beach at night. (The ecotourism office at Santa Rosa National Park is designing an educational display with this type of information.) Additional signs should be posted next to the beach entrance.

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Table 1. Summary of marine turtle data available for Playa Naranjo, Santa Rosa National Park, Costa Rica. Number of crawls, nests, and/or predated nests encountered by Cornelius (C), Arauz-Almengor and Morera Avila (A), Phillipe Mayor (M) and our team (D) during the respective seasons. Crawls (Cr) are any emergence of a turtle onto the beach regardless of the outcome. Nest (N) is a crawl that resulted in the deposition of eggs. P is a depredated nest.

Season	# of days	Observer	Survey target	Survey periodicity	<i>Dermochelys coriacea</i>			<i>Lepidochelys olivacea</i>			<i>Chelonia mydas agassizi</i>		
					Cr	N	P	Cr	N	P	Cr	N	P
9 Nov 71 - 3 Mar 72	202	C	Tracks	Daily	119	106		811	710		437	326	
13 Dec 83 - 3 Mar 84	80	C	Tracks	6 wks; 5-7 d/wk	312			40			63		
1 Oct 89 - 28 Feb 90	151	A	Tracks		466			304			431		
10 Oct 90 - 28 Feb 91	151	A	Tracks		1212			447			364		
1 Nov 96 - 15 Feb 97	107	M	Cr, N, P	1-2d/wk	76	76	22	452	439	396	110	102	54
1 Nov 97 - 15 Feb 98	107	M	DC tracks	1-2 d/wk	50								
11 Oct 98 - 28 Feb 99	140	D	Cr, N, P	Daily	48	25	1	292	215	159	24	11	7

The Principal Beaches of Nesting Sea Turtles (*Caretta caretta* and *Chelonia mydas*) in Quintana Roo, Mexico, the Xcaret Program

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INTRODUCTION

Since 1996, staff of the sea turtle program of the park Xcaret has performed the protection-related programs in the central coast of Quintana Roo. The Park, following its own initiative, promotes and supports sea turtle investigations. One of its main goals is to give continuity to the investigations started in 1987 with loggerhead turtles (*Caretta caretta*), and green turtles (*Chelonia mydas*), which nest in the area. These populations are unique regarding their genetic diversity (Encalada *et al.*, 1998 and 1999).

Objectives

To evaluate the number of nests of both species in the central coast of Quintana Roo, Mexico, emphasizing the situation of the main nesting areas: Aventuras DIF, Chemuyil, Xcacel, and Xel'ha.

Study Area

The nesting beaches are located between Playa del Carmen to the North and Punta Allen in the Sian Ka'an Biosphere Reserve to the South. The area encloses six beaches with camps and six beaches that are monitored every two weeks, without camps (Fig. 1).

METHODS

From May till October, Xcaret staff performed the following activities: daily visits to the nesting sites to locate and protect breeding females; recording of nursing details, counting of breeding females, their nests and eggs laid; collection and moving of eggs to protect incubation units, especially those nests vulnerable to being destroyed by natural phenomena or predators; egg incubation, care and observation of broods, and rate of deaths at birth (Arenas *et al.*, 1998).

In order to analyze the situation of the 1999 season in the main nesting beaches, Aventuras DIF, Chemuyil, Xcacel and Xel-há, several experts, pertaining to the participating institutions in the sea turtle investigation program, were required to meet with members of the Quintana Roo University (UQROO, in charge of the management program of sea turtles in Xcacel-Xcacelito), and the Colegio de la Frontera Sur (ECOSUR, who worked many years in the area and that continues assessing and capacitating biologists interested in the protection and conservation of sea turtles).

RESULTS AND DISCUSSION

The number of loggerhead nests recorded was of 1705 and for the green turtle, the number of nests was of 219. The highest number of nests was found in Aventuras DIF, Chemuyil, Xcacel and Xel-há. (Table1). The general hatchling success in situ was of 87.73%, and of 87.16% in the moved nests for loggerhead. The general hatchling success in situ was of 91%, and of 80.73% in the moved nests for green turtle (Table 2). For both species, the hatchling success was higher in nests in situ, not including the nests lost to poaching, flooding, and depredation.

Actual Situation of the Main Beaches

Xcacel-Xcacelito: The Park Xcaret has the permit to work in the area with sea turtles from 1996 to 2001. Permit given by the National Institute of Ecology Instituto Nacional de Ecología INE/DGVS/TM 002 Q. ROO.

Declared State Preservation Area for Sea Turtles in February 1998

The Area includes only 100 m inland and no one is officially in charge of the administration. The UQROO presented its first management plan, but the influence area has not been established yet.

ECOSUR Recommendation: Condemned Land

The amount of protected land of 100 m inland, makes it vulnerable ecologically speaking, and less practical. This allows the presumption that the effects in the area will be very intense and include habitat fragmentation, pollution, and invasion of undesirable species. In the long term, with the changes at sea level and aquifer layer, the animals won't have the possibility of moving through the resorts and cities

surrounding the protected area. This little piece of land does not allow a proper development of the species.

Aquifer Layer and its Extension

The document confirms the importance of the conservation of the aquifer layer, related to the cenote of Chemuyil. In order to maintain the quality of the aquifer layer, very sensitive to any change of the landscape, and to guarantee the quality of the marine water, the area to be preserved needs to be extended, at least, to the road Cancún-Tulum.

Importance and Compromises

The importance of Xcacel-Xcacelito for sea turtle nesting is out of question. Their protection is one of the most important responsibilities of the government. If you take into account that only 2.5 km of beach will be transformed into natural preserve, out of the 120 km of the Mayan Riviera, that means that only less than 2% of the territory will be protected, remaining free of golf clubs and resorts. The PROFEPA authorities are investigating the damage. More than a dozen open rifts, protected species by the Norma Mexicana have been destroyed and robbed. Since the announcement of its sale, the area has been closed and the situation questioned by the international press (Hernandez *et al.*, 2000).

Chemuyil

The area has been sold and closed to the public. It is an unknown tourist project authorized and already a construction site.

Xel-há

No existing projects to proceed with the constructions. It has strong collaboration with the administration of the Xel-há Natural Park.

Aventuras DIF

The beach and nesting areas description done by Zurita *et al.* (1990) of the 1989 season was compared to the 1999 season. In 1999, the new tourist resort started working, and the modification to the dune-beach due to this resort has been observed. The problems for the turtle population are the same in every nesting area affected by tourist resorts, as the one described by Viveros (1991). The main impact is due to beach light, tourists, constructions, native plants, rock extraction and domestic animals. The most important activity of the sea turtles is the nesting, which occurs during the summer, the tourism's most relevant period. This fact is a clear consequence of the huge economic development of the region. The participation of all sectors is required to maintain these populations, since the light of the resorts, cars and houses within 120 km affects the turtles. The lights of the Islands of Cozumel and Isla Mujeres are going to be another obstacle the turtles will have to deal with in order to survive.

ACKNOWLEDGMENTS

We thank the many volunteers and field workers special thanks to Julio C. Zurita Gutierrez for the help to make this work.

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Table 1. Registered nests of the 1999 nesting season.

Beach	Total nests of <i>C. caretta</i>	Total nests of <i>C. mydas</i>
Punta Venado	39	1
Paamul	83	5
Aventuras DIF	202	3
Chemuyil	144	1
Xcacel	310	67
Xel-há	215	28
Punta Cadena	132	4
Tankah	79	15
Kanzul	188	47
Cahpechen	205	39
Yu-yum	32	2
San Juan	76	7
Total	1705	219

Table 2. Reproductive data for loggerhead and green sea turtles nesting in Quintana Roo.

	<i>Caretta caretta</i>		<i>Chelonia mydas</i>	
	Translocated	In situ	Translocated	In situ
Analysed nests	975	494	98	93
Incubated eggs	113,596	55,235	11,702	10,912
Protected hatchlings	96,551	46,517	9,069	9,962
% hatchling success	87.16	87.73	80.73	91

Fig. 1. Study area.



Leatherback Sea Turtle (*Dermochelys coriacea*) at Humacao Beaches in Puerto Rico

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Since 1997 we have conducting intensive census of leatherback sea turtles (*Dermochelys coriacea*) at Humacao beaches, southeast coast of Puerto Rico. This work is providing new insight into nesting data, hatching success, habitat uses, and threats for survival in the area. The following presentation will discuss these results and the status of the leatherback sea turtles in the area.

INTRODUCTION

The Humacao Sea Turtle Conservation Program started its labor in the 1980's decade. This was the first project established in Puerto Rico; however, some studies with the sea turtles were realized in the islands of Culebra, Vieques and Mona. Since 1997, the Sea Turtles Project has been working thanks to a cooperative agreements between the Puerto Rico Department of Natural and Environmental Resources (DNERPR) and the Sea Grant College Program of the University of Puerto Rico in Humacao.

Only a few research about the area, that brings complete information about the nesting activities of Humacao, were known. Corbat *et al.* (1991) reports for the Humacao area since 1985 to 1989 a nesting activities of 66 nests. Matos (1986 and 1987) said "the recent surveys have recorded 10 or fewer nest each annually on Playa Humacao, Paulinas and Piñones" Unfortunately, the data obtain from this research do not represent the real nesting activity of Humacao area. The data compiled from this research are not consistent and do not cover all the coastal zone.

In the last three years (1997-1999) of research we have obtain a valuable information about the leatherback sea turtle known as "tinglar" at Humacao coastal area.

Sea turtles are confronting a series of threats that endanger its survival, in spite of the efforts to protect the species and to educate communities. The major threats for the sea turtles in this area are illegal capture/poaching, coastal development and beachfront lighting.

The purpose of this research is to actualize the nesting activity data of the leatherback sea turtle at Humacao's beaches and to document the importance of the area as wildlife habitat, especially for the sea turtles.

STUDY AREA

The Sea Turtle Conservation Program is located at the town of Humacao in the southeast coast of Puerto Rico (18°10' latitude, 65°46' longitude) and is approximately 1,656 km to southwest of Miami, Florida and San Juan, Puerto Rico, respectively (Fig. 1). The study area consists

of approximately 8 km of coastal coast, which is divided in four main beaches (Fig. 2). Among these they are Punta Santiago Pier to Villa Palmira (Punta Santiago Public Beach, approximately 2.5 km); Humacao Natural Reserve to Humacao River (Las Ochenta, approximately 3 km); Buena Vista to Candelerio River (approximately 1.5 km); and Candelerio River to Palmas Del Mar Marine (approximately 1 km). These nesting areas are interrupted by rocky promontories and two river mouths.

The coast is characterized to be high energy beaches, which not possess rocky promontories or reefs that serve as a barrier. These are deep areas in the coast; which facilitates the entrance of *Dermochelys coriacea* in the nesting moment.

METHODS

At the beginning of the month of February 1997, the beaches were measured and marked every 25 m to facilitated the nest location.

Diurnal monitoring began on March 1st on all four beaches to observe possible nesting. These patrols were conducted by ATV every day and beginning at 4:00 am with the Puerto Rico Department of Natural and Environmental Resources (DNERPR) Rangers. When a turtle track was found, the location of the nest was calculated and registered by triangulation measurements that were taken from the two closest points. Also measurements from vegetation distance from water edge were taken. All this information was documented on a data sheet.

Night monitoring began on April in the primary beaches. The method that was used was the nine nights cycle after each nesting activity. Beach patrols were conducted by walking the beach area every 45 minutes with voluntaries at Humacao Natural Reserve and an ATV were used at the other three beaches. The methods used to collect data were as follows.

Nesting Turtles

When a nesting turtle was found on the beach she was left alone until she had at least begun to dig the nest chamber. At this stage, staff and volunteers would quietly move up behind her and observe the digging of the nest. This was done in preparation for conducting eggs counting and when possible the visitor will be oriented about the nesting behavior of the turtle. When egg laying had started, staff members would begin to move around the turtle. At this point measurements of the carapace and fins will be taken using plastic metric tape. The used of lights is minimum, we use, specially, penlight to examined for diagnostic

markings, deformities, ectoparasites and injuries. Sometimes depending on how critical, photos were taken.

Tagging

All turtles were checked for flipper tags. If a flipper tag was not present, a metal tag was attached to each front flipper. Tags were imprinted with DNERPR on one side and a three-digit number on the other.

Morphometric Measurements

All nesting turtles were measured for curved carapace length and curved carapace width. These were done with a metric tape measure. Carapace length was measured from the anterior notch to the posterior tip alongside the vertebral ridge. Carapace width was measured to each side at the widest point of the carapace, just posterior to the front flippers. Individuals were measured each time they were found, and the measurements averaged for the season.

Photographing

A photograph was taken of the top of nearly every turtle's head to record the shape of the pink spot and surrounding marks to aid in identification of remigrants that lose all flippers tags between seasons.

Nest Location

At the time of eggs lying or when we found one nest in the morning we verify for imminent threats like erosion or inundation, if the nests are situated in a previously identified erosion zone, the eggs were collected upon deposition or redeposited in a safer area of the beach. Also, relocation was done when the turtle was nesting in an area that could be affected by beach user's or beachfront lights.

Emergence and Excavation

Nests were monitored every day, daily and nightly monitoring starting five days before the expected emergence date. Beaches were monitored for hatchling tracks very early in the morning, and excavation were done in the early morning or before sunset. After emergence the location, date, time and hatchling orientation were recorded. Hatchlings were guarded from any beach debris by removing them from their path. Disoriented hatchling or those trapped in vegetation were assisted to the water's edge. After emergence, nests were excavated to determine hatchling success. If the nest doesn't emerge following the 75 days of incubation were also excavated. All unhatched eggs were opened to determine stage of development and then were recorded in the data sheet. Additional data on hatchlings was recorded: signs of predation, dead of embryos, trapped hatchlings, condition of the nest or any abnormalities to determine possible causes for poor hatchling success. Any alive hatchling found in the nest were released. They were allowed to crawl down to the beach and into the sea. If the hatchlings are too weak to crawl was taken to near the water's edge and then released.

Volunteer Programs

Each monitoring night ten volunteers were invited to participate with the project. Volunteers are university students and general public from the Humacao communities. They know about the project and make contact by telephone to make reservations and give the date and the meeting place. Before monitoring, an orientation was done by the staff members to explain the methods used when conducting beach patrols.

DISCUSSION

Although studies carried out in recent years, 1997 reported a low nesting activity in the coast of Humacao, during the time the nests census was carried out (1997-1999) there were identified a total of 189 of *Dermochelys coriacea* nests. According to the gathered data the number of nests for the years 1997, 1998, and 1999 stayed in a range from 53 to 71 nests per year (Fig. 3). The number of nests stayed constant. In a same way the quantity of false crawls and crawls varied very little for the same course of years (Fig. 4).

The season of the 1997 seems to be the one with more nests activity. However, it was the season where the reproduction success was very low. The hatching success was of 38% and the emergence success was of 37% (Fig. 5). The causes for which the reproductive success was low could be given by the following conditions: for this season several robberies of eggs were reported; the roots of the beach vines (*Hipomea* sp.) covered several nests avoiding that the hatchlings could come out to the surface; the great surf of the area maintained a high humidity in the nests, therefore the embryos were not developed; and some nests were lost due to the motor vehicles that run over them.

For the 1997 a gradual increase in the quantity of nests from the month of March until May occurred, being May the last month of the nesting season where more activity was reported. After May the activity began to diminish until in July it ceased completely (Fig. 6).

1998 was a productive year in terms of reproduction success. It was obtained a hatching success of 70% and an emergence success of 62%. This is the percent average reported for a normal nesting season (Fig. 6).

However, the smaller nesting activity was reported for 1997. Contrary to the season of the 1997 and of the 1999, the month where more nesting activity was reported was March, in April an insignificant decrease was reported and in May it happened a significant decrease (Fig. 6). For this year a curious situation has occurred, mature turtles nested on other nests that were previously in the area. This could have caused that the hatchlings that were in the original nest could not arrive until the surface or that the embryos were not developed.

Finally for the season of the 1999 the nesting activity was quiet low than the ones reported for the 1997 and 1998 seasons. The reproductive success was high; it was a

hatching success of 69% and an emergence success of 68%, although machineries stuffed several nests. For the season a very high pick was obtained, being the month of May the month of more nesting activity (Fig. 6).

CONCLUSION

According to the gathered data through the census of nests carried out from 1997 up to 1999 for the Humacao Sea Turtle Conservation Program, it is demonstrated the great importance of Humacao beaches for the nesting activity of *Dermochelys coriacea*. The Natural Reserve is the area of more importance to carry out the nesting activity for this species in the course of years of the census (Fig. 3). It is also evident that as it passed each season the nest activity diminished. This evidences that nesting areas of *Dermochelys coriacea* can be being affected by the coastal development that is carrying out in certain areas of the coast of Humacao, the artificial lights in the beaches and, among others, the loss of beaches.

We recommend to maintain an intensive education program and to integrate the Humacao's communities to the monitoring program of the sea turtles, especially for *Dermochelys coriacea*. This is in function to decrease the threats that endanger the survival of the sea turtles.

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Fig. 1. The Sea Turtle Conservation Program is located at the town of Humacao in the southeast coast of Puerto Rico (18°10' latitude, 65°46' longitude).

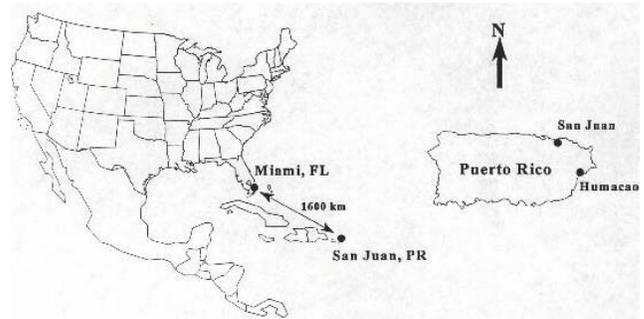


Fig. 2. The study area consists of approximately 8 km of coast, which is divided into four main beaches.



Fig. 3. Number of nests by beach for *Dermochelys coriacea* in Humacao, Puerto Rico.

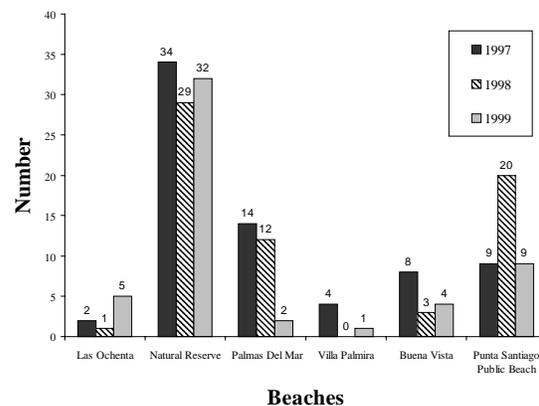


Fig. 4. Nesting activity of *Dermochelys coriacea* in Humacao, Puerto Rico.

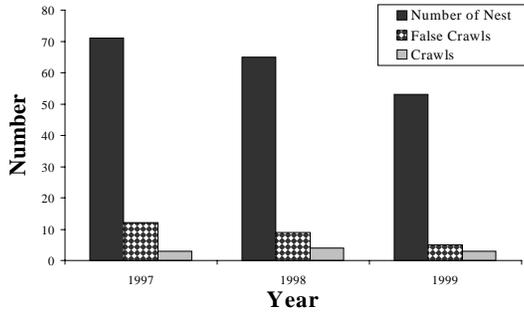


Fig. 5. Hatching and emergence success for *Dermochelys coriacea* per year in Humacao, Puerto Rico.

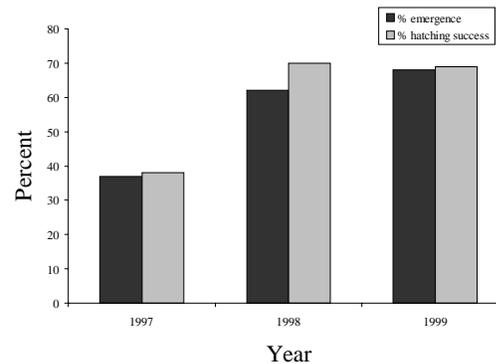
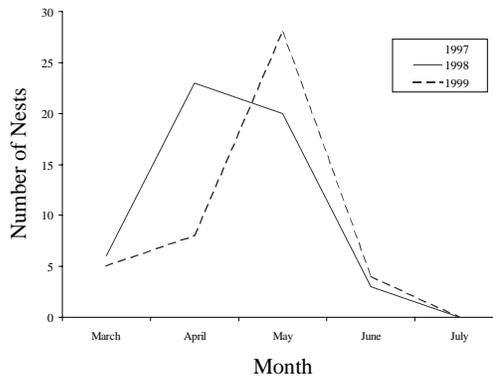


Fig. 6. Annual nesting activity for *Dermochelys coriacea* in Humacao, Puerto Rico.



Sea Turtle Conservation Project: Hawksbill Turtle at Humacao Beaches in Puerto Rico

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Three years data (1997-1999) on nesting activity of hawksbill turtle were collected from a Turtle Conservation Project at Humacao Puerto Rico. This work provides new insight into nesting data, hatchling success, habitat uses and threat for survival in the 9 km area of the Project. Some of the principal reasons for this treat in Humacao beaches are: beachfront lighting, predation and nest affecting by domestic animal, poachers and coastal developments. The following presentation will discuss these results and the status of the hawksbill turtle in the area.

INTRODUCTION

Since 1996, the Sea Grant College Program of the University of Puerto Rico in Humacao in a cooperative agreement with the Department of Natural and Environmental Resources of Puerto Rico (DNERPR), established

the first Sea Turtle Conservation Program in Puerto Rico. Previously, a few studies in the coastal zone of Humacao, were realized, but the results of these studies do not bring a complete information about the nesting activity in the beaches Humacao. Corbet *et al.* (1991) reports, for the Humacao area, a nesting activity of 21 nests approximately from 1985 to 1989. In NMSF and USFWS (1993), the most important sites are Mona Island (Puerto Rico) and Buck Island (St Croix, USVI). Nesting also occurs on other beaches of St. Croix, Culebra Island, Vieques Island, mainland Puerto Rico, St. John, and St. Thomas. The gathered data from this research are not consistent and do not represents the real nesting activity in the Humacao coast.

In these last three years (1997-1999) of research we have obtain a valuable information about the species *Eretmochelys imbricata*, also know as hawksbill sea turtle, in the Humacao area. In spite of the efforts we have made

toprotect the species and to educated the Humacao communities, the sea turtle are confronting a series of threats that endanger their survival. Some of these threats are: illegal capture/poaching, disorientation by beachfront lighting and loss of nesting areas. The purpose of this research is to document the nesting activity data in the Humacao area and to demonstrate that the studied beaches are the most important ecological habitats for sea turtle, especially for the species *Eretmochelys imbricata*.

STUDY AREA

The Sea Turtle Conservation Program is located in the town of Humacao in the southeast coast of Puerto Rico (Fig. 1). The study area for *Eretmochelys imbricata* consists of approximately 9 km of coast, which is divided in four main beaches (Fig. 2). Among these they are Punta Santiago Pier to Villa Palmira (which consists of approximately 2.5 km); Reserva Natural of Humacao to Humacao River (Las 80's) (which consists of approximately 3 km); the Reserva Natural of Humacao is located in the southeast coast of Puerto Rico (18°10' latitude, 65°46' longitude) and is approximately 1,656 km to southwest of Miami, Florida and San Juan, Puerto Rico (respectively); Buena Vista to Candelero River (which consists of approximately 1.5 km); Candelero River to Palmas Del Mar (which consists of approximately 2.0 km). The latter zone possesses rocky promontories, between this promontories we found small beaches or sand pockets that the turtle use for nesting (Fig. 2).

METHODS

At the beginning of the month of February the beaches were measured and placement markers every 25 m to facilitate the nest location.

Only diurnal monitoring began on March 1st on all four beaches to observe possible nesting. These patrol were conducted by ATV every day and beginning at 4:00 am with rangers of the Department of Natural and Environmental Resources (DNERPR). When a turtle track was found, we calculate the location of the nest by triangulation measurements that were taken from the two closest points. Also measurements from vegetation distance from water edge were taken. All this information was documented on a data sheet. The methods used to collect the following data.

Nesting Turtles

When a nesting turtle arrive on the beach, she was left alone until she had at least begun to dig the nest chamber. When egg lying had started, staff members would begin to move around the turtle. At this point measurements of the carapace and fins will be taken using plastic metric tape. The used of lights is minimum, specially we use penlight to examined for diagnostic markings, deformities, ectobiota

and injures. Sometimes depending on how critical, photos were taken.

Tagging

All turtles were checked for flipper tags. If a flipper tag was not present, a metal tag was attached to each front flipper. Tags were imprinted with DNERPR on one side and a three-digit number on the other.

Morphometric Measurements

All nesting turtles were measured for curved carapace length and curves carapace width. These were done with a metric tape measure. Carapace length was measured from the anterior notch to the posterior tip. Carapace width was measured to each side at the widest point of the carapace.

Photographing

A photograph was taken to record the surrounding marks to aid in identification when all flipper tags were loss between seasons.

Nest location

At the time of egg lying or when we found one nest in the morning we verify for imminent threats like erosion zone, the eggs were collected upon deposition or redeposited in a safer area of the beach. Also, relocation was done when the turtle was nesting in an area that could be affected by beach users or beachfront lights.

Emergence and Excavation

Nests were monitored every day, daily and nightly monitoring starting five days before the excepted emergence date. Beaches were monitored for hatchling tracks very early in the morning, and excavations were done in the early morning or before sunset. After emergence the location, date, time and hatchling orientation were recorded. Hatchlings were guarded from any beach debris by removing them from their path. Disoriented hatchling or those trapped in vegetation were assisted to the water's edge.

After emergence, nests were excavated to determine hatchling success. If the nest don't emerges following the 75 days of incubation they were also excavated. All unhatched eggs were opened to determine stage of development and then were recorded in the data sheet. Additional data on hatchling was recorded: signs of predation, dead of embryos, trapped hatchling, condition of the nest or any abnormalities to determine possible causes for poor hatchling success. Any alive hatchling found in the nest were released. They were allowed to crawl down to the beach and into the sea. If the hatchlings are too weak to crawl was taken to near the water's edge and then released.

Volunteer Programs

For the monitoring three volunteers were invited to participated with the project. They are assistance in the Sea Turtle Project. Volunteers are university students and

general public from the Humacao communities.

RESULTS AND DISCUSSION

Since 1997 to 1999 diurnal monitoring were realized from the months of March to December. From these period 292 nest of *Eretmochelys imbricata* were detected. The 1999 nesting season was the one with the highest nesting activity, a total of 160 nest in comparison to the 52 nest in 1998 and the 80 nest found for 1997 (Fig. 3).

The 1998 nesting activity was affect by a few hurricanes, and they produce high erosion on the nesting beaches. The problem in Puerto Rico is that the hurricane season conflicts with the months when the activity peak of the nesting season of the *Eretmochelys imbricata* occurs. Data shows that the nesting activity increase during the months of July to November (Fig. 4). The peaks of activity differ per year, the 1997 were on September, the 1998 were on October and 1999 was on July.

There was a significant difference in the numbers of sea turtles nesting on Humacao beaches. The three most important nesting beaches for *Eretmochelys imbricata* are the Natural Reserve, Las Ochentas and Palmas Del Mar Resorts (Fig. 5). During the 1997 nesting season in the Natural Reserve and Las Ochentas beaches we found 29 nest, in 1998 we found 23 and in 1999 83 nest were found. Palmas Del Mar and the Natural Reserve beaches were the most important nesting beaches for *Eretmochelys imbricata* for the 1999 season.

During the nesting season 25% to 50% of all the nest are monitored. The study areas present a hatching success between 75% to 89%. The emergence success is between a 77% to 89% (Fig. 6). The hatching and emergence success from 1997 to 1999 maintains a similar numbers between the years. This could be caused because in those years we have a high precipitation and low temperatures. These climatic changes had a direct effect over the incubation temperatures, causing a decrease in the hatching and emergence success. Meanwhile, the hatching and emergence success, in 1998, was of 88%. In this year the

Fig. 1. The Sea Turtle Conservation Program is located in the town of Humacao in the southeast coast of Puerto Rico.



precipitation was lower than 1997 and 1999. In spite of being affected by a series of climatologic events, the impacts of these events were characterized by beach erosion and this will cause a decrease of the nesting activity.

The most serious environmental problems that affected the nesting activity of *Eretmochelys imbricata* throughout the census were illegal recollection of egg became a serious impact in 1999; in July we lost 50% of detected nests; beach erosion in the area; the high illumination cause by coastal development in the area; and the trash carried out by rivers down the streams accumulates on the beaches and block the access to the sea turtles to the nesting sites.

CONCLUSION

We have concluded, that the Humacao beaches, are important ecologic habitats for sea turtles, especially for *Eretmochelys imbricata*. In the last three years of research, we have obtained a very high reproductive success. The total quantity of nest found in this three years increased, but Hurricane Georges affected the 1998 season. It strike the island and the numbers of nest decrease. If we compare with the 1997 season the decrease was not significantly. We need to continue the education program for Humacao communities, especially for the coastal and fisheries communities, to decrease the threats for the survival of sea turtles. We recommend, also, to introduced communities to the monitoring program.

ACKNOWLEDGMENTS

We thanks the following: Alliance for Minority Participation (AMP-PR), University of Puerto Rico-Humacao Campus, Sea Grant College Program University of Puerto Rico-Mayaguez, The David and Lucile Packard Foundation and the Twentieth Annual Symposium On Sea Turtle Biology And Conservation.

Fig. 2. The study site.



Fig. 3. Nesting activity of *Eretmochelys imbricata* in Humacao, Puerto Rico.

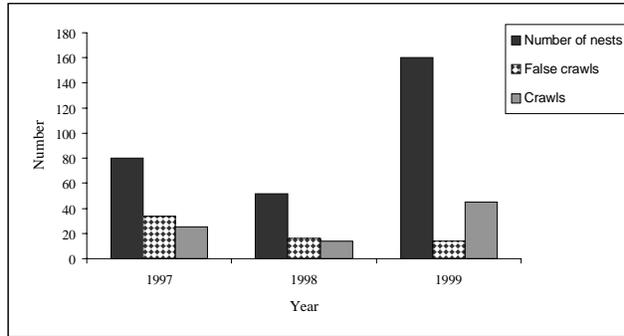


Fig. 4. Annual nesting activity of *Eretmochelys imbricata* in Humacao Puerto Rico.

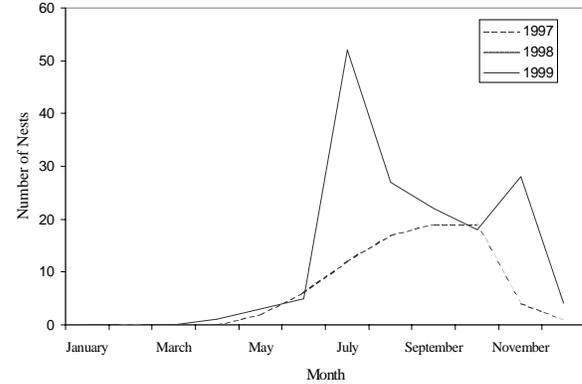


Fig. 5. Number of nest by beach of *Eretmochelys imbricata* in Humacao, Puerto Rico.

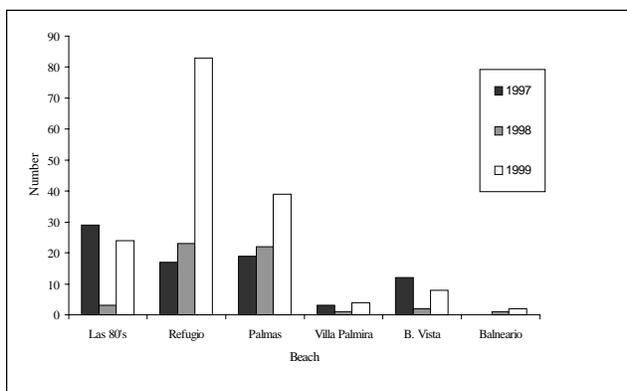
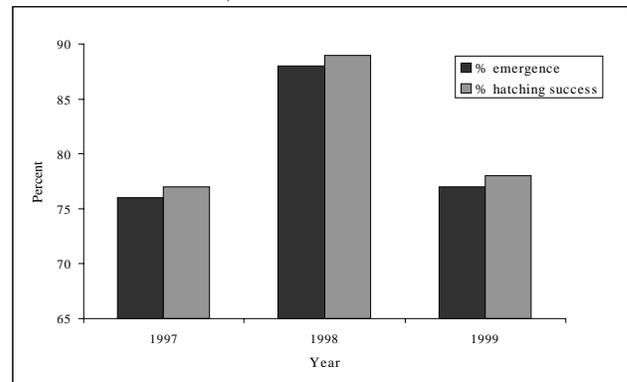


Fig. 6. Hatching and emergence success per year of *Eretmochelys imbricata* in Humacao, Puerto Rico.



The Hawksbill Turtle Nesting Population of the Dimaniyat Islands in the Gulf of Oman

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Hawksbill turtles (*Eretmochelys imbricata*) are considered critically endangered species (Groombridge, 1982; Groombridge and Luxemore; Meylan and Donnelly, 1999). Therefore, knowledge concerning the status and ecology of the remaining populations is of vital importance for their conservation.

Coral reef areas like the Dimaniyat Islands, in the Gulf of Oman, still provide good feeding and nesting areas for this species. This inhabited archipelago of nine sparsely vegetated islands is also free from mammal predators and it is not easily reached even by the most adventurous tourists, even though it is located less than 100 km north of Muscat.

Prior to this study, the only available extensive information on this specific population was recorded in 1996 by Salm (1991), who also referred to this population in later publications (Salm and Salm, 1991; Salm *et al.*, 1993),

where he has made clear that due to the protected status of these islands and the high pollution levels that exist in the Arabian Gulf, this is the last sanctuary of any real value to hawksbills in the region.

In spring 1999 and early summer 1999, during the nesting season of the hawksbill turtles, we decided to return to the Dimaniyat Islands in order to up-date our information on this population.

In our study, we observed the number of tracks per night during our field trips to the islands, from April to July. We also tagged female turtles coming ashore to nest, and recorded data on curved carapace length and width. At the end of the nesting season of hawksbill turtles, in late June and early July, we counted the number of nests on all beaches of each island, by walking in pairs parallel to the water line and shouting to each other the nest number. The area of the beaches was also recorded in order to obtain

nesting densities. Beach selectivity was tested comparing nest densities, using one-way Analysis of Variance, ANOVA (Underwood, 1997).

As previously recorded, we also observed that the peak of the nesting season was in April. A maximum of 16 tracks/night were recorded; two more than the previous maximum found by Salm in 1986 (Salm, 1991). Mean size of hawksbill turtles was larger in 1999 (mean \pm 95% confidence intervals = 81.81 \pm 1.28 cm; range = 79 - 84 cm; n = 5) than was found in 1986 (mean = 76 cm; n = 9; Salm, 1991). We expect to continue our study in order to increase our sample size and to observe any trends. However, the new size records of female hawksbill turtles are now closer to those found further south in the Indian Ocean in the Seychelles (e.g., Brook and Garnett, 1983; Diamond, 1976), and in the Great Barrier Reef in Australia (Limpus, 1980, 1992).

Against our expectations, the total number of nests in 1999 (1205 nests), showed an increase of 33%, when compared with data from 1986 (900 nests; Salm, 1991). In fact, with the exception of Haywt island, the number of nests have increased on all islands. However, natural fluctuations in this population are not known. It may also be that the nesting population is increasing, or that female turtles are shifting from their nesting grounds in the nearby mainland beaches, just 20 km away, to these less disturbed islands, even though there is some fishing activity in the coral reef areas, especially at Jabal Al Kabier, the largest island and at Al Kharabah, the most eastern island. Nevertheless, no significant differences were found between the islands when comparing nests/beach (ANOVA: $F = 0.8$, $P = 0.56$) or nests/area (ANOVA: $F = 1.08$, $P = 0.39$), which suggests that there is no beach preference by these nesting females on these islands.

We also consider our counts as underestimates as some nests were on top of previous ones (nest density ranged from 0.2 to 1.4 nests/m²), showing that space might

be a very limiting factor, if not the main limiting factor, for the expansion, or at least preservation, of the population of hawksbills in the Dimaniyat Islands, as we recorded 1205 nests on 1.5 km of beach on the six islands where nesting activity was observed, which is equivalent to 0.8 nests/m of beach or 800 nests/km of beach in a single nesting season.

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Historical Trends in Sea Turtle Nesting Activity in Sarasota County, Florida, USA: 1980-1998

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Sea turtle nesting data has been collected on the central west coast of Florida for nearly twenty years. Sarasota County is an important nesting habitat for loggerhead (*Caretta caretta*) sea turtles, recording the most nests and the highest nest densities on the west coast of Florida. Numerous volunteers contribute a substantial amount of time in association with various organizations and agencies to document this activity annually. The data collected is summarized and submitted to the State of Florida Fish and Wildlife Conservation Commission (FWCC—formerly under the jurisdiction of Florida Department of Environmental Protection) each year since 1979. Using these summaries, historical trends in recorded sea turtle

nesting activity throughout Sarasota County have been compiled. Manasota Key and Casey Key have the largest percentages of nesting in Sarasota County with the most recorded nests and highest nesting density (nests/km) of all areas. These areas also constitute the longest portions of shoreline within Sarasota County that is used for sea turtle nesting habitat. The use of historical sea turtle nesting trends on a state, county, local, and even individual property level is useful to both researchers and government personnel monitoring population status and projects which may impact sea turtle nesting habitat.

INTRODUCTION

Sarasota County, Florida is located in Southwest Florida and is bordered by the Gulf of Mexico. There is approximately 53.9 km (34 mi) of coastline with beaches that support sea turtle nesting. The coastline is comprised of several barrier islands and one peninsula. These areas are Longboat Key (8.6 km in Sarasota County), Lido Key (4.2 km), Siesta Key (9 km), Casey Key (11.8 km), Venice Beach (7.4 km), and Manasota Key (12.9 km in Sarasota County).

Sarasota County, Florida supports the largest number and highest density of sea turtle nests on the West Coast of Florida. Nearly all of the nests along the Gulf Coast of Florida are loggerhead sea turtle nests, with a few green (*Chelonia mydas*) sea turtle nests being recorded in recent years. During the 1999 nesting season, two Kemp's ridley (*Lepidochelys kempii*) nests were confirmed on Siesta Key (Foote, personal communications).

Sea turtle nest inventory and monitoring, as well as tagging of nesting females has been recorded in Sarasota County since 1980. In 1980 and 1981 Caretta Research, Inc. conducted a tagging program on Manasota Key and recorded limited nesting data. In 1982 nest inventory and monitoring was taken over by Mote Marine Laboratory and Sarasota County Government staff. Today all beaches are monitored each morning by staff from each institution and a large force of volunteers.

All the barrier islands of Sarasota County have some extent of urban development. Longboat Key, Lido Key, Siesta Key, and Venice Beach are all heavily developed with high-rise condominiums, hotels, single and multi-family residences. Casey Key and Manasota Key are much less developed, with mostly single family residences and very few low-rise hotels. As a result of human encroachment, predation of some type occurs in all areas. Raccoons, armadillos, ghost crabs, and fire ants are the major sources of predation especially along the lesser-developed areas. Predation and disturbance of nests has also been recorded by domestic pets, red fox, and humans, although on a much smaller scale.

METHODS

Sarasota County nesting data was gathered from annual Florida Fish and Wildlife Conservation Commission (FWCC), and Florida Marine Research Institute (FMRI) Marine Turtle Nesting Summaries. Nesting summaries were supplied by Mote Marine Laboratory's (MML) Sea Turtle Research and Conservation Program for all areas that this organization monitors. Nesting summaries for Manasota Key were supplied partially from Manasota Key Sea Turtle Patrol and Coastal Wildlife Club, Turtle Division. The data that were not available from permit holders was obtained from FMRI.

RESULTS

Sarasota County shows an upward trend in loggerhead nesting. The largest number of nests ever recorded in Sarasota County was in 1998 with 4146 (Table 1). Manasota Key has the largest number of nests each year and has recorded 53% of the total nesting activity in Sarasota County from 1980-1998 (60.81% in 1998). It also comprises 23% of the total shoreline in Sarasota County, which is the longest of all areas in Sarasota County. Casey Key had the second largest number of nests in Sarasota County with 27% of the total recorded nests from 1980-1998 (21.16% in 1998). Casey Key has 22% of monitored shoreline in Sarasota County, which is the second largest stretch. The most recorded nests on Casey Key were 1073 in 1995.

Previous reports state that Sarasota County contributes 2.6% of the loggerhead nests in the State of Florida (Meylan, 1992). In 1998 this contribution climbed to 4.82% of the total recorded loggerhead nests-85,989 nests (FDEP, 1999). Green sea turtle nesting is minimal in Sarasota County. Three nests were recorded in 1998 which is less than 0.01% of statewide green turtle nesting. The largest total for green sea turtle nests is five, which occurred in 1994.

Several shifts in nesting totals are apparent in Figure 1. Nesting inventories prior to 1986 are not as accurate as data after 1986 because of the amount of effort that was dedicated to monitoring beaches (e.g., not all beaches were monitored daily). Once beaches were monitored more thoroughly an accurate account of nesting activity starts to be realized in 1986. Another spike occurred in 1991 with the addition of another monitoring permit by Mote Marine Laboratory (TP-028) for Casey Key and Venice Beach. The last jump in nesting was in 1995, which may be attributed to the addition of another permit for Manasota Key (TP-117).

CONCLUSIONS

1. Sarasota County has the largest number of recorded loggerhead nests and highest densities of nests on the entire gulf coast of Florida each year.
2. Green turtle nests have been recorded in Sarasota County in recent years, however in very limited numbers. It is possible that limited green turtle nesting has always occurred on these beaches, but have been missed or miss identified.
3. Within Sarasota County, Manasota Key and Casey Key have the longest amount of shoreline, the most recorded nests, the highest density of nesting, and the least amount of development.
4. Increases in surveying effort and personnel can account for large changes in historical nesting totals. Currently in Sarasota County all beaches are monitored each morning for nesting activity during sea turtle nesting season and there are enough volunteers to get accurate

inventory of sea turtle nesting.

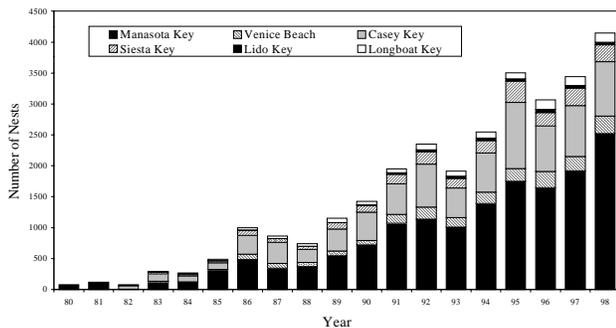
5. Historical nesting data on a state, county, local, and even individual property basis are used by researchers, government personnel, and non-governmental organizations to assess population status, as well as projects (i.e. beach nourishment, armoring, development) which may impact sea turtle nesting habitat. For these reasons it is important to monitor and inventory all sea turtle nesting in all areas.

6. Recorded sea turtle nesting data for Sarasota County is only available through 1979. Data prior to this is scarce and inaccurate.

ACKNOWLEDGMENTS

Sarasota County Environmental Services Business Center Natural Resources Department, John McCarthy-Manasota Key Sea Turtle Patrol, Wilma Katz and Zoe Bass-Coastal Wildlife Club, Turtle Division, Jerris Foote and Tracey Mueller- Mote Marine Laboratory, Florida Fish and Wildlife Conservation Commission, and Karen Dusseau-Eckerd College.

Fig. 1. Sarasota county sea turtle nesting activity by beach from 1980 to 1998.



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Table 1. Sarasota county sea turtle nesting activity by beach from 1980 to 1998. The beaches and (km) are as follows: MK = Manasota Key (12.8), VB = Venice Beach (7.4), CK = Casey Key (11.8), SK = Siesta Key (9.0), LK = Lido Key (4.2), LBK = Longboat Key (8.6).

Year	MK	VB	CK	SK	LK	LBK
80	80					
81	117					
82		7	57	6	0	8
83	126	7	120	25	2	14
84	114	9	98	30	2	13
85	312	11	107	32	6	21
86	486	86	304	82	3	39
87	347	74	342	59	2	42
88	371	68	210	50	1	42
89	548	74	357	101	1	71
90	722	71	459	106	12	57
91	1068	148	495	154	22	64
92	1139	196	692	202	32	91
93	1006	157	478	156	35	84
94	1388	188	633	201	37	101
95	1752	203	1073	343	34	97
96	1646	263	739	212	50	156
97	1921	227	825	282	45	142
98	2521	285	878	272	42	151
Total	15,664	2074	7867	2313	326	1193

Hawksbill (*Eretmochelys imbricata*) Nesting on the Pearl Cays of Nicaragua

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The extensive continental shelf found on the Caribbean coast of Nicaragua provides nesting, foraging, and developmental habitat for all life stages of hawksbill turtles (*Eretmochelys imbricata*). Miskitu Indians and Creoles harvest hawksbills opportunistically either by hand while diving for lobsters, in nets set for green turtles (*Chelonia mydas*), or from the nesting beaches. Although harvested primarily for their scutes, which are fashioned into various types of jewelry, eggs and sometimes the meat are consumed. It has been reported that the offshore cays, particularly the Pearl Cays, and the extreme southeast beaches of mainland Nicaragua are important for nesting

hawksbill turtles. However, since the 1970s, no information is available on the status of nesting populations of hawksbills in this area. We conducted terrestrial beach surveys in the Pearl Cays from 14 April to 28 August 1999. The purpose of the surveys was to quantify nesting activity, spatially and temporally, and to identify threats to their survival. In conducting these surveys it is clear that the Pearl Cays continue to be a very important area for both development and reproduction of hawksbill turtles. In addition, results of these surveys have provided us with information that has enabled us to plan appropriate conservation actions for the 2000 nesting season.

ACKNOWLEDGEMENTS

The Sea Turtle Conservation Program of Caribbean Nicaragua (which includes this research) is primarily supported by the Wildlife Conservation Society's International Program. We would like to thank all the fishers in the Pearl Lagoon area who have helped in the

conservation of hawksbills. We especially thank Wesley McCoy, Wilfred McCoy, Harold Taylor, Shony Tyne, and Ralf Cambalan, Jr. for their efforts in conducting beach surveys and saving hawksbills and their eggs. We also would like to thank Felicity Arengo and Diane Lawlor for assisting with nest relocations or excavations.

Preliminary Study of Sea Turtle Nesting Sites in the Tikling Islands, Eastern Samar, Central Philippines

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To date, most of the research and conservation efforts on sea turtle in the Philippines have focused in the Turtle Islands. This is mainly due to the reason that there seems to be no area(s) within the Philippine coasts where aggregations of nesting sea turtles similar to those in Turtle Islands have been recorded. However, this preliminary study shows that there are also other potentially important areas within the islands of the Philippine archipelago. Sea turtles have been recorded (in 1993) to nest in at least three islands and one islet, collectively called Tikling Islands, in the province of Eastern Samar, central Philippines (facing the Pacific Ocean). Some 50 to 60 heads of hawksbill and

green turtles have been observed nesting and breeding within these islands. Occasionally, the leatherback turtle, a suspected seasonal migrant species has been recorded. These species have been observed during the period of April to August. The regional office of the Department of Environment and Natural Resources has proposed this site to be a marine reserve or marine protected area by virtue of such initial findings. However, due to lack of funding this proposal was abandoned. The local community has, however, found this reasoning unacceptable and would like to embark on a region-wide conservation and research program for sea turtles.

Reproduction and Conservation of the Leatherback Turtle, *Dermochelys coriacea* (Testudines: Dermochelyidae), on Playa Gandoca, Costa Rica: The Nineties

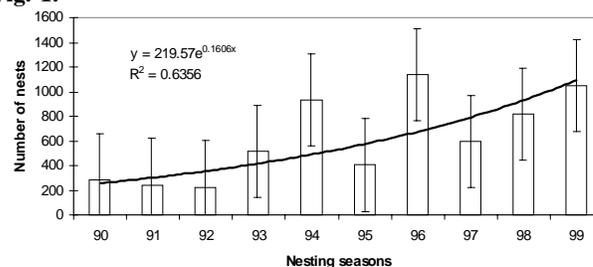
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The leatherback turtle was studied at Gandoca Beach, an important nesting beach on the south Caribbean coast of Costa Rica (82°37'W; 09°37'N). From 1990 to 1999 (February-July), 9 km of the beach were patrolled every night from 2000 through 0400 hours in two shifts of four hours by 6 groups (local staff and volunteers), so that all nests/tracks were identified and 20 parameters were collected including data about the nesting females. A total of 5,159 nests were recorded during the nesting seasons and 1780 leatherbacks were tagged. Seven hundred and ninety-three were remigrants from Gandoca. Two hundred and twenty-nine were remigrants from other beaches like Tortuguero, Mondonguillo in Costa Rica, Bluff and Changuinola Beach in Panamá and La Playona/Acandí in the Urabá Gulf, Colombia. The trend for the number of nests every year is growing but keeping the pattern of cycles. The number of nests each season ranged from 226 to 1,135, with an average of 570.8. Most of the nests were deposited in April and May (35.14% and 34.32%, respectively).

Gandoca had an average density of 53.24 nests/km (21-101/nest/km); the biometric data show coincident information with other nesting rookeries in the Caribbean Sea. The illegal collection of the eggs (100% in 1985 to 8.13% in 1999), extensive erosion and beach debris represent the main hazards for nesting in Gandoca. The project has developed a socio-economic model with the participation of part of the community and the Wildlife Refuge Authorities. Work in microbusiness in ecotourism and associated activities with volunteers provided over \$15,000 annually to the local economy.

Fig. 1.



Results of the 1998 and 1999 Sea Turtle Monitoring Activities in the Laguna De Tacarigua National Park, Venezuela

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The Laguna de Tacarigua National Park was created by presidential decree #1607 in 1974. In 1991, an offshore marine area was added by presidential decree #1639, in order to protect the important sea turtle nesting and feeding areas (Guada and Vernet, 1995; Guada *et al.*, 1998). There are five species of sea turtles in the area, the green turtle (*Chelonia mydas*), the hawksbill turtle (*Eretmochelys imbricata*), the loggerhead turtle (*Caretta caretta*), the leatherback turtle (*Dermochelys coriacea*) and the olive ridley turtle (*Lepidochelys olivacea*) (Gómez *et al.*, 1999).

Since 1990, three training activities have been organized in order to improve the capacity of the personnel to register information, which is important for the management goals. In 1991 and in 1992, the park personnel received short courses on sea turtle biology and conservation techniques (Guada and Vernet, 1992; Guada *et al.*, 1998) and in 1999, several rangers participated in a "Course on Monitoring of Crocodiles and Sea Turtles", held in the Laguna de Tacarigua National Park (Arteaga, 1999). The results of the sea turtle monitoring project in the Laguna de Tacarigua National Park during 1998 and 1999 were presented there.

METHODS

Between 1998 and 1999, sea turtle monitoring activities were conducted in the Laguna de Tacarigua National Park. Beach surveys were conducted along four, 5 km sectors of a sand bar with a length of near 30 km. The nests remained *in situ* unless the freatic level was threatening their survival. The tracks and nests were camouflaged to avoid their loss.

RESULTS AND DISCUSSION

Tracks

In 1998, 13 sea turtle tracks were documented between Club Miami and El Cazote, in the eastern area of the park. During 1999, 15 sea turtle tracks were documented, eight corresponding to leatherback turtles and seven to hawksbill turtles. The tracks were documented between Las Cruces and El Cazote.

Nesting and hatching success

In 1998, four nests were found. Three of them were from loggerhead turtles (n = 112, n = 110 and n = 115 eggs, respectively) and one of them was from a hawksbill turtle (n = 95 eggs). In 1999, only two nests from leatherback turtles could be found (n = 120 eggs for one of them). Hatching success was 90% for the hawksbill turtle (n = 1 nest), between 52% and 83% for the loggerhead turtle (n = 3), and 93% in one nest of the leatherback turtle.

MORTALITY

During 1998 and 1999, several sea turtle carcasses were recovered and determined to have been killed in undetermined interactions with fisheries. In 1998, a leatherback turtle and an olive ridley turtle were found dead on the sand bar (this is the first report of this turtle for the central coast of Venezuela). A third carcass was reported but could not be found along the eastern border of the National Park. In 1999, at least five carcasses were found on the sand bar: three adult leatherback turtles, one hawksbill turtle, and another olive ridley turtle. Another leatherback turtle was found in the lagoon.

The data show the importance of the Laguna de Tacarigua as a nesting area for the sea turtles in the central coast of Venezuela, as well as the importance of the monitoring activities conducted by the personnel of the National Park.

CONCLUSIONS

The hawksbill turtle and the leatherback turtle are the most important nesting species in the Laguna de Tacarigua National Park. The sectors between Club Miami and El Cazote are the most important nesting areas on the sand bar.

One of the main problems for the survival of the sea turtle nests in the national park is the tidal levels. Clear field protocols must be developed to translocate the nests. More park rangers and volunteers must be participating in the sea turtle monitoring program.

ACKNOWLEDGMENTS

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Marine Turtle Nesting in Eastern French Guiana

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INTRODUCTION

Three species of sea turtles can frequently be observed on the shores of French Guiana: the leatherback turtle (*Dermochelys coriacea*), the olive ridley (*Lepidochelys olivacea*), the green turtle (*Chelonia mydas*). Two others can also be seen, though more infrequently: the hawksbill (*Eretmochelys imbricata*) and the loggerhead (*Caretta caretta*) (Pritchard, 1969; Fretey and Lescure, 1998). For more than twenty years, the western part of French Guiana has had a conservation program for sea turtles (Fretey and Lescure, 1998).

The Hattes beach, situated in the Amerindian village of Awala-Yalimapo is now considered as the last important nesting site for leatherbacks, in spite of a significant decrease during the last few years. In 1998, 7,800 nestings were counted, which was the smallest number since the beginning of site monitoring (Chevalier and Girondot, 1999). These results most probably mean a decline in the populations but could also be at least partly the result of recent shifts of sea turtle populations on the Guyanese coast, especially towards the east (i.e., the Island of Cayenne and Kourou).

To confirm this hypothesis, a conservation program has been set up in the eastern part of the region, which is primarily aimed at the identification of the species present there, and of the main nesting sites as well as the number of nestings and their development during the year.

Moreover as the greatest number of people live near

Cayenne or Kourou, in the vicinity of nesting sites, we have made an awareness campaign one of our priorities.

METHODS

The monitoring of the sea turtle populations that nest on the eastern shores of Guiana has been done by counting the turtle tracks from 2 December 1998 to 20 January 2000.

Study Sites

In June 1999 a low flight over the whole coast confirmed that the only beaches in French Guiana were West of Organabo, towards Surinam and, in the East, close to Cayenne and Kourou (Fig. 1).

RESULTS

Four species of sea turtles nested on the eastern beaches, totalling about 2,000 nestings (Fig. 2).

Two peak nesting seasons have been observed for the leatherback, a main one from May to July and a small one in December and January. The second species which nests in eastern Guiana is the olive ridley which comes from May to August (Fig. 3).

We also counted deaths: six leatherbacks, eight olive ridley, two green turtles and one hawksbill, due to poaching, nests and dogs. Fifteen leatherbacks trapped in nests were set free.

DISCUSSION

Bimodal Nesting Season for Leatherback Turtles in French Guiana

In the 1980s the world population of leatherbacks was estimated at 115,000 adult females then at 34,500 only in the middle of the 90s. Nowadays, the female population nesting in the Guyanas makes up, on its own, more than half the world population (Spotila *et al.*, 1996). A one year's study of the eastern part of Guiana allows us to show that the nesting sites in the Island of Cayenne and Kourou have totalled 1,350 leatherback nestings, which ranks them among the major nesting sites for this species in the Guyanas. This study also shows that there exist two different leatherback nesting seasons. A similar phenomenon can also be observed in the West of Guiana and seems to extend to the whole of the Guyana shield.

The leatherbacks frequenting the northern hemisphere beaches usually nest in May-June in the Guyanas and South East Asia. In the southern hemisphere, the nesting sites are frequented in December-January on the shores of Brazil, Gabon and South Africa (Eckert *et al.*, 1989). These two yearly periods coincide with the two nesting seasons observed in the Guyanas, we can therefore wonder if the leatherback nesting during the main and small nesting seasons belong to two different populations (Chevalier *et al.*, 2000).

A genetic study, marking with Passive Integrated Transponder tags and the implementation of a monitoring program with the help of satellite telemetry (Argos) could supply some answers. In addition to that, prospecting North Brazil beaches and especially the Marajo Island would help to widen our knowledge about possible shifts in populations between the two countries.

Olive Ridley Turtles

In the last fifteen years or so the number of olive ridley turtles in the Guiana-Surinam area has been sharply declining (Reichart and Fretey, 1993). This phenomenon has been noticed in Brazil too (M.H. Godfrey, personal observations). On the other hand this year, sparse nestings have been seen in western Guiana and Surinam. Otherwise, 1999 has been confirming the facts that eastern Guiana beaches are nowadays the major olive ridley nesting site on the whole of the west Atlantic side (Pritchard and Reichard, personal communications).

INTERACTIONS WITH HUMAN

Population

Poaching on eastern beaches has been consistently noted. In French Guiana, sea turtles are fully protected and digging their eggs is a criminal offence. Dogs also cause a lot of damage: daily destruction of nests and bodily harm causing the death of several olive ridley turtles.

The nests cast along the coasts by holiday fishermen are also the cause of serious problems; they are prohibited along the shores of French Guiana (prefectorial order 21 July 1984). This problem of fishing is most certainly the main cause of death for reproductive animals. It doesn't only affect sea turtles. Many dolphins (*Sotalia fluviatilis*) have been found dead with net marks on their bodies (G. Talvy, personal observations).

Most nesting beaches are situated in an urban environment. The large numbers of people frequenting them and the activities which take place are likely to affect the population of sea turtles. On the other hand, the easy access to the sites is very much a reason for organising activities (such as school outings) and trying to make people contribute to the conservation of these species. It is also a reason to set up eco-tourism.

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Fig. 1. Map of French Guiana showing Cayenne and Kourou beaches.

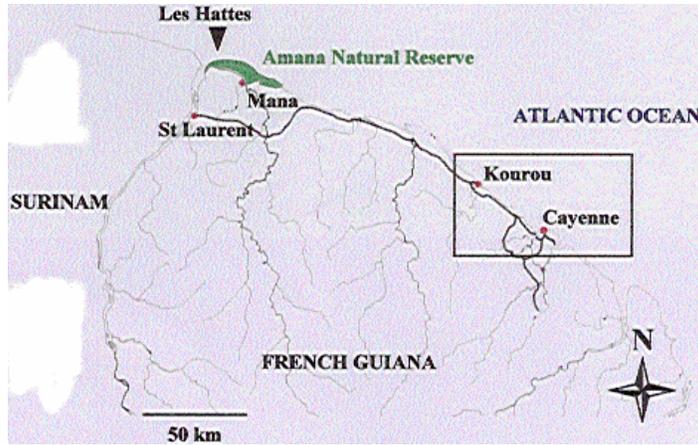


Fig. 2. Number of nestings (classified by species) on the western beaches of Guiana.

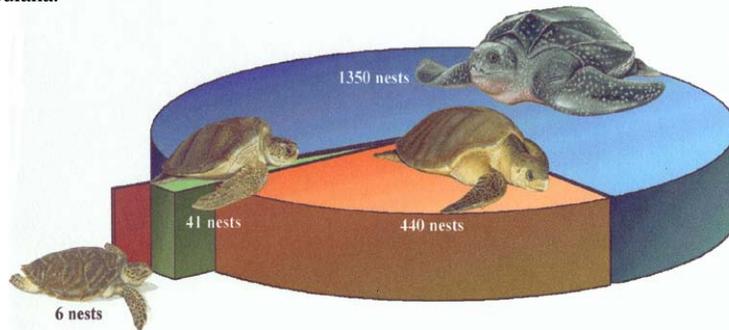
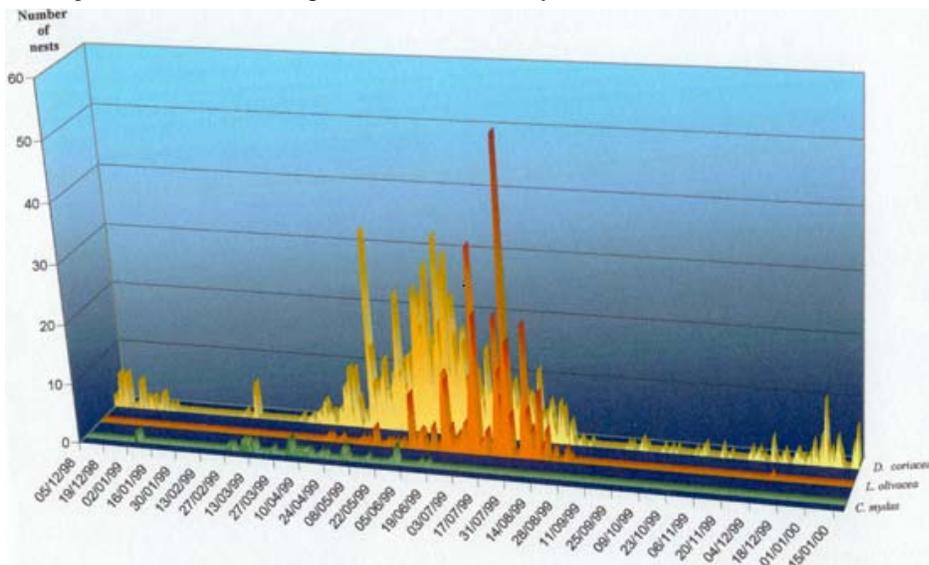


Fig. 3. Development of the number of nestings on the eastern beaches of Guiana from 07/12/1998 up to 20/01/2000 (counting on Kourou beaches only started on 01/03/1999).



Two Kemp's Ridley (*Lepidochelys kempii*) Nests on the Central Gulf Coast of Sarasota County Florida (USA)

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During June of 1999 two Kemp's ridley nests were documented on Sanderling Beach, Siesta Key, a residentially developed barrier island along the central gulf coast of Sarasota County Florida (USA). The nests were laid on June 7th and June 22nd, approximately 900 ft apart. Both nests were located on the upper beach of the narrow sloping shoreline. Hatch success for the nests were 84.6% and 88.3%, respectively.

DESCRIPTION

Nesting turtles were observed by residents of the Sanderling Club, a private beach located on South Siesta Key, Sarasota County, Florida. The first turtle was observed on June 7, 1999 between 1040 and 1120 hours. Residents observed the turtle as she was nesting and photographed her from the left side as she was covering. The activity and nest was reported to Mote Marine Laboratory Sea Turtle Conservation and Research personnel on June 27th. At this time, no evidence of the crawl was visible and no mounding, resulting from nest covering, was observed. An attempt was made to verify the nest but the egg clutch could not be found. The nesting area (nest #1) was marked with four wooden stakes and signage designating the site as a protected sea turtle nest.

The second nesting (nest #2) was observed, also by residents of the Sanderling Club, on June 22nd, 1999, at approximately 1500 hours. The turtle was photographed as she was nesting and covering. Photographs were taken from both the right and left side of the turtle. Mote Marine Laboratory personnel were notified after the turtle had returned to the water. Shortly after sunrise on the following day (6/23) the tracks made by the turtle were observed but were very faint. The tracks were very lightly cut and had alternating oblique marks made by the forelimbs. No tail drag was apparent. A flexible tape was stretched, perpendicular to the direction of the crawl, between the most exterior marks made by the forelimbs. The track width measured in this way was 85.5 cm. This nest was verified and a self-releasing wire predator proof cage was placed around and over the nest. The nest was additionally marked with two wooden stakes and signage designating the site as a protected sea turtle nest.

Although the turtle(s) was not observed by Mote Marine Laboratory biologists, it is apparent from the photographs that all four flippers were intact. There was no evidence of external flipper tags, living tags, injury or deformity. Areas of darker pigmentation on the head, left

shoulder and on the left marginal scales located along the first vertebral and the first and second costal (or lateral) scutes are identical in the June 7th and June 22nd photographs. The identical pigmentation indicates that the nests were completed by the same turtle. The turtle was reported as being small, almost as wide as long, and the photographs show the light grey to olive-green color typical of the species.

The data collected for each of the two nests is shown in Table 1. The characteristics used to distinguish between Kemp's ridley hatchlings and loggerhead hatchlings are shown in Table 2.

ARCHIVED SPECIMEN

Three dead hatchlings (one post-emergent and two dead pipped) were brought to Mote Marine Laboratory. Two of these (one post-emergent and one dead pipped) are preserved as voucher specimen at the University of Florida Museum of Natural History (FLMMH) in Gainesville. Archival numbers are UF 120097 and UF 120098. The third is being archived at Mote Marine Laboratory. Tissue samples were sent to Dr. Peter Dutton at the Southwest Fisheries Science Center, La Jolla California to be archived for possible future genetic analysis (Table 3).

DISCUSSION

Only a small number of Kemp's ridley nesting records exist for localities other than Mexico and Texas (Bowen *et al.*, 1994). To date, a total of seven successful nests have been documented on Florida beaches. Two of these were recorded on the Atlantic Coast and five on the Gulf coast (Johnson *et al.*, 1999). Two additional nests have been recorded, one each, on North and South Carolina beaches (Bowen *et al.*, 1994). All of the above nesting activity occurred between 1989 and the present.

Although the first Florida nesting of a Kemp's ridley was documented in 1989, it is possible that intermittent nesting occurred prior to this date but was missed or misidentified. The tracks of the first nest reported in this poster were not visible the following morning. Thus it is possible that on a secluded or moderately developed beach, as in this situation, Kemp's ridley nests might occur but go undocumented because: 1) the turtle was not observed and 2) the faint shallow tracks were obliterated by natural elements or human activity.

It is well documented in the literature that Kemp's ridleys nest in the daytime while loggerheads (*Caretta caretta*) nest at night. In the past nine years we have documented 21 loggerhead turtles nesting between 0630 and 2100 hours on Sarasota County beaches. The majority of these turtles were verified as loggerheads by observation and/or photographs. It is possible, if a turtle was not photographed or observed by someone familiar with the morphological characteristics of the different species, that a turtle could be "assumed" to be a loggerhead.

The tracks of loggerhead and Kemp's ridley turtles can be difficult to tell apart. Pritchard and Mortimer (1999) describe both tracks as being alternating (asymmetrical) slanting marks made by the forelimbs. The tail drag mark is inconspicuous or lacking in both. The track width for the loggerhead is typically 70-90 cm, while the Kemp's ridley track is typically 70-80 cm. The only major difference between the tracks of the loggerhead and the Kemp's ridley is that the tracks of the former are of moderately deep cut and the later are very lightly cut and may be quickly obliterated by wind.

The presence of subadult and adult Kemp's ridley in coastal waters near Sarasota County are verified in the Mote Marine Laboratory sea turtle stranding database. These records document 63 Kemp's ridley strandings between

1987 and 1999. The strandings occurred in all months except January and October (Table 4). It was determined during necropsy that the two adult turtles were female. Of the 22 subadult turtles, eight were greater than 54 cm carapace length and five of these were determined to be female. Thus, although the numbers are small, the stranding data support the presence of subadult and adult females which could contribute to a nesting population on the west coast of Florida.

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Table 1. Nest data.

Nest Date	Hatch Date	Days Incubation	Total Eggs	Hatch Success	Emergence Success
6/7/99	08/04/99	58 days	117	84.6%	100%
6/22/99	08/11/99	50 days	94	88.3%	95.2%

Table 2. Hatchling identification key from Pritchard and Mortimer, 1999.

	Kemp's ridley	Loggerhead
Typical or usual/costal scutes	five pairs	five pairs
Inframarginal scutes	four pairs	three or four pairs
Carapace length	43mm SCL (38-46 mm)	45mm SLC (38-50mm)
Color (above and below)	very dark gray/black	dark/light brown

Table 3. Archive numbers for tissue samples.

Turtle ID	Lab ID	Field ID	Date
LK3023	14908	99SK5B010 #1	1999/8/14
LK3024	14909	99SK5A036 #2	1999/8/14

Table 4. Mote Marine Laboratory stranding records for Sarasota County, Florida. The size code classifications are from the Florida Fish and Wildlife Conservation Commission's Marine Turtle Facility Monthly Report Forms. CL is the curved carapace length.

Juvenile	Subadult	Adult	Unknown
>5 cm and < 45 cm CL	>45 cm and < 60 cm CL	> 60 cm CL	
54% (n=34)	36% (n=22)	3% (n=2)	6% (n=4)

Marine Turtles in the Cayman Islands, British West Indies

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INTRODUCTION

The first comprehensive study to assess the marine turtle reproductive activity in the Cayman Islands was conducted in 1998 and 1999. The aim of the study was to

identify marine turtle nesting beaches, species nesting, and quantify nesting activity.

Historically, marine turtles were abundant in the Cayman Islands (Williams, 1995), so much so that the three small islands may have supported the largest green turtle

rookery in the Caribbean (Groombridge, 1982; King, 1982). Years of exploitation decimated the local marine turtle population, with the green turtle species thought to be extinct by the 1800's (Groombridge, 1982).

Colloquial reports by residents and environmental enforcement officers suggest that marine turtle nesting still occurs in the Cayman Islands. The results of this study confirm those reports and describe the extent of marine turtle reproductive activity.

METHODS

On both Grand Cayman and Little Cayman the coastline suitable for marine turtle nesting beach is not continuous, and beach lengths range from 100 m to 7600 m. Beach morphology is uniform with the exception of a long, deep stretch of beach on Grand Cayman's west coastline (Seven Mile Beach). Suitable marine turtle nesting beaches are found around most of both islands. Twenty-one kilometer of Little Cayman's 37 km coastline and 32 km of Grand Cayman's 129 km coastline contain beach suitable for marine turtle nesting.

The suitable marine turtle nesting beaches were walked during the day every three to four days in search of marine turtle nesting activity. In Little Cayman, the beaches were surveyed between 23 May and 20 October 1998. In Grand Cayman the beaches were surveyed between 26 April and 14 October 1999.

Species identification was based on track symmetry, body pit depth, and verification with live or dead hatchlings.

RESULTS AND DISCUSSION

In this study six beaches with marine turtle nesting activity and 20 beaches suitable for marine turtle nesting were found on Little Cayman in 1998 (Figs. 1 and 2), and seven beaches with marine turtle nesting activity and 19 beaches suitable for marine turtle nesting were found on Grand Cayman in 1999 (Figs. 3 and 4).

Green turtles (*Chelonia mydas*), hawksbill turtles (*Eretmochelys imbricata*), and loggerhead turtles (*Caretta caretta*) were found to nest in the Cayman Islands between May and September of both years (Table 1). Differences in the relative abundance of each species were found between islands and years. Green turtles were responsible for the majority of the nesting in Little Cayman in 1998 and loggerhead turtles were responsible for the majority of nesting in Grand Cayman in 1999 (Figs. 2 and 4; Table 2).

Much has changed in regards to the number of marine turtles reproducing in the Cayman Islands. The islands, at one time, likely had the largest rookery in the Caribbean with tens of thousands of marine turtles nesting per season (Groombridge, 1982; King, 1982). Now Cayman has less than 40 nests per season.

Marine turtles can no longer be considered extinct in the Cayman Islands. However, the extremely small reproducing population places them on the verge of local extinction. The risk is amplified when we consider the low hatch success of the marine turtles nesting in Little Cayman in 1998 (Table 3).

The greatest threats to marine turtles reproducing in the Cayman Islands are anthropogenic, and include poaching and coastal development (artificial lighting and habitat destruction) (Table 4).

Marine turtles do not reproduce every season. Therefore multiple season surveys are necessary to establish population abundance. Even more years of collecting beach monitoring data are necessary to establish trends in seasonal abundance and overall population status. However, while continuing with beach monitoring surveys it is necessary to eliminate or reduce any potential threats to nesting marine turtles. This will decrease any chances of local extinction and enhance efforts for stock recovery.

ACKNOWLEDGMENTS

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Table 1. The number of marine turtle nests each month from May through September on Little Cayman in 1998 and Grand Cayman in 1999. The nest associated with the unknown month was found when the eggs were exposed by beach erosion.

Month	Number of nests	
	Little Cayman	Grand Cayman
May	0	4
June	2	8*
July	5	5
August	6	5
September	2	0
Unknown	0	1
Total	15	23

Table 2. The number of nests of loggerheads (*Caretta caretta*), hawksbills (*Eretmochelys imbricata*), green turtles (*Chelonia mydas*), and unidentified marine turtle species on Little Cayman in 1998 and Grand Cayman in 1999.

Species	Number of nests	
	Little Cayman	Grand Cayman
Loggerhead	0	18
Hawksbill	2	2
Green turtle	9	1
Unidentified	4	2
Total	15	23

Table 3. The mean clutch size and hatching success for loggerheads (*Caretta caretta*), hawksbills (*Eretmochelys imbricata*), green turtles (*Chelonia mydas*), and marine turtle nests not identified to species on Little Cayman in 1998 and Grand Cayman in 1999.

Species	Little Cayman		Grand Cayman	
	Clutch size	Hatching success	Clutch size	Hatching success
Loggerhead			119 (n=18)	86% (n=18)
Hawksbill	152 (n=3)	42% (n=3)	151 (n=2)	77% (n=2)
Green turtle	120 (n=9)	31% (n=9)	53 (n=1)	2% (n=1)

Table 4. A list of potential natural and human threats to marine turtles in the Cayman Islands.

Natural threats	Human threats
Magnificent frigate bird (<i>Fregata magnificens</i>)	Poaching
Ghost crabs (<i>Ocypode quadrata</i>)	Coastal development
Red shank crabs (<i>Geocarcinus lateralis</i>)	Artificial lighting
Snake (<i>Alsophis cantherigerus caymanus</i>)	Feral cats
Great barracuda (<i>Sphyræna barracuda</i>)	Wild and domestic dogs
Jacks spp. (<i>Caranx</i> spp.)	Licensed turtle fishermen
Other coral reef fish species	
Gray flesh flies (<i>Sarcophagidae</i>)	
Beach erosion	

Fig. 1. Map of Little Cayman showing the 3 distinguishable regions (North, Southeast, and Southwest), suitable marine turtle nesting beach coastline, and coastline with marine turtle nesting activity.

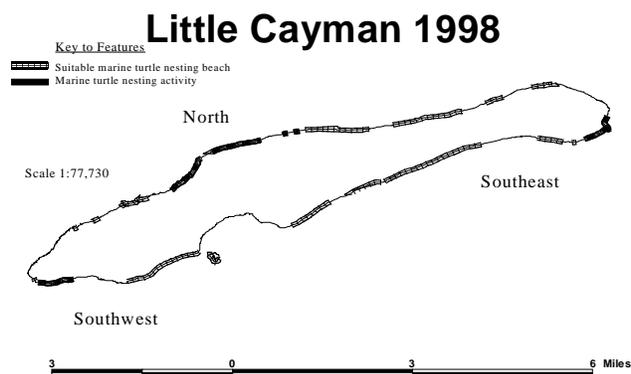


Fig. 2. Number of marine turtle nests by species in each region of Little Cayman.

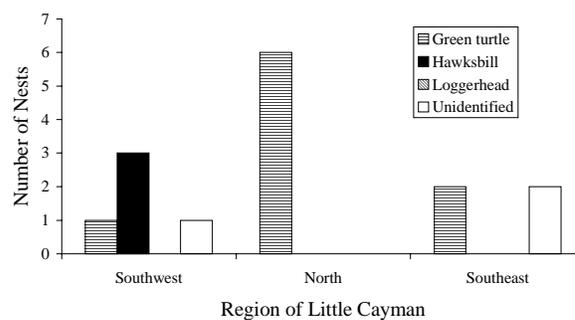


Fig. 3. Map of Grand Cayman showing the 5 distinguishable regions (Northwest, Northeast, East, South, and West), suitable marine turtle nesting beach coastline, and coastline with marine turtle nesting activity.

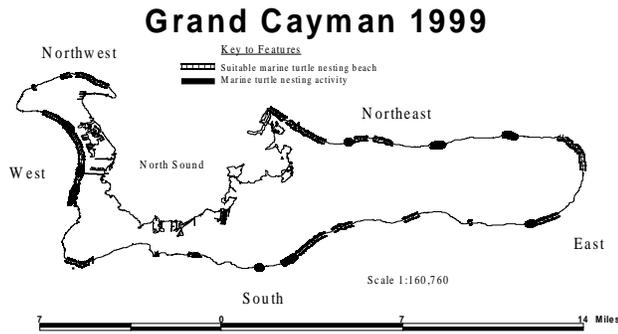
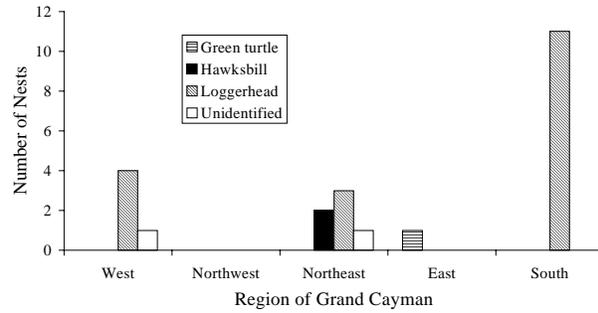


Fig. 4. Number of marine turtle nests by species in each region of Grand Cayman (see Fig. 3).



Decrease of the Number of Nests of the Green Turtle (*Chelonia mydas*) in the Beaches of Alto Lucero, Veracruz, Mexico

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Starting from 1996, in the beaches of the municipality of Alto Lucero, Veracruz, work on green turtles began, although in these beaches the appropriate conditions existed so that they nested in them without any setback, they have suffered year after year an enormous erosion, which has caused that the turtles have to look for other appropriate places to nest.

During this year (1996) it began the registration of the climatic factors and their influence on the beaches. The effects caused by the hurricanes are those that bigger damages has caused, since the strong rains, big tides and wind have disappeared near 10 km of nests area with that which the turtles that end up being nested displaced to area with better conditions.

The strong currents of wind that have whipped the area also caused a great erosion in the beaches, which it has little defense when containing little their protection so that they stay intact.

The climatic factors influence directly in the number of nests that were protected in 1999, although there was a great arrival of turtles (102 tracks located), alone they possible to protect 15 nests of green turtle and it is considerable the reduction of nests protected during the time in that they have been carried out the activities of community protection since in those beaches.

NESTING BEACH PROBLEMS

Since 1996, when marine turtle community protection activities were initiated on the beaches of Alto Lucero in

Veracruz, México, a record of climatic conditions was made with the objective of observing the changes in the characteristics of the beaches and the behaviour of the turtles in the presence of these changes.

During the time when the climatic conditions were recorded, the effects caused by hurricane Josefina, which struck these beaches in August 1996, was the most severe damage that has affected these beaches in the last four years. Since the waves carried away approximately 10 km of dunes, where important nesting zones were located, at least during this season. Another effect, which the hurricane caused with its heavy rainfalls, was the raise of the Santa Ana River's basin, this resulted in enormous amount of low lying stones from an extensive nesting zone, to be washed away, which because of the plant covering (mainly from cassowaries), had not eroded. However, the stones were a great obstacle for the turtles when they tried to nest, and they ended mostly abandoning the place in order to look for another with better conditions, in spite of this problem during this year, 93 nests of green turtle were protected.

In 1997, climatic conditions played an important role to the number of nesting turtles, because winds this year, caused the erosion of an extensive beach zone and on counting the majority of dunes with a plant covering percentage of approximately 30%, these were eroded to an extent that the majority of nesting which were recorded were located in beach zones where a great quantity of stones used to exist, mainly in woodland areas, although they caused the turtles problems when making their nests or reaching a high area of the beach, the turtles were very persistent in their objective. During this year it was notable

that even though the beach did not have a native woodland area, this influenced notably the selection of the nesting beach, since thanks to this, the condition in the area were kept stable. This year 68 nests were protected but a considerable amount of turtles arrived without being able to nest.

In 1998, the beach had a minor regeneration, principally in the areas which had not been stuck by the effects of hurricane Josefina which ravaged the area in 1996. At the beginning of the year the beach continued to be struck by winds, causing a constant movement of sand which caused the principal nesting areas to have a minor recuperation and these areas were visited the most by the nesting turtles. It was observed that the turtles preferred, at least on these beaches, areas with a lot of vegetation given that 93% of this season's nesting were recorded there, which was a total of 372.

On the beaches of Alto Lucero, the vegetative areas are very scarce with as little as 20% of its total length (25 km) and in this areas during 1998 nesting season, the largest number of the turtles were concentrated there. There was a great competition in the selection of the nesting spot and when carrying out this process, the turtles moved a great amount of sand changing the conditions of this beaches areas, which remained completely eroded, this factor, in addition to the factor caused by the weather during 1999 only led to 15 green turtle nest being recorded on these beaches. Despite the existence of the great influence of marine turtles (102 recorded tracks), these turtles did not find better conditions to lay their eggs. Out of the located nests, 80% were laid in the lower parts of the beach, since in these areas, the turtles managed to have the adequate conditions to do it, therefore these eggs were moved to a protected place for their incubation.

HUMAN ALTERATION TO THE BEACHES OF ALTO LUCERO, VERACRUZ, MEXICO

In the surrounding areas of the beaches of Alto Lucero there are various towns whose inhabitants, during the

nesting season, see this as easy products to obtain and sell at high prices. Even though the inhabitants of these beaches have been involved in the community protection of marine turtles, human presence continues to be one of the factors which directly influences the reduction in the number of green turtles nests which have been recorded year after year.

The slaughter of turtles is an activity which commonly practiced on these beaches, so it is often that people who carry out this activity disturb the turtles that are nesting, therefore they prefer to abandon the area to look to safer places.

Another problem, which currently has a major impact on the nesting beach, is the increase of housing areas, which contribute to the increase of artificial light, it is lit most of year, causing serious problems to the turtles that nest in those places. The presence of Laguna Verde nuclear power plant has to taken into account, since with the illumination that it generates, renders almost 3 km of the beaches unusable. In this zone only seven green turtles tracks have been found since 1996.

Despite a low record of green turtle nesting in 1999 on the beaches of Alto Lucero, Veracruz, it is an area of great importance of this turtle's nesting, for this reason it is important that community protection work is continued. It is only necessary for those persons, who participate in these activities and who try to obtain the necessary support so that these activities are carried out with adequate technology and equipment, to make a great effort, with the purpose of truly helping the recuperation of the turtle population that nest in these beaches.

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Observations on the Ecology of Marine Turtles Nesting on the Mediterranean Coast of Egypt

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INTRODUCTION

Two species of marine turtle are known to nest on Mediterranean shores, *Caretta caretta* (the loggerhead turtle) and *Chelonia mydas* (the green turtle). The status of nesting populations in the major rookeries of Greece,

Turkey and Cyprus has been known for some time. However, the numbers utilizing the smaller rookeries in Israel, Libya and Egypt have only recently been quantified (Clarke *et. al.*, 2000; Kuller, 1999; Venizelos, 1996). The status of both species is threatened on a global scale (IUCN, 1998) and a concerted international effort is currently

underway to identify and protect those Mediterranean beaches on which marine turtles nest. During a survey in 1998 a small population of loggerheads and the occasional green turtle were found to nest on the Mediterranean coast of the Sinai Peninsula (Clarke *et al.*, 2000). This population is under pressure from beach development, pollution, and heavy predation from both human and natural sources. Immediate conservation measures need to be implemented in order to ensure survival (Clarke *et al.*, 2000). This study quantifies a number of physical and ecological parameters known to be of importance to the implementation of marine turtle conservation programs.

METHODS

Temporal and Spatial Nesting Patterns

During the period 15 May to 15 September 1999 (which encompasses the marine turtle nesting season in the Egypt; Clarke *et al.*, 2000) the 200.7 km of sandy beaches that lie along the 220 km coastline between the towns of Rhafa and Port Said were surveyed for evidence of turtle emergence tracks and nesting. The areas most heavily utilized by nesting turtles were then identified and the periods of intensive nesting activity determined.

Incubation Period, Clutch Size and Hatching Success

The coordinates of nests found containing eggs were recorded and the position marked with a stake and fluorescent tape allowing nests to be relocated at a later date. Forty days after clutch deposition each nest was checked for signs of hatchling emergence on a two-day cycle. This allowed the incubation period to be accurately calculated to within one day. Six vulnerable nests were transplanted to a hatchery and inspected daily. Several days after the eggs had hatched a nest was excavated and the number of successfully hatched eggs, unfertilized eggs, dead hatchlings and embryos at various stages of development counted.

Incubation Temperature

A Tidbit temperature logger (Onset Computer Corporation) was placed in the centre of a clutch of eggs during transplantation to the hatchery. Air temperature in three nests at six-hour intervals was recorded throughout the incubation period. This was done in nests containing eggs laid during the early (June), mid (July) and late (August) nesting season.

Adult Mortality

During the survey many turtle carcasses were found on the beaches. These turtles had either died on the beach or had died at sea and been subsequently washed ashore. When possible the turtle species was identified and the cause of death determined.

Beach Development

The position and scale of beachfront developments, and their proximity to important nesting beaches, was surveyed by measuring the distance along the coast a development stretched.

RESULTS AND DISCUSSION

Temporal and Spatial Nesting Patterns

A total of 61 emergence tracks and 27 nests containing eggs were found during the 1999 season. All the nests were from *C. caretta*; no *C. mydas* nests were found. The total number of emergences was lower than the 106 found the previous year, but the number of nests in which egg deposition was confirmed was slightly higher than the 21 recorded in 1998 (Clarke *et al.*, 2000). The nesting season started on 23 May, when the first emergence track was found, and ended on 11 September when the final clutch of eggs hatched. The last recorded emergence of a female was on 1 August. The region of main nesting activity had shifted approximately 40 km east from the previous year. The cause for this shift was not immediately apparent as there was no obvious change in the profile of the shoreline between seasons. It is possible that the uniformity of the coastline in this area provides no physical landmarks to aid female turtles in navigating to their natal beaches, causing them to emerge at random locations. However, if this were the case, specific areas of concentrated nesting activity would not be expected. This result highlights the need for multi-season surveys and the limitations of those based on a single year's data when trying to identify nesting sites. Any recommendations regarding protection of important nesting sites in northern Sinai based solely on the 1998 survey would have been misleading.

Clutch Size, Hatching Success and Incubation Period

The average clutch size was 64.7 eggs ($n = 19$; $SD = 28.0$). The mean hatching success rate was 68.9% ($n = 13$; $SD = 28.1$) for undisturbed nests and 67.6% ($n = 6$; $SD = 15.8$) for transplanted nests. Mean incubation period was 48.7 days ($n = 13$; $SD = 2.7$) for undisturbed nests, and 46.8 days ($n = 6$; $SD = 2.0$) for transplanted nests. The average clutch size was within the range cited for *C. caretta* in northern Cyprus (Broderick and Godley, 1996) but was considerably lower than that the south of the island (Demetropoulos and Hadjichristophorou, 1995). Mean hatching success was lower than that reported from southern Cyprus (79.1%) yet comparable to the rate (67.7%) reported for *C. caretta* from Zakynthos, Greece (Peters and Verhoeven, 1992). Transplantation of eggs did not appear to have a detrimental affect on hatching success. The mean incubation period of 48.7 days is similar to that reported from both southern and northern Cyprus for *C. caretta* (Demetropoulos and Hadjichristophorou, 1995; Broderick and Godley, 1996). Overall, the nesting

Preliminary Findings of the Socotra Biodiversity Project Sea Turtle Survey

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As part of a broader biodiversity survey, nesting sea turtles were monitored and their habitats were described for the Socotra archipelago. Fieldwork was carried out from 1 May 1999 to 29 May 1999 on Socotra and adjacent islands (Fig. 1), and augmented with reports from local inhabitants. The primary objectives of the survey were to establish which sea turtle species were nesting and inhabiting the nearshore waters of Socotra, Abd Al Khuri, Samha and Darsa (Kal Faraon and Sabouniya being isolated rocks with no nesting), and to assist the UNDP office with training and education projects for their staff and the Socotri people, and in the development of protected areas for sea turtle nesting. Additionally, a first-ever description of the nesting beaches, sand grain size analysis and cataloging were carried out.

Nesting turtles were identified to species, measured and weighed, and tagged using a new series of tag numbers, to be based at the Yemeni Environmental Protection Council (EPC). Each sandy beach was physically examined on foot or by vehicle, and all of them walked at least once. Data collected at each beach included: GPS position (single point on small beaches, start and end extent on larger beaches), beach slope, length, suitability for nesting, description, number of nesting tracks and their age (where possible), records of dead turtles, and other notable features. At the fishing communities within these zones data was collected on dead turtles at the discard piles, turtle utilisation and fishing habits, and other information related to turtle conservation.

Nesting takes place primarily on the main island of Socotra, with only scattered nesting on the beaches at Abd Al-Khuri and Samha. No nesting occurs on Darsa, Kal Faraon or Sabouniyah. The stretch from Gubba to Ras Gaddama is the main nesting beach during the pre-monsoon period on Socotra, with most nesting (~90%) occurring 2.5 km on either side of Ras Abalhan. During this period nesting averaged approximately two turtles per night over 5 km of beach. Nesting on all other beaches is of low density,

probably not exceeding one to two turtles per night on any beach. It is unknown for how long this nesting frequency is maintained, but it is doubtful that it lasts no longer than three months. This roughly translates to a nesting population of about 50 to 100 females and an unknown number of accompanying males. Although green turtle (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) remains were identified on the beaches, only the loggerhead (*Caretta caretta*) was found nesting at any of the beaches (Table 1). It is possible that the green turtle and hawksbill nest at earlier or later dates, or are simply non-nesting residents (Table 2). Being as the survey was carried out at the peak of the reported nesting season, it is strongly believed the latter is the case.

The use of turtle meat and eggs by the northern and southern Socotri people is clearly evident. During May 1999 up to three turtles were brought to the market in Hadibo daily. These had been captured from as far distant as Gubba and sold readily to the local households. Eggs are similarly collected when possible, particularly on the southern coast. No turtle or egg collection was evident at Shoab, though occasional slaughtering of adult females is reported to occur. No major nesting was detected at Qualansiyah. I believe conservation measures should first be aimed at households and at the sale of the eggs and meat in open markets.

Several options exist for conservation, although all will require the participation of the Socotri people. Initially, one protected beach should area be established between Gubba and Ras Gaddama, inclusive of an area at least one to two nautical miles offshore in which turtles spend their interesting period. Secondly, an education programmes should be developed to get children and housewives against turtle meat consumption. A third option would be a 'Turtle Safe' certification programme, in which fishermen that do not catch turtles have their boats and catch certified as 'Turtle Safe', to curb harvests and demand.

Fig. 1. Map of Socotra and adjacent islands.



Table 1. Morphometric summary of adult loggerhead turtles in Socotra.

	Mean	SD	Max	Min	n
Curved carapace length (cm)	94.3	4.26	103.0	79.0	49
Curved carapace width (cm)	85.8	3.27	93.0	79.0	49
Straight carapace length (cm)	86.3	5.16	91.0	70.0	15
Straight carapace width (cm)	69.1	2.53	73.5	64	15
Plastron length (cm)	75.0	9.09	91.5	62.0	49
Plastron width (cm)	65.5	10.09	89.0	6.0	49
Head width (cm)	17.5	1.64	21.0	12.5	49
Tail length (cm)	15.7	2.71	21.0	10.5	49
Weight (kg)	94.5	6.52	108.0	84.0	11

Table 2. Morphometric summary of turtle carapaces and skulls on Socotra.

	Mean	SD	Max	Min	n
Green turtle					
Curved carapace length (cm)	83.4	19.45	103.5	40.0	17
Curved carapace width (cm)	75.4	17.94	95.0	37.0	17
Head width (cm)	23.5	29.73	84.0	7.0	6
Hawksbill					
Curved carapace length (cm)	52.2	14.93	70.5	34.0	8
Curved carapace width (cm)	46.6	13.17	63.0	29.5	8
Head width (cm)	7.4	1.89	9.0	5.5	4
Loggerhead					
Curved carapace length (cm)	99.4	6.12	109.0	92.0	5
Curved carapace width (cm)	89.1	2.53	92.0	87.0	4
Head width (cm)	18.8	2.31	21.5	16.0	7

Dry Tortugas Sea Turtle Monitoring Program: Five Year Status Report

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Encompassing seven islands and 260 km² (100 mi²) of ocean, Dry Tortugas National Park (DTNP) is situated at 24°38'N latitude and 82°52'W longitude, approximately 113 km (70 mi) west of Key West, Florida. Devoid of mammalian nest predators and anthropogenic disturbances found elsewhere, these isolated islands provide ideal sea turtle nesting habitat and research opportunities. The Dry Tortugas Sea Turtle Monitoring Program (DTSTMP) was instituted to establish and maintain a baseline inventory and monitoring program for sea turtle nesting and hatching activities within the park. Presented here are the findings of the DTSTMP during five seasons (1995-1999) of daily monitoring. Data collected suggest the Dry Tortugas supports the largest loggerhead (*Caretta caretta*) rookery within the Florida Keys and the largest green turtle (*Chelonia mydas*) rookery in Monroe County, Florida. A

total of 2881 turtle crawls were documented, comprised of 1245 nests (1101 Cc and 144 Cm) and 1636 false crawls (1461 Cc and 175 Cm). An estimated 100,064 eggs were excavated, with 75,944 hatchlings estimated to have entered the Gulf of Mexico. While annual loggerhead nesting activity remained relatively steady, great seasonal variability in green turtle activity was observed. Data suggest a two-year nesting cycle for green turtles in DTNP, with a significantly larger even-year nesting population. In addition to critical nesting habitat, the Dry Tortugas-with continued monitoring efforts-could provide valuable life history information on the area's nesting populations of the endangered green and threatened loggerhead sea turtles. Unfortunately, due to a lack of funding, the Dry Tortugas Sea Turtle Monitoring Program cannot be conducted in year 2000 and future monitoring efforts remain uncertain.

Sea Turtle Monitoring and Management Activities in the Archipelago Los Roques National Park: Results of 1998 and 1999

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INTRODUCTION

With the creation of the Wildlife Program in 1990 in the National Parks Direction (DGSPN), several opportunities arose to offer training in wildlife monitoring for the park rangers and to incorporate the information gathered by

them in the management and zoning plan of the parks. The Archipiélago Los Roques National Park, created by presidential decree in 1972, is a good example of the implementation of the wildlife monitoring programs, here focused on sea turtles. In 1991 a management and zoning plan was promulgated (Gaceta Oficial No. 4250, 18/01/

91). The plan included specific regulations to protect the most important sea turtle nesting and feeding areas. There are four species of sea turtles in the area, the green turtle (*Chelonia mydas*), the hawksbill turtle (*Eretmochelys imbricata*), the loggerhead turtle (*Caretta caretta*) and the leatherback turtle (*Dermochelys coriacea*) (Medina *et al.*, 1987).

After 1990, three training activities were organized in order to improve the capacity of the personnel to register information which is important for the management goals. Park rangers of the Archipiélago Los Roques National Park participated in a wildlife monitoring course for personnel of the coastal areas in 1992, which included a component about sea turtles (Guada and Vernet, 1992). In 1994, the park personnel received a short course on sea turtle biology and conservation techniques (Guada *et al.*, 1998) and in 1999, several rangers participated in a "Course on Monitoring of Crocodiles and Sea Turtles" offered within the Research Component of the National Parks Institute (INPARQUES). In addition, one of the park rangers has a wide experience identifying sea turtle tracks and nests in the field.

The results of the sea turtle monitoring project in the Archipiélago Los Roques National Park were presented there during 1998 and 1999.

METHODS

Within the vigilance and control program, rangers of the Archipiélago Los Roques National Park conducted sea turtle monitoring activities on the following islands: Los Castillos, Los Canquises, Isla Larga, Dos Mosquises, Cayo de Agua, Carenero, Espenquí, Noronquises, Isla Vapor, and el Gran Roque. The period when these activities were conducted was between May and November of 1998 and 1999 (Mata and Duran, 1998; Mata *et al.*, 1999). Sea turtle tracks and nests were identified and surveyed early in the morning. The nests remained in situ unless the freatic level or the possibility of poaching by fishermen were threatening their survival. The tracks and nests were camouflaged to avoid their loss.

RESULTS AND DISCUSSION

The nests were found mainly in June and August and mainly on Los Canquises and Los Castillos. The last key has problems with the freatic level and the nests of Los Castillos had to be frequently translocated to other keys. Within the zoning and management plan of the archipelago, Isla Larga and Los Canquises have the most strict protection (Integral Protection Zone according the management and zoning plan). Los Castillos has a lesser grade of protection.

Thirty-two sea turtle nests were found in 1998 and 33 nests were found in 1999 (Table 1). The hawksbill turtle, continues to be the species with the greatest number of

nests, followed by the loggerhead turtle and the green turtle. The leatherback turtle only nested in 1999, and this species continues to be an occasional nester in the archipelago. During 1999, most nests were poached because of the change in the time of the beach surveys. The sea turtle eggs are highly appreciated by fishermen although they know that it is illegal to poach them. The data of the hatched nests found during the beach surveys is presented in Tables 2 and 3. The reproductive success it is not extremely high in the nests evaluated.

CONCLUSIONS

The hawksbill turtle is the most important nesting species in the archipelago. The islands or keys with the best protection through the zoning and management plan (little or no visitors in the area), such as Los Canquises and Los Castillos, are the preferred nesting sites for the sea turtles.

One of the main problems for the survival of the sea turtle nests in the national park is nest poaching. The beach surveys must be done early in the morning again for the 2000 nesting season (such as in 1998) in order to avoid the poaching of the eggs. Clear field protocols must be developed to translocate eggs to other beaches or to the hatchery on Dos Mosquises key. More park rangers and volunteers must be participating in the sea turtle monitoring program. An environmental education program geared toward fishermen must be established in order to try to diminish the illegal poaching of nests in the Archipiélago Los Roques National Park.

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Table 2. Data of the *in situ* hatched nests found in the Archipiélago Los Roques National Park in 1998. The locations are as follows: LCT = Los Castillos, VHT = Viejo Hotel, ISL = Isla Larga, and LCQ = Los Canquises.

Species	Clutch size	Dead hatchlings	Live hatchlings	Undeveloped	Location
<i>Eretmochelys imbricata</i>	168	16	16	136	LCT
<i>Eretmochelys imbricata</i>	142	0	7	135	LCT
<i>Eretmochelys imbricata</i>	113	7	43	63	LCT
<i>Eretmochelys imbricata</i>	111	9	52	50	LCT
<i>Eretmochelys imbricata</i>	?	?	33	?	VHT
<i>Eretmochelys imbricata</i>	146	18	113	3	ISL
<i>Eretmochelys imbricata</i>	96	?	?	15	LCT
<i>Eretmochelys imbricata</i>	198	0	0	0	LCT
<i>Chelonia mydas</i>	4	1	0	3	LCT
<i>Caretta caretta</i>	120	4	59	57	LCQ
<i>Caretta caretta</i>	151	11	32	8	LCQ
<i>Caretta caretta</i>	124	25	14	85	LCQ

Table 1. Species and reproductive events on eight islands of the Archipiélago Los Roques National Park during 1998 and 1999.

Species	False nests 1998	False nests 1999	Poached nests 1998	Poached nests 1999	Hatched nests 1998	Hatched nests 1999
<i>Eretmochelys imbricata</i>	15	6	1	10	16	10
<i>Chelonia mydas</i>	2	3	0	7	3	3
<i>Caretta caretta</i>	1	0	0	0	12	1
<i>Dermochelys coriacea</i>	0	0	0	0	0	2
Total	18	9	1	17	31	16

Table 3. Data of the *in situ* hatched nests found in the Archipiélago Los Roques National Park in 1999. The locations are as follows: CRN = Carenero, DMQ = Dos Mosquises, CDA = Cayo de Aqua, and ISL = Isla Larga.

Species	Clutch size	Dead hatchlings	Live hatchlings	Undeveloped	Location
<i>Eretmochelys imbricata</i>	?	0	75	0	CRN
<i>Caretta caretta</i>	?	?	33	?	DMQ
<i>Caretta caretta</i>	201	22	105	74	DMQ
<i>Caretta caretta</i>	109	81	18	10	CDA
<i>Dermochelys coriacea</i>	88	0	59	29	ISL
<i>Dermochelys coriacea</i>	76	1	0	75	DMQ

New Reports About Sea Turtles for the North Coast of Falcon State, Venezuela

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Five species of sea turtles have been reported for the Venezuelan coasts, all these present in the Falcon State, which is in the northwest of Venezuela. These species are *Chelonia mydas*, *Caretta caretta*, *Eretmochelys imbricata*, *Dermochelys coriacea* and *Lepidochelys olivacea*. During field work carried out in this part of Venezuela, we have found occasionally some skeletal parts of the body of sea turtles. By means of interviews of fishermen we have information about the commercial exploitation of these animals in this area; however it fit highlight that the fishing fleet and the commercial fishing for the sale to commercial establishments, restaurants and for the habitants of the zone for their consumption, they are some of the causes of the death of these turtles in the referring region. The studied area is very important as a zone of nesting and feeding since several of these species gets the same a favorable place for said end.

INTRODUCTION

There are eight species of sea turtles in the world today, five of which have been reported to inhabit the coasts of Venezuela, where they come to feed and spawn in the

beaches of this zone. The species found in Venezuelan waters are the green turtle, caguama turtle, carey turtle, cardón turtle, and lora turtle.

These shelled animals have been commercially exploited to the point where a large part of their population has completely disappeared, altering the biological chain. And still, very few crimping boats use devices the exclusive to turtles that could help bring their disappearance to an end (Parra, 1998).

This report is intended to present more detailed information about the actual situation of each of the species of sea turtle in specific zones in the State of Falcón. These coasts comprise a principal part of the feeding area for there are coral reefs and an abundance of *Thalassia* and hard-shelled mollusks. Also, the existence of ample sandy areas makes it a great spawning area for the various species of sea turtles (Pritchard, 1984).

METHODS

The area of study is centered around the beaches of Cabo San Roman, Puerto Escondido, Adícora, El Supí, and Tiraya. In these zones two activities were carried out: the

fisherman and inhabitants of the area were interviewed, and field trips were taken to be able to collect specimens of sea turtles and observe characteristics of the area. The interviews were based on questions about the acquisition of sea turtles in the area such as where they were captured, what was done with them, what species was most frequently encountered, and what the newest finds were. The sites were reached in automobile during the field trips, and then the shoreline and around the houses were inspected on foot. To perform measurements on the shells found in the field, metric tapes were used. Large, resistant plastic bags were used in the preservation of any evidence of sea turtles, and also for their transportation to the laboratory. Shovels and large bags were used to dig up individuals in advanced states of decomposition. Photographs were also taken of the evidence for later specie identification, beach characterization, and the observation of the uses of the various body parts of the turtles by the local population.

DISCUSSION

The study was conducted, taking into account the inhabitants and their surroundings, in the beaches of Cabo San Roman, Puerto Escondido, El Supí, Adícora, and Tiraya, located in the northeast coast of the State of Falcón, Venezuela. The materials collected included as many entire shells as pieces of them, which were found between houses, in the garbage, and lying in with dirt and rubble. Skulls and plastrons of sea turtles were also found. It is presumed that the remains found in these areas are from the consumption and exploitation of the animals by local inhabitants, and that they were then dumped to avoid their being seen by public officials, since their exploitation is now against the law.

The green or white turtle turned out to be the most abundant due to the presence of seagrass (*Thalassia testudinum*), a type of sea grass that contains high amounts of cellulose, which is a principal food source for that species (Hirth, 1997). The trapping of this turtle is very profitable due to the high quality of its meat, and as a result is very sought after by the fisherman of the area. Its shell is also used as an ornament in local homes and restaurants, and are sometimes sold to tourists for large amounts of money. Turtle oil, which is extracted from this species and others, is also very commercialized. It sells for \$7.57 (Bolivares 5.000) a liter, due to its healing properties on lung diseases (Pritchard, 1984).

The second most abundant species was the carey (or caray) turtle. This species is strongly threatened by the commercialization of its plates, from which carey, a raw material, is extracted and used in the manufacturing of commercial goods such as combs and rings (Pritchard, 1984). This species is especially abundant in the area due to the presence of large banks of coral reefs and to the wide variety of sponges, which constitute an important part of the diet of these shelled animals (Lutz *et al.*, 1996).

Little information was collected related to the caguamo, or calabazo turtle. This species is more commonly found in the southwest region of the Paraguana Peninsula in the Gulf of Coro, which is an important nesting and feeding zone due to the presence of hard shell mollusks (Pritchard, 1984). Only one shell was found, being used as a decoration in a restaurant.

In the area of Tiraya, a local inhabitant reported the presence of nests and of baby turtles during the month of August every year. No information was obtained about the looting of their nests in the area.

CONCLUSION

The presence of sea turtles in the northern coasts of the State of Falcón, Venezuela, has been confirmed, specifically in the beaches of Cabo San Roman, Puerto Escondido, Adícora, El Supí, and Tiraya, by the presence of bone remains. Of the five species of sea turtles reported to exist in the coasts of Venezuela, three were discovered in the State of Falcon. From the species *Chelonia mydas*, evidence such as shells (broken but complete), skulls, and plastrons were found. Information was also obtained about their feeding in the beaches of Tiraya and Puerto Escondido during the months of August and September. Information was gathered about the species *Eretmochelys imbricata* thanks to the data obtained in the interviews performed in the zone. Finally, of the cabezona turtle, one specimen was found being used as a decoration in a restaurant in Puerto Escondido. The fisherman of the zone commercially exploits the meat, shells, and plates of sea turtles. The oil is extracted from them for sale due to the belief that it contains properties that are healing to respiratory diseases. The shells are also used as tubs in restaurants and as decorations in tourists' areas. Several of these remains were deposited in the Department of Herpetology in the Museum of Biology of the University of Zulia (MBLUZ).

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Table 1. Data obtained during the study performed in the northern coast of the State of Falcon, Venezuela. The places are CR (Cabo San Roman, TI (Tiraya), PE (Puerto Escondido), AD (Adícora), and ES (El Supí). The collectors are HB (H. Barrios), TB (T. Barrios), TL (T. León), and RC (R. Calchi). The species are CC (*Caretta caretta*), CM (*Chelonia mydas*), and EI (*Eretmochelys imbricata*).

Date	Place	Collectors	Species	Observations
1/98	CR	HB	CM	a juvenile shell (MBLUZ)
5/16/98	TI	HB, TL	?	a small bone of shell; two bones of plastron (MBLUZ)
5/23/98	PE	HB, TL	CM	eight broken shells
5/23/98	TI	HB, TL	?	three bones of shells (MBLUZ)
2/12/00	PE	HB, TB, TL, and RC	EI	two broken shells (MBLUZ)
2/12/00	PE	HB, TB, TL, and RC	?	shell bones, coracoids and scapula (MBLUZ)
2/12/00	PE	HB, TB, TL, and RC	CM	a skull and a shell (MBLUZ)
2/12/00	PE	HB, TB, TL, and RC	?	two plastron (MBLUZ)
2/12/00	PE	HB, TB, TL, and RC	CC	a shell in a restaurant (66 cm x 59cm)
2/12/00	PE	HB, TB, TL, and RC	?	a shell and many bones (MBLUZ)
2/12/00	TI	HB, TB, TL, and RC	CM	incomplete mandible (MBLUZ)
2/12/00	AD	HB, TB, TL, and RC	EI	a complete juvenile (MBLUZ)
2/12/00	ES	HB, TB, TL, and RC	CM	a shell (116.5 cm x 115 cm)

Genetic Structure of the Foraging Green Turtle (*Chelonia mydas*) Population Around Barbados, West Indies

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Green turtles (*Chelonia mydas*) forage around Barbados, the most easterly island in the Caribbean, but are not known to nest on the island. The foraging population is composed primarily of juveniles distributed between several relatively small and isolated pockets of sea grass habitat. Adult green turtles are rarely seen in Barbadian waters, and preliminary tagging studies suggest that the immigration rate of juveniles into these habitats may be relatively high, and residency brief. Tissue samples were

obtained from 44 juveniles (35-70 cm CCL) that were either hand-caught or netted at three sites on the west, south-west and east coasts of the island between March-September 1999, in order to carry out genetic stock analysis. Analysis of haplotype frequency data, based on 487 bp sequences of the mtDNA control region (dloop), suggests that the Barbados foraging population is of mixed stock composition, consisting of cohorts from the Caribbean, South Atlantic and possibly East Atlantic.

Extraordinary Capture Rates of Juvenile Green Turtles Over a Near Shore Reef at Sebastian, Florida in the Summer of 1999

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INTRODUCTION

The summer of 1999 was the eleventh consecutive year that the Marine Turtle Research group has captured marine turtles over the Sabellariid worm rock reef in the nearshore Atlantic near Sebastian, Florida. Benign ocean conditions during the late summer months provided for longer duration of net soak than in the past. In the previous 10 year, nets were set for an average of nine days during the summer months. An average of 33 green turtles were captured per year. In the summer of 1999 we were able to net on 19 days, capturing 220 juvenile green turtles. There was a dramatic increase in the numbers of turtles captured as well as an increase in CPUE (catch per unit effort). The CPUE represents a consistent unbiased statistical method by which we can objectively measure the trends in population size.

METHODS

Netting over the reef is conducted during summer months since calm seas and relatively good visibility are required for this activity. Nets are set in the early morning hours, before the sea breezes develop and conditions deteriorate. A large mesh tangle net 220 m long by 4 m deep is suspended by bullet-shaped buoys attached to the topline (Ehrhart, 1999). Snorkellers monitor the length of the net continuously. Captured turtles are quickly untangled and brought aboard the boat. Turtles are measured, weighed and photographed; blood and lavage samples are collected by specially trained crew members. Each turtle is tagged with two external metal tags and one Passive Internal

Transponder, or PIT tag (inserted subcutaneously). All injuries, abnormalities and evidence of fibropapillomatosis (FP) are documented. Catch per Unit Effort (CPUE) is expressed in captures per kilometer-hour as described by Ehrhart (1982).

RESULTS AND DISCUSSION

Netting over the nearshore reef at Sebastian in 1999 resulted in the highest capture rates in 11 years with a CPUE of 43.8 captures per km-hour. One exceptional netting day resulted in 12 turtles captured in less than 30 minutes; a CPUE of 148.8! From 1989 to 1998, the number of green turtles captured per year over the worm rock reef ranged from eight to 63 individual animals. In contrast, 220 green turtles were captured during the summer of 1999, constituting 40.4% of the total cumulative catch for 11 year. Another highlight of this netting season was the first recorded recapture of a green turtle from the Indian River Lagoon study site, initially tagged 3.5 years ago. During the period of this study 27 of the 544 green turtles were recaptured, however, only 10 of those were considered long-term (one year or longer between captures). The overall long-term recapture percentage remains below 2%.

The first green turtle presenting FP was caught in 1997. FP, a potentially debilitating herpes-virus disease, is manifested as fibrous tumors usually present on the softer portions of the skin and on the cornea of the eyes (Herbst and Klein, 1995). The FP prevalence in the reef population for 1997, 1998 and 1999 was 21%, 8%, and 17%, respectively.

Analysis of straight-line carapace length data for the past 11 year revealed that the smallest green turtle captured was 24.7 cm and the largest was 72.3 cm (mean = 42.7 cm). Both of those were caught during the 1999 season, probably a consequence of the greatly increased number of captures.

The rise in CPUE reflects an increase in the relative density of the population. High capture and low recapture rates suggest either there is an extremely large resident population or there are large numbers of transient individuals utilizing the reef. Either explanation leads us to believe that we are only "scratching the surface" in our tagging efforts. The protection extended to marine turtles in 1978 under the Endangered Species Act (National Marine Fisheries Service, 1991) is a plausible explanation for the increased numbers of juvenile green turtles. Continued research efforts and long-term studies are necessary to assess trends in marine turtle populations.

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A Preliminary Assessment of the Population Structure of Sea Turtles in Bahía De Los Angeles, Gulf of California, Mexico

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INTRODUCTION

A considerable body of information on the nesting of sea turtles in the Eastern Pacific is available, but the biology of sea turtles at their feeding grounds in this region has been neglected. The general poor understanding of sea turtle population structure and dynamics has been highlighted on numerous occasions (Crouse *et al.*, 1987; Erhenfeld, 1995). Sea turtles need to be studied in the feeding grounds where a wider cross-section of the population is available. Population structure in these areas is an important element of sea turtle demography and life history, and knowledge about particular foraging areas can help wildlife managers develop more appropriate conservation strategies for endangered sea turtle populations. The coastal waters of the Baja California peninsula have been considered important to the life history of a number of sea turtle species (Caldwell 1962; Felger 1976; Clifton *et al.*, 1982). This

semi-enclosed sea hosts diverse assemblages of marine algae and invertebrates. Here we report on the population structure of the east Pacific green turtle (*Chelonia mydas*), the loggerhead (*Caretta caretta*), the hawksbill (*Eretmochelys imbricata*), and the Pacific ridley (*Lepidochelys olivacea*) in Bahía de los Angeles, Gulf of California, México. Methods Turtles were captured with specialized entanglement nets (100 m x 8 m, mesh size = 60 cm stretched) along near-shore margins of Bahía de los Angeles between May 1995 to October 1999. Nets were set during both day and night periods and monitored at 0.5 hours to 12 hours intervals. Entangled turtles were removed upon encounter and transferred to the Centro Regional de Investigación Pesquera Sea Turtle Research Station (CRIP-STRS) in Bahía de los Angeles. Upon capture, size measurements and other physical data were recorded. Turtles were released at site of initial capture within 24 hours. Prior to release, each turtle was tagged with two

flipper tags. Initially, we applied plastic Roto-tags (Style YL-AA-2CMB; Modern Farm, Cody, Wyoming) in the proximal tagging location of each front flipper. The use of these tags was discontinued in July of 1996 due to poor design and an apparent increased likelihood of entanglement in local fishermen's set nets (Nichols *et al.*, 1998). For the remainder of the 1996 summer field season, turtles were marked by the notching of posterior marginal scutes. Commencing in January 1997, all turtles were tagged with Inconel tags (Style 681; National Band and Tag Company, Newport, Kentucky), at flipper locations corresponding with tagging protocol at nesting beaches: *C. mydas* were tagged in the first large proximal scale of each of the rear flipper; all other species were tagged in the first large proximal scale of each front flipper. Turtles were measured for straight carapace length (SCL), tail length (TLC), and weight. SCL (± 0.1 cm) was measured from the nuchal notch to the posterior-most portion of the rear marginals using a forester's caliper. TLC (± 0.5 cm) was measured from the trailing edge of the carapace to the tip of the extended, straightened tail with a vinyl tape measure. Turtles were weighed using a 300 lb. Hanson spring balance (± 1.5 kg; Model 8930, Shubuta, Mississippi). For maturity assessment, we used mean size of nesting females at the nearest rookery to distinguish maturity status. We determined sex based on tail length (Wibbels, 1999). Turtles with elongated tails (TLC³ 20) were identified as males. Though most larger turtles with short tails are likely female, the possibility that some were late maturing males required that short-tailed, adult sized turtles were classified as unsexed. We estimated population size, survivorship, immigration, and probability of capture of *C. mydas* inhabiting the Bahía de los Angeles foraging area during warm-water periods from recapture data (Jolly, 1965).

RESULTS

We carried out sea turtle capture effort at a total of 22 different near-shore sites in Bahía de los Angeles. Net sets occurred during nine calendar months with the greatest cumulative effort in July. Netting occurred during all periods of a 24 hour cycle. A total of 8892 net-set hours yielded 195 captures of 152 individual *C. mydas*, eight captures of eight *E. imbricata*, eight captures of eight *L. olivacea*, and seven captures of seven *C. caretta*. Captures were successful from 14 sites with most turtles landed in July ($n = 46$).

Bahía de los Angeles hosts both immature and adult turtles. Among *C. mydas*, mean SCL was 75.1 cm (SE=0.79, range 46.0 to 96.6 cm) with slightly more immatures (83) than adults (69). Twenty seven adult-sized turtles exhibited tail differentiation consistent with male sex.

All recaptures were *C. mydas*, thus growth was assessed for this species only. There were 17 growth increments measured over intervals greater than six

months. No turtles were captured in more than two seasons and all turtles were assessed for growth based on two captures only. The mean growth rate was 1.97 cm year⁻¹. The 95% confidence interval about this growth mean shows that the true value is between 0 to 5.09 cm year⁻¹. There were no significant differences between the five size classes assessed for growth (ANOVA = 0.45, P = 0.77).

We performed Jolly-Seber analysis of the annual capture-recapture data for green turtles only. Averaged over three separate estimates, there was a mean warm-water population of 229 *C. mydas* in Bahía de los Angeles (mean SE=36). A 95% confidence interval about the mean for this value suggests that the true population size is between 75 and 382 turtles. The mean survivorship of these turtles was 0.52 (mean SE=0.21) and the mean annual recruitment was 88 turtles (mean SE = 13) or approximately 38% of the estimated population. The estimated population of 229 turtles at Bahía de los Angeles was equivalent to a density of 5.08 turtles km⁻². By multiplying the average weight of turtles over the course of this study, we estimated that the standing crop of this turtle in Bahía de los Angeles is roughly 14,381.2 kg in 4500 hectares, or 3.2 kg ha⁻¹.

DISCUSSION

Sea turtles were once very common in Bahía de los Angeles (Caldwell, 1962; 1963) and by the early 1900s, and the abundant populations apparently supported this fishery for decades as Carr (1962). Speaking of the Bahía de los Angeles harvest Caldwell (1963) wrote 'I saw over 500 landed in a three week summer period in 1962 at Los Angeles Bay alone, and a comparable number, considering fishing effort, per week in winter. In total 186.47 tons of sea turtles were landed that year from Bahía de los Angeles (Márquez, 1984). All turtles were *C. mydas* or *C. caretta*. By the early 1980s, Gulf sea turtle populations had crashed (Márquez, 1984; Clifton *et al.*, 1995). As a result, the sea turtle fishing cooperative of Bahía de los Angeles disbanded in 1982 (Seminoff, Unpublished data.). Although not quantified, legal fishing continued at low levels in this region during the years following the organized commercial harvest. Anecdotal information from local fishermen suggests that by the 1990 Mexican ban on sea turtle fishing (Anonymous, 1990), the population in Bahía de los Angeles was totally depleted. Current evidence reveals that the local population has increased at least slightly since the introduction of protective legislation by the Mexican Government.

Capture data indicate that this region continues to be important for *C. mydas*, and to a much lesser extent *C. caretta*, *E. imbricata*, and *L. olivacea*. Information derived from mark-recapture study and flipper tag returns show that the Bahía de los Angeles foraging population of *C. mydas* appears to be comprised of both resident turtles and transients, however, it remains unclear how many of the adult-sized turtles captured during this study were resident

and what proportion were transients from other feeding habitats en route to and from distant breeding grounds. While *C. mydas*, *C. caretta*, and *E. imbricata* appear to inhabit the study site during both summer and winter periods, current evidence shows that *L. olivacea* visits this feeding habitat during summer months only.

An accurate assessment of sea turtle population structure and a thorough understanding of the negative impacts to these populations are vital to the implementation of appropriate conservation strategies. To do so will require additional studies in both nearshore and offshore feeding areas throughout the range of these endangered species.

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Surveillance of Sea Turtles by Direct Observations in the Central Coast of Venezuela

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In Venezuela sea turtles have been traditionally surveyed by non-direct observing methods. Therefore, it has not been possible to observe and register their activities in the natural environment. The aim of this work was to establish the population structure, distribution and nesting places of sea turtles that wander along the Venezuelan coasts, and also to get acquainted with the nourishing habits by direct observation in the sea. From September 1999 to February 2000, six beaches between San Francisquito and Petaquire, were surveyed. In each of these places the

species of turtles, as well as their activities were registered. Then the turtles were followed by snorkeling and scuba diving techniques. The presence of four out five species of sea turtle were determined (*Chelonia mydas*, *Eretmochelys imbricata*, *Caretta caretta* and *Dermochelys coriacea*). Of these, *E. imbricata* was the most frequently observed (60-70%). *D. coriacea* was observed swimming parallel to the coast probably establishing migratory routes to nesting places in the eastern part of the country. Regarding the alimentary behavior, *E. imbricata* was seen eating sponges

and *C. mydas*, the seagrass *Thalassia testudinum*. The results obtained from this work will be included in the "Sea Turtle Recovery Actions Plan Of Venezuela", for they provide a new and more direct source of information. This study sets the beginning of a new research team effort toward the sea turtles in Venezuela.

METHODS

The methods used to identify sea turtles were basically followed by snorkeling and scuba diving techniques. The population size was determined by means between the number of turtles and the number of observation hours in the water. Six beaches and small bays were surveyed between September 1999 and February 2000.

RESULTS AND DISCUSSION

The six places surveyed assign difference in distribution and density of species. On the map we can observe how the species with the main distribution in the area surveyed was the carey turtle (*Eretmochelys imbricata*), demonstrating difference with the other turtles of the same species. San Francisquito, Caracolito and Pto. Francés (westside), they look like the most important places. This is probably because the presence of the coral reef and other kind of resources.

The green turtle (*Chelonia mydas*) also present a great distribution area. Pta. Tagua (westside of the central coast), present the higher density of these turtles. We can assume this behavior because of the presence of a wide seagrass bed *Thalassia testudinum* (100 m² approximately). Some of them had been seen eating and others just resting. In this place the green turtles appear in the water more frequently on account of diving hours, than other places.

On the other hand, the caguama turtle (*Caretta caretta*), is the less frequent than the other species. The places where they had been highly seen were Qda Seca and Osma. The presence of this turtles were observed mainly swimming, none of them were eating.

The cardón turtle (*Dermochelys coriacea*), it was sight at the distance swimming about four of five miles parallel from the coast. Because of the direction that the turtles has been seen and considering that most important nest places for the species are in the eastside of the country, it is possible to think that this movements belong migratory routes. However, it is necessary to begin studies where we can introduce in a direct way the genetic populations with the object to elucidate this kind of behavior.

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Spatial and Temporal Distribution of Leatherback Turtles Observed off the Coast of Georgia (USA), 1999

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INTRODUCTION

Historically, leatherback turtles (*Dermochelys coriacea*) have occurred at higher than normal abundances in the coastal waters of Georgia during the spring [March-May; Georgia Department of Natural Resources (GADNR), Unpublished data]. Several commercial fisheries, including shrimp and shark drift gill-net fisheries, are active during these periodic episodes of high abundance. In order to assess incidental capture and mortality associated with commercial fisheries, the GADNR conducts weekly aerial

surveys during April and May. The goal of these surveys is to determine densities of migrating leatherback turtles in Georgia's coastal waters (10 nm seaward of the COLREG lines) and to provide information to the National Marine Fisheries Service (NMFS) on leatherback abundance. According to the Leatherback Contingency Plan (LCP; 50 CFR part 217, vol. 60 no. 92, May, 12, 1995), leatherback turtle sightings exceeding 10 animals per 50 nm of trackline may result in gear restrictions and area closures for commercial fisheries.

METHODS

We flew weekly aerial surveys from 1 April through 31 May 1999. Aerial surveys consisted of 14 transects from the beach to 10 nm offshore on east-west latitude lines. We flew at an altitude of 229 m (750 ft) and a ground speed of 100 knots. For each turtle sighted, we recorded the following: 1) location, 2) angle of inclination, 3) species, 4) side of the plane the animal was located, 5) glare (0-none to 3-severe), and 6) the animals position in the water column (on surface, below surface). Observers used a Digital Protractor (Kell-Strom Pro360, Kell-Strom Tool Co., Wethersfield, Connecticut) with a 30 mm Red-Dot Rifle Scope (BSA Optics, Ft. Lauderdale, Florida) mounted to the long axis of the protractor to determine the angle of inclination from the plane to the sighted animal. We used the altitude of the plane and angle of inclination to calculate the perpendicular distance of each turtle from the transect line.

We used strip transect methodology to analyze our data. A histogram was constructed including all perpendicular sighting distances of leatherbacks observed during our surveys. We used the histogram to estimate the strip width in which the probability of sighting a leatherback was not reduced by nearness or distance from the plane (0.25-0.50 km). Observations within this strip were used to calculate estimates of density. We excluded transects from our analysis when surface winds exceeded Beaufort 4 (11-16 knots) or glare exceeded a 2 (moderate).

In addition to conducting aerial surveys, we coordinated efforts to monitor Georgia's beaches for stranded leatherbacks. Following the offshore survey, we conducted low-altitude surveys of all barrier island beaches. In addition, beaches were surveyed approximately once a week by Sea Turtle Stranding and Salvage Network (STSSN) volunteers.

RESULTS AND DISCUSSION

We located a total of 25 leatherbacks during 10 aerial surveys conducted in April and May 1999 (Table 1). Five of the 25 leatherbacks were located while traveling between transect lines (north-south). Surface densities of leatherbacks varied from 0 in early April to 15.7 leatherbacks/100 km² in early May. Leatherback sightings were relatively evenly distributed throughout the study area with the exception of the southern most four transect lines. Twenty-three of 25 leatherbacks observed were on the surface (92%).

According to the LCP, NMFS must close an area to fishing for two weeks if leatherback turtle sightings exceed 10 animals per 50 nautical miles of transect line on two consecutive flights. Although we observed 14 leatherbacks including 10 animals within a 50 nm length of transect line on our 3 May survey, we were unable to confirm the high leatherback abundances on a follow-up survey on 4 May

(Table 1). Concurrent surveys conducted by South Carolina Department of Natural Resources indicated consistently high concentrations of leatherbacks in the southern part of South Carolina. As a result, NMFS announced the area closure effective 11:59 p.m. 7 May 1999 through 21 May 1999 for latitude 32, an area which includes a small portion of Georgia's territorial waters. We discontinued surveys after the May 28 when no leatherbacks were sighted.

From 8 May to 21 May, GADNR and STSSN volunteers located seven leatherback strandings on Georgia's beaches. Necropsies performed on three of the stranded animals indicated the animals were generally healthy and had been actively foraging prior to death. The results of these necropsies were consistent with those of turtles incidentally captured and drowned by commercial fisheries.

Data collected in the spring of 1999 suggests modifications to the LCP are necessary to adequately protect migrating leatherbacks in Georgia's coastal waters. Densities of leatherbacks observed during aerial surveys in early May (15.7 leatherbacks/100 km²) resulted in seven documented strandings. According to Epperly *et al.* 1996, 7-13% of the sea turtle mortality associated with the summer flounder fishery in North Carolina is stranded. Leatherback strandings observed on the Georgia coast in 1999 may represent more than 70 at-sea mortalities. Necropsies conducted by GADNR indicated mortalities were associated with commercial fishing activity. Given the concern over declining leatherback populations worldwide, the LCP density trigger (over 10 animals/50 nm trackline) should be reduced to provide additional protection for migrating leatherbacks in Georgia's coastal waters.

Other problems with the LCP encountered during the 1999 season were related to the inefficiency of our aerial survey technique. A comparison of leatherback densities from our 3 and 4 May surveys suggests that survey results can be highly variable. Estimated leatherback density on 4 May was less than half the estimate from 3 May. Based on documented movement rates of leatherbacks, it is unlikely that over half the turtles moved out of the survey area in a 24-hour period. Because of this potential variability in aerial survey density estimates, the LCP requirement to confirm high leatherback densities on a second survey before implementation of fishery restrictions should be eliminated.

During our surveys, a large proportion of leatherbacks observed in strip transects were on the surface (92%). By contrast, over 50% of the leatherbacks observed in 1999 during surveys in South Carolina were observed below the surface (T. Murphy, personal communications). During most surveys conducted in Georgia, turbid water (<1 m visibility) extended out to the end (10 nm) of approximately 50% of the transect lines. Under low visibility conditions, it is unlikely that observers detect leatherbacks swimming just under the surface. It is possible that estimates obtained from aerial surveys in Georgia are negatively biased as a

result of poor visibility. Additional data on water clarity and turtle location in the water column should be collected during future surveys to assess the extent of this potential bias on density estimates. Further refinement of LCP may be necessary to reduce Georgia's density trigger (over 10 animals/50 nm trackline) relative to other southeastern states.

CONCLUSIONS

1. As a result of high leatherback mortality rates associated with commercial fisheries in Georgia, the LCP density trigger of over 10 leatherbacks/50 nm trackline should be reduced.

2. Because of this potential variability in aerial survey density estimates, the LCP requirement to confirm high leatherback densities on a second survey prior to implementation of fishery restrictions should be eliminated.

3. Additional data on water clarity and turtle location in the water column should be collected to assess the extent to which of these variables bias leatherback density estimates.

ACKNOWLEDGMENTS

Robin Fortuna and Jan Mackinnon served as observers. Aircraft support was provided by GADNR pilots Barry Vaughn and Steven Turner. Mike Frick and Nathan Schwalen assisted with necropsies.

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Table 1. Surface density estimates of leatherback turtles (*Dermochelys coriacea*) from aerial surveys conducted off the coast of Georgia, 1999.

Survey date	Total leatherbacks observed	Leatherbacks sighted within strip transect	Total area sampled (km ²)	Density (leatherbacks/100 km ²)
8-Apr-99	0	0	65	0.00
2-Apr-99	1	1	25	4.00
9-Apr-99	1	1	70	1.43
7-Apr-99	0	0	35	0.00
03-May-99	14	11	70	15.71
04-May-99	5	2	70	2.86
11-May-99	1	1	55	1.82
13-May-99	1	1	70	1.43
18-May-99	2	2	45	4.44
24-May-99	0	0	55	0.00
Total	25	19	560	

Initial Assessment of Sea Turtles in the Southern Indian River Lagoon System, Ft. Pierce, Florida

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INTRODUCTION

The Indian River Lagoon System (IRLS), located on the east central coast of Florida between Ponce De Leon Inlet and Jupiter Inlet, provides developmental habitat for immature loggerhead (*Caretta caretta*) and green sea turtles (*Chelonia mydas*) (Ehrhart *et al.*, 1996). Studies of these marine turtles have been conducted in the northern region (Ehrhart and Yoder, 1976; Ehrhart and Yoder, 1978; Mendonca and Ehrhart, 1982; Ehrhart, 1983; Ehrhart, 1984; Witherington and Ehrhart, 1989; Schroeder *et al.*, 1990; Provancha *et al.*, 1998) and central region of the IRLS (Ehrhart, 1985; Ehrhart and Witherington, 1986; Luepschen and Ehrhart, 1987; Ehrhart and Redfoot, 1992; Redfoot *et al.*, 1992; Ehrhart *et al.*, 1996, Ehrhart *et al.*, 1999), but no study has ever focused on the southern region of the lagoon.

In an attempt to characterize marine turtles utilizing the southern IRLS an open water net capture program was developed and initiated in September 1998. This study intended to address fundamental questions concerning relative abundance, population dynamics, fibropapillomatosis (FP) rates and movements of marine turtles associated with the southern region of the lagoon.

Data collected between September 1998 and January 2000 are presented here and provide a preliminary profile of the marine turtles utilizing this previously unstudied region of the IRLS.

METHODS

The sampling effort in this study has been limited to a single site in the southern IRLS, although future sampling will include additional sites. The study site is east of the Intracoastal Waterway approximately 2 km south of the Ft. Pierce Inlet between 27°25.5' and 27°26'N, in an area known as Jennings's Cove. The water depth in this cove is typically between 1.0 and 2.5 m with the exception of a deep dredge hole 150 m west of the east shoreline. The depth in this section ranges between 6.0 and 7.5 m and extends approximately 500 m north to south and 250 m east to west. Netting effort is focused primarily in this area of Jennings's Cove.

Turtles were captured by deploying a large mesh tangle net from a 14' Jon boat. The net measures 100 m long by 5 m deep and consists of 40 cm stretch (knot to knot) multi-

filament mesh. The mesh is suspended from a foam core braided polyethylene top line with large fixed bullet buoys spaced 2.5 m apart. The bottom line consists of a small diameter lead core line.

Once the net was fully deployed it was carefully monitored and the lead line was pulled hand over hand every 40 minutes. When turtles encountered the net and became entangled, they were quickly removed from the net and Inconel #681 tags, supplied by NMFS, were applied to the trailing edge of both front flippers. Morphometric data were recorded and photographs were taken dorsally and ventrally, after which the turtle was released near the area of capture. All straight-line measurements were taken with forestry calipers and curved measurements were taken with a flexible tape. Beginning in November of 1999, PIT tags were also applied to the right front flipper.

To determine the relative abundance of marine turtles at this study site the catch per unit effort (CPUE) was standardized using the formula found in Ehrhart et al. (1996). In this formula effort is expressed in net km hours (one km of net fished for one hour) and the CPUE was calculated using the formula $C/(LT)$. Where C = the number of turtles captured, L = the length of net fished (in km), and T = the amount of time the net was fished.

RESULTS

Between September 1998 and January 2000 a total of 73 green turtles and 10 loggerhead turtles were captured at the Jennings's Cove study site. Nets were set at this site on 29 different days for a total of 174.4 hours. Total netting effort expressed in kilometer net hours was 17.44. Overall CPUE was calculated at 4.76 turtles per km/net hour.

Straight standard carapace lengths (SCL) for 71 of the 73 green turtles captured ranged from 36.4-74.8 cm with a mean of 54.8 cm (± 9.9 SD). (Fig. 1). The overall CPUE for green turtles was 4.19 turtles per km/net hour. Seasonal CPUEs were calculated for winter, spring, summer and fall and showed highest green turtle abundance in the spring (Fig. 2).

An overall fibropapillomatosis (FP) rate of 63.0% was found in green turtles captured at this study site. Of the 73 green turtles captured, 46 displayed visible tumors. A seasonal breakdown of FP rates among green turtles is presented in Figure 3. Rates between seasons ranged from a low of 52.6% in the winter to a high of 77.3% during the spring.

CPUE for loggerheads (0.57 per km/net hour) was considerably lower than that recorded for green turtles. Interestingly, six of the 10 loggerheads captured had curved carapace lengths (CCL) greater than 86.0 cm. These large loggerheads were too heavy to safely pull into the boat for accurate SCL measurements, but reliable CCLs were obtained with the turtle in the water. CCLs were taken for nine of the loggerheads captured and ranged from 61.3-102.0 cm with a mean of 82.6 cm (± 13.1 SD). Due to the

lack of sufficient loggerhead data seasonal variations were not addressed in this report.

DISCUSSION

Results of this study show some marked contrasts with data collected on marine turtle populations in the more northerly portions of the IRLS. The SCL mean of 54.8 cm for green turtles found at the Jennings's Cove site is over 10 cm greater than that found in the IRLS near Sebastian Inlet (43.6 cm, Ehrhart *et al.*, 1999) and green turtles found in the nearshore environment of Florida's Atlantic Coast (39.6 cm, Bresette *et al.*, 1998; 43.9 cm, Ehrhart *et al.*, 1999, 43.5 cm CCL, Wershoven and Wershoven, 1990). Schroeder *et al.* (1990) documented green turtles of a similar size (52.3 cm) in the Mosquito Lagoon during a cold stunning event in December of 1989 but noted that green turtles collected in two previous cold stunning events were significantly smaller, and results from cold stunning samples may not be directly comparable to netting studies. Additional sites in the Southern IRLS need to be sampled before significance of the size differences can be evaluated.

Rates of FP found here are comparable to other IRLS sites. While the FP rate among green turtles at the Jennings's cove site was 63%, the FP rate in the adjacent marine habitat sampled by the St. Lucie Power Plant Program was less than 4%. This is consistent with the results of Ehrhart *et al.* (1999), which found much lower rates of FP in marine habitats versus estuarine habitats. Results of this study confirm that, whatever the underlying cause, in the east-central region of Florida, FP is clearly associated with the IRLS.

Tag returns of turtles captured in this study and by other researchers in the area would provide crucial information on the movement of turtles within the IRLS as well as between the IRLS and the nearby marine habitats. Extensive capture and tagging programs to the north and to the south of our study site provide a good opportunity for obtaining tag returns to elucidate movement patterns.

To appropriately characterize the marine turtles associated with the southern IRLS, data from a variety of sites between the Ft. Pierce and St. Lucie inlets will be needed. In addition, a more in depth study is needed to determine what factors within the IRLS contribute to the proliferation of FP.

ACKNOWLEDGMENTS

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Fig. 1. Size class distribution of green turtles (*Chelonia mydas*) captured in the southern Indian River Lagoon System from September 1998 to January 2000.

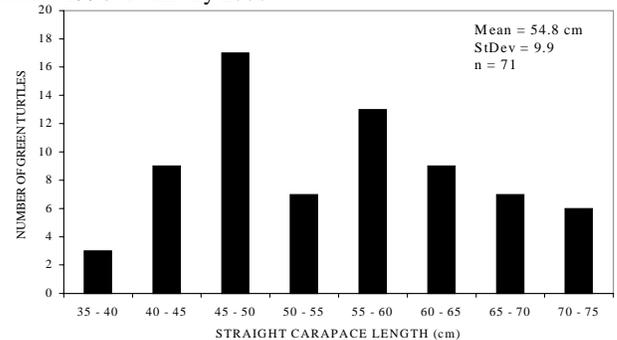


Fig. 2. The catch per unit effort by season of green turtles (*Chelonia mydas*) in the southern Indian River System, September 1998 to January 2000.

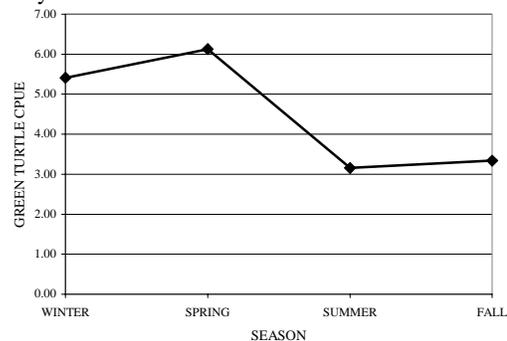
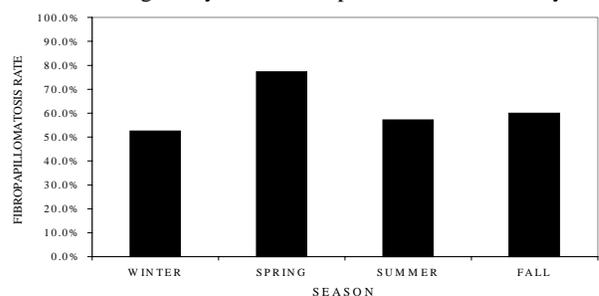


Fig. 3. The percent occurrence of fibropapillomatosis by season among green turtles (*Chelonia mydas*) captured in the southern Indian River Lagoon System from September 1998 to January 2000.



Forage Area Identified for Green Turtles in Northern Chile

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INTRODUCTION

East Pacific green turtles are widely distributed in the coastal waters of Mexico and Central America, where the main breeding aggregations occur in Michoacan, Mexico, and where animals forage around coasts of Baja California and throughout Central America. Although stranded animals have been reported as far north as Prince William Sound, Alaska, and as far south as Isla Desolacion (53°S), Chile, the northernmost forage aggregations occur in San Diego Bay, California, and the southernmost reports of forage aggregations are from around the Galapagos Archipelago, and off the coast of Peru (National Marine Fisheries Service, and U.S. Fish and Wildlife Service, 1998). Recent sightings of a group of green turtles in the vicinity of the thermal effluent of an electric power generating station located on the coast in the north of Chile prompted this study, which began in February, 1999, to assess the number, size and stock origin of this group of animals.

RESULTS

A 300 m beach seine was used to capture turtles seen in the vicinity of the power plant at Mejillones (23°S, 70° 28'W). Capture effort was confined to three days; on February 9th, and September 9-10, 1999. A total of 27 different animals were tagged, measured, sampled and released. Sizes ranged from 46.0-83.5 cm curved carapace length (CCL), and included adult males and juveniles/females (Fig. 1). Preliminary genetic analysis of tissue biopsies from eight of the animals suggests they originate from the Galapagos Islands, since all had the same mitochondrial DNA (mtDNA) haplotype matching that of the single mtDNA haplotype identified to date from females nesting in the Galapagos Islands (Dutton, unpublished data). All appeared healthy and active. Visual surveys from shore produced numerous sightings around the Bahia de Mejillones along a stretch of coastline extending approximately 100 km southward. In addition, sea turtles (presumed/unconfirmed to be green turtles) were sighted around Isla Santa Maria, approximately 70 km offshore.

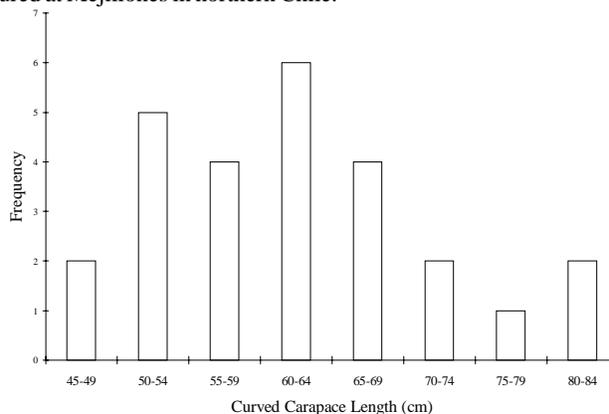
SUMMARY

The relatively high catch per area and unit effort over the three days of capture operations, combined with the extent of sightings during this period suggests that the 27 turtles are only a small portion of the population foraging in this area. Although the turtles most likely are attracted by the power plant's warm water effluent, the presence of turtles around the offshore island and along the coast, suggests that this area may support a significant forage aggregation of green turtles. More extensive monitoring at this study site is planned for the future.

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Fig. 1. Length (CCL)-frequency distribution of green turtles captured at Mejillones in northern Chile.



Evaluation of the Bay Systems of Alabama (US) as Potential Foraging Habitat for Juvenile Sea Turtles

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INTRODUCTION

Estuarine ecosystems represent a vital habitat for sea turtles in the northern Gulf of Mexico (Hildebrand, 1982; Ogren, 1989). These estuaries are of particular importance to the survival of turtles such as the endangered Kemp's ridley, since they serve as developmental habitat for juveniles (Ogren, 1989; Musik and Limpus, 1990). In fact, estuaries may be optimal foraging grounds for juvenile turtles, since the location of turtles can often be correlated with certain crabs species which are abundant in estuaries (Ogren, 1989). Further, the severely endangered Kemp's ridley primarily occurs in the Gulf of Mexico; thus the estuaries of the northern Gulf may be a critical asset for its survival.

Although the coast of Alabama represents one of the major estuarine systems in the northern Gulf of Mexico (Hoskings *et al.*, 1990), the abundance of juvenile sea turtles in this ecosystem has never been adequately examined. It is clear that numerous juvenile turtles have been captured in trawls in this area (Carr, 1980; Ogren, 1989), but this is based on anecdotal observations in the past. Additionally, stranding data clearly indicate that sea turtles such as Kemp's ridleys and loggerheads inhabit the near shore waters and bay systems of Alabama, but such data does not identify specific foraging areas within these waters.

In the current study we have begun a systematic survey of the Alabama bay systems in an effort to identify potential foraging grounds for juvenile sea turtles. Information of this sort is a prerequisite for designing an optimal management strategy for Alabama estuaries that would protect sea turtles and prevent possible conflicts with fisheries and coastal development (Magnuson *et al.*, 1990).

METHODS

During 1999 we have implemented a tangle net methodology for capturing sea turtles that is similar to that routinely used by sea turtle projects in Florida and Texas (Ehrhart, 1983; Goodman *et al.*, 1996; Schmid, 1998). The tangle net is a relatively long (223 m), shallow depth (3 m), wide mesh (25 cm) net. It is anchored on both ends and supported by floats along the top line of the net. The net is set in potential foraging areas and is checked at regular intervals of approximately 30 minutes. All turtles (as well as other marine life such as sharks and stingrays) are

immediately removed from the net. Turtles will be weighed, measured, and tagged with Inconel sea turtle flipper tags. We intend to use a subset of turtles for a radio tracking study. Additionally, diet data will be collected (e.g. fecal samples and gastric lavage). Blood samples will also be drawn from turtles soon after capture in order to predict sex based on serum testosterone levels. We anticipate releasing turtles approximately 20 minutes after capture. During the next one to two years we will continue sampling a wide variety of areas in the bay systems of Alabama, including areas near Dauphin Island, Bon Secour Bay, Perdido Bay, throughout Mobile Bay, and in the Mississippi Sound north of Dauphin Island.

RESULTS AND DISCUSSION

We began the netting project during June of 1999 and continued through the fall until the temperature of the bay water dropped to less than 20°C. During the summer and fall of 1999, our sampling focused on a large number of locations in waters spanning the length of Dauphin Island and including the waters adjacent to the channels at both the east and west ends of Dauphin Island. This included 20 days of sampling at 20 different locations. Although some locations were rich in megafauna, such as sharks and stingrays, no sea turtles were captured, thus suggesting a low abundance of sea turtles in those areas. However, anecdotal stranding and sighting data suggest that some of the locations might occasionally be frequented by sea turtles. For example, we found the remains of one stranded juvenile turtle near one of the sampling locations in the bay near the west end of Dauphin Island. Additionally, there were multiple sightings of a grey sea turtle (a probable Kemp's ridley) in a boat basin near another one of our sampling locations.

In 1999, we also developed and tested radio tracking equipment, so we are confident that we will be able to effectively track turtles after their capture and release. In addition to tracking turtles captured in our netting operation, we are currently collaborating with the Sea Turtle Stranding and Salvage Network in order to track any rehabilitated juvenile turtles that have been previously captured or stranded in the Alabama bay system.

We are continuing our sampling of the bay systems of Alabama over the next one to two years. A survey of this sort represents a unique opportunity to effectively evaluate the abundance and distribution of sea turtles within the Alabama

bay systems. The information gained from this study (whether positive or negative) is critical to the development of prudent management strategy for protecting sea turtles while sustaining the productivity of the fisheries.

ACKNOWLEDGMENTS

This research is made possible through funding from the Alabama Center for Estuarine Studies (ACES). This project represents a collaboration between researchers from several institutions including the University of South Alabama, the University of Alabama at Birmingham, and the Dauphin Island Sea Lab.

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Investigation of Immature Sea Turtles in the Coastal Waters of Southwest Florida

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INTRODUCTION

Information concerning the distribution and abundance of sea turtles in coastal southwest Florida is limited to observations from nesting surveys and strandings. Consequently, the current status of immature sea turtles in southwest Florida is unknown, particularly the highly endangered Kemp's ridley turtle. The purpose of this project is to determine the relative abundance, temporal and spatial distributions, movements, growth, and habitat requirements of immature sea turtles in the nearshore waters of southwest Florida. Our research efforts focus on the highly endangered Kemp's ridley turtle, but other turtle species are also collected during routine sampling operations.

METHODS

The study area is located on the southwest coast of

Florida in the Ten Thousand Islands, Gullivan Bay, between Cape Romano and Gomez Point. The main sampling sites within this area are located at Whitehorse Key, Gullivan Key, Long Rock, and Sugar Bay. The area is characterized by numerous small mangrove islands and relatively shallow water with sandbars, mud banks, and oyster reefs.

Mark-recapture techniques were used to determine the distribution, relative abundance, seasonal occurrence, movements, and size composition of immature turtles in southwest Florida. In-water sampling was conducted monthly. The turtles were observed breathing at the surface by survey personnel from a stationary commercial netboat, and a strike net was quickly deployed around the turtles. The captured turtles were then measured, weighed, fitted with two inconel flipper tags, and photographed prior to release. Internal Passive Integrated Transponder (PIT) tags were also applied to all captured Kemp's ridley turtles. Several Kemp's ridley turtles were held 24-48 hours to collect fecal samples for prey species identification. Tissue samples were taken from green and loggerhead

turtles for mtDNA analysis to determine nesting beach origins. The number, sizes, and locations of any fibropapillomas on the green turtles were noted as well as photographed.

Environmental data (water temperature, salinity, dissolved oxygen) and bottom type were also collected at the sampling sites. Benthic invertebrates entangled in the net from the turtle capture sites were photographed and samples were collected for identification. The by-catch from the netting activities was also recorded. Weather observations were recorded daily as well as sightings of large loggerhead turtles and marine mammals (dolphins and manatees).

PRELIMINARY RESULTS

Preliminary results indicate that significant numbers of immature Kemp's ridley, loggerhead, and green turtles utilize Gullivan Bay. Additionally, numerous adult loggerhead turtles have been observed in the area, with nesting occurring on nearby Cape Romano and various isolated beaches of the Ten Thousand Islands. Spatial distribution of turtle captures suggests habitat partitioning by species. Green turtles were usually captured near sea grass habitats, while Kemp's ridley and loggerhead turtles were usually captured on or near live bottom habitats characterized by sponges, gorgonians, bryozoans, and tunicates. The mean size of the immature Kemp's ridley turtles sampled ($n = 63$) was 40.9 cm SSCL.

Tagging results indicate that recaptures of Kemp's ridley turtles occur within and between sampling seasons, indicating foraging site fidelity. It is interesting to note that the single hawksbill turtle has been recaptured three times

within a year, all within the same area. Also, an immature tagged loggerhead turtle with an amputated foreflipper was captured in a mangrove channel. This was a rehabilitated stranded turtle that was released two years prior at Key West, Florida and appeared healthy and active.

A cursory examination of Kemp's ridley feces indicates they are feeding primarily on tunicates and crustaceans (spider crabs and horseshoe crabs). Interestingly, tunicates have not been reported from previous Kemp's ridley feeding studies. By-catch species predominantly consisted of southern sting rays, cownose rays, and spotted eagle rays.

FUTURE RESEARCH

The survey for immature sea turtles will continue in Gullivan Bay. Supplementary research activities will eventually include: collecting blood for sex determination, monitoring local movements via radio and sonic telemetry, and developing a GIS model for analyzing turtle habitat associations. A low-light underwater video camera will be used to map benthic habitats at capture sites. Proposed satellite telemetry would enable us to monitor longer-term seasonal movements of Kemp's ridley turtles as they move along the southwest Florida coast.

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The Epibionts of Hawksbill Sea Turtles (*Eretmochelys imbricata*): Mona Island, Puerto Rico

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INTRODUCTION

Sea turtles provide suitable substrate for diverse assemblages of epibiotic organisms. The composition of this assemblage will be dependent on the turtle's environment, and if the ranges of the epibiotic organisms and their host overlap. Therefore epibionts may provide clues as to the range, habitat, biology and behavior of the chelonian hosts. The purpose of this investigation is to describe the epibiotic assemblage of hawksbill turtles (*Eretmochelys imbricata*) of Mona and Monito Islands, Puerto Rico. Characteristics unique to *E. imbricata* promote the settlement of a variety of larvae. Previous studies have sampled either stranded turtles or nesting *Caretta caretta* and *Chelonia mydas* (Caine, 1986; Frazier *et al.*, 1991; Frick *et al.*, 1998; Sentías *et al.*, 1999), yet the information on epibiotic assemblages of live non-nesting turtles is scarce. The percent occurrence (%O) of the epibiotic assemblage on turtles of a known locality and different size (age) classes, may provide a better understanding of this host-epibiont relationship.

METHODS

Mona Island is located 40 nm east of the Dominican Republic, and 42 nm west of Puerto Rico (18°05'N, 67°56'W). Mona is surrounded by coral reefs at depths of 4-20 m, on most of the southern coast, and cliff walls to 20-30 m depths around the rest of the island. The smaller island, Monito, located northwest of Mona, is surrounded completely by cliff walls reaching 25-34 m depths. The reef habitat is mostly composed of patch and barrier reefs with hard and soft corals, on an irregularly sloping insular shelf. Wall habitats are composed of vertical cliffs covered by encrusting forms of sponges, algae, and soft corals.

Data on *E. imbricata* epibionts was collected during July and August 1999, from turtles captured by C. Diez and R. van Dam for long-term ecological studies carried out since 1992 (Diez and van Dam, 1998). Turtles were hand captured free diving or with the aid of SCUBA, and their location was recorded by GPS. In the boat, turtles were identified, measured with a vernier caliper [straight carapace length (SCL) and width], weighed to the nearest 0.1 kg with a Pezola spring scale, photographed, and epibiont locations were noted. Epibionts were removed from areas where visible to the unaided eye. Samples

originating from different locations on the turtle were stored separately. After separating algae from animal epibionts with a dissecting microscope, they were preserved in 10% formalin and 70% alcohol, respectively. Samples were identified to the lowest possible taxon for animals, and algae were classified in functional groups (crustose, turf, macro-algae, and erect calcareous forms). Percent occurrence (%O) for each epibiont taxon was calculated overall, for each habitat (reef and wall), and for 13 different size classes. Size classes were determined by SCL (Table 1).

RESULTS AND DISCUSSION

Epibionts were sampled from 105 turtles ranging in size from 20.4 cm to 85.1 cm SCL.

Sixty-seven turtles were captured in cliff wall habitats and 38 in coral reef habitats.

Organisms collected were classified into groups including 13 phyla for the animals, and 4 functional groups for the algae. For groups considered common (%O > 20), higher taxonomic divisions and the position occupied on the turtle are given below.

Algae

The greatest percent occurrence (94%O) was for the filamentous algae or turf composed of green (*Chlorophyta*) and red algae (*Rhodophyta*). Turf algae was found overgrowing exposed areas including the carapace, plastron, head, flippers and skin. Turf growing on the plastron and posterior ventral regions was mostly red algae. Thin turf covered all marginal scutes, yet was denser towards the posterior marginals and under the vertebral and costal scutes overlapping other scutes. Filamentous algal (turf) carpets may act as filters for suspended particles (larvae, sand grains). Crustose calcareous algae (82%O) of the Kingdom Rhodophyta class Corallinaceae, encrusted the carapace and the plastron. Erect coralline algae (56%O), family Corallinales, could be found under the overlapping scutes. Leafy forms of brown and green algae (23%O) occupied the posterior carapace, and under scutes.

Animals

Polychaetes (84%O) were the most common group in terms of percent occurrence, including the families Serpulidae, Nereidae, Syllidae, and Eunicidae. Sessile

calcareous tubeworms (Family Serpulidae) attached directly to the scutes on the posterior one-third of the carapace.

Barnacles (76%O), order Cirripedia (Arthropoda: Crustacea: Malacostraca) included *Platylepas decorata*, a small (6 mm) barnacle found mostly on the skin, and marginal scutes of turtles of all size classes. Gooseneck barnacles, *Lepas anatifera*, were only observed on the posterior marginal scutes of class one and two turtles. Larger *Chelonibia caretta* were only observed on adults (class 12 and 13), on the anterior two-thirds of the carapace. These produced hard, heavy encrustations on females larger than 60 cm SCL, and males larger than 75 cm SCL.

Bryozoans (53%O) of encrusting and erect forms were found attached to the carapace scutes and under overlapping scutes.

Copepods (48%O) of the order Harpacticoida (Arthropoda: Crustacea) were present in the turf algae collected from all turtle surfaces.

Foraminiferans (Superclass Sarcodina, class Rhizopoda) occurred on more than twice the percentage of reef habitat (63%O) than wall habitat (25%O) turtles, within the turf and sand collected.

Sponges (34%O) of at least 6 different forms were identified on the basis of texture and color. These poriferans were commonly located within the cavity formed under the posterior scute of the carapace. The turtles of wall habitat (43%O) had sponges more frequently than on reef habitat (18%O).

Nematodes (21%O) associated with algae growing under carapace scutes appear to be non-parasitic forms. The percent occurrence was almost four times greater in reef habitat (39%O) compared to wall habitat (10%O).

Molluscs (21%O) included gastropods, bivalves, opisthobranchs, and a limpet.

The rest of the epibiotic groups identified were not considered common and they are listed in order of percent occurrence: sipunculids (19%O), amphipods (18%O), dipterans (15%O), tunicates (14%O), tanaids (reef only, 10%O), isopods (7%O), hydrozoans (7%O), ostracods (6%O), decapods (6%O), cnidarians (5%O), echinoderms (4%O), vertebrates (2%O), and flatworms (1%O). Most of these occurred within the posterior scute cavity. Foraminiferans, nematodes, sipunculids, dipterans, echinoderms, and ostracods are described as turtle epibionts for the first time.

Primary results of this descriptive study reveal aspects of turtle epibiosis, which require further investigation. For example, a juvenile (26.3 cm SCL) *E. imbricata* had gooseneck barnacles (*Lepas anatifera*), which usually grow on floating objects at sea, a remora (*Echeneis naucrates*) and a pair of columbus crabs (*Planes minutus*) previously reported as oceanic occurring in association with the brown alga *Sargassum* (Davenport, 1994). No algal forms were present on this small turtle. It could be assumed that this juvenile recently arrived at Mona, floating from where the 'lost years' are spent.

A great diversity of invertebrate larvae recruit and grow directly on the host or in the microhabitats (turf, sand, and cavern) available on the turtle. Movement through water causes drag, limiting the distribution of some epibionts on the carapace. Various turtles presented scrape markings on the carapace probably caused when wedging into crevices in the walls or reefs. A blue tang (*Acanthurus coeruleus*) was seen biting on the posterior carapace of a swimming turtle and banded coral shrimp (*Stenopus hispidus*) were observed picking on the turf on the carapace of an adult resting turtle. The combination of limiting factors mentioned above may modify the epibiotic assemblage.

Frazier *et al.* (1991) concluded that the relationship between tunicates and turtles was casual based on a very low probability of finding this association. In Mona Island's population of *E. imbricata* tunicate epizoans occurred 15 times. Mature reproductive colonies of a compound tunicate (*Trididemnum solidum*) were found as epizoans. This species has short-lived larvae, which may disperse greater distances by turtle assisted mechanisms. Describing the epibiotic assemblages of wild populations of migratory Chelonians, may help define the habitat requirements of both host and the epibiotic assemblage. Many new questions arise, as we look closer onto the carapace of a turtle.

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Table 1. Range of straight carapace length (SCL) cm in 13 size classes.

Class	Range
1	20.00-24.99
2	25.00-29.99
3	30.00-34.99
4	35.00-39.99
5	40.00-44.99
6	45.00-49.99
7	50.00-54.99
8	55.00-59.99
9	60.00-64.99
10	65.00-69.99
11	70.00-74.99
12	75.00-79.99
13	> 79.99

Epibiont Community Succession on Nesting Loggerhead Sea Turtles, *Caretta caretta*, from Georgia, USA

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Docks, buoys, and limestone outcroppings in Georgia support an extensive community of motile and non-motile organisms commonly referred to as 'fouling' organisms. Prior to colonization by fouling forms, a submerged substrate develops a 'slime' coat that consists mainly of algae, bacterium, and nematodes. The accumulated 'slime' coat provides nutrients that ultimately attract larval invertebrates to settle upon the substrate. The first macroscopic fouling forms to colonize the substrate are referred to as the 'pioneer species'. The pioneer species observed in most fouling communities are barnacles (Dean, 1981). Initial colonization by barnacles provides refuge and substrate for the immigration of certain fouling forms into the community based upon how the barnacles have three-dimensionally shaped and nutritionally enriched the existing community. Thus, the presence of a particular fouling organism ultimately influences the colonizing ability of later arriving species.

Generally, fouling communities can be categorized as either successional or non-successional based upon the patterns of immigration and emigration of sessile organisms to and from the observed community (Sutherland and Karlson, 1977). A fouling community is considered to be non-successional when: 1) a pioneer species impedes the subsequent development and colonizing ability of other fouling forms, 2) species recruitment into the fouling community is highly variable

from year to year during comparable time periods, or 3) community development does not result in a stable climax.

A fouling community is considered to be successional when: 1) an orderly and directional process of community member recruitment is observed from year to year during comparable time periods, 2) certain fouling organisms prepare the way for other fouling forms, or 3) community development results in a stable climax or common endpoint that perpetuates itself.

By monitoring tagged, nesting loggerhead sea turtles (*Caretta caretta*) we tried to determine whether or not a turtle's epibiota colonized the carapace in a successional pattern. If a successional colonization pattern was observed, we wanted to determine how long it took the observed community to climax. If the observed community climaxed, we wanted to document the species composition of the climax community. Once species composition was determined we would be able to identify any predators which may aid in community turnover or removal or the possible mechanisms a turtle might use to rid itself of the climaxed community.

METHODS

Epibiont data was collected from nesting loggerheads on two Georgia barrier islands during the 1998 and 1999

nesting seasons (May-August): Wassaw Island (31°53.4'N, 80°58.4'W) and Jekyll Island (31°03.9'N, 81°24.9'W). Data were collected either by identifying and mapping epibionts onto data sheets or by photographing turtles. Digital photographs were catalogued and sorted into a computer database archive program. To assure that the natural integrity of the observed epibiont communities remained intact no epibionts were removed from turtles for this study.

Frequently observed turtles were picked out of the compiled data. We were able to determine if epibiont colonization was occurring in a successional pattern by using data from only relatively 'clean' remigrators that nested approximately every two weeks and that were observed or photographed from the onset of the nesting season to the end of the nesting season. Data from turtles that were initially seen and not observed for the remainder of the nesting season were not used for epibiont succession analysis. However, notes about their epibiont community were compared to the data obtained from frequently observed turtles and are discussed below.

RESULTS

Out of 52 individual loggerheads surveyed, 12 turtles were seen approximately every two weeks from the onset of the nesting season to the end of the season. Twenty-three percent of the loggerheads observed for this study (23% = 12 turtles) hosted epibiont communities that exhibited a successional pattern of colonization. The average intranesting interval observed from 12 nesting loggerheads from Jekyll Island (n = 7) and Wassaw Island (n = 5) was 12.2 days (range: 10 days-16 days). The average number of nests deposited was 4.6 (range: 4 nests-7 nests).

All 12 turtles had relatively no epibionts when first observed nesting in May, with the exception of a few barnacles (*Chelonibia testudinaria*). *Chelonibia* colonization increased over the next two nesting observations and provided habitat to an assortment of small motile fouling forms (amphipods, crabs, polychaetes, etc.). By their fourth nesting observation (or approximately 42 days after the initial observation) all turtles had well developed epibiont communities of barnacles (*C. testudinaria*), bryozoans (*Bugula neritina*), and hydrozoans (*Tubularia crocea*) that covered approximately 75% of the carapace. Large aggregations of the aforementioned epibionts were also occasionally inhabited by several individual tunicates (*Molgula manhattensis*).

Three of the aforementioned turtles nested more than four times. All three turtles had retained their excessive epibiont loads up through their fifth nesting (or approximately 56 days from the initial observation). Additionally, tunicates (*Molgula manhattensis*) had almost completely overgrown the existing epibiont communities on all turtles. Two of the three aforementioned turtles had lost all their epibionts by their sixth nesting

observation (or approximately 70 days after the initial observation). One turtle retained her epibiotic load through the sixth nesting observation. By this time her epibiont community consisted almost entirely of tunicates (*M. manhattensis*) and very few hydrozoans and bryozoans. The aforementioned turtle had lost all of her epibionts by the seventh nesting observation (or approximately 84 days after the initial sighting).

DISCUSSION

Some nesting loggerheads in Georgia appear to host epibiont communities that exhibit a successional pattern of colonization similar to fouling community colonization patterns described by Dean (1981). Barnacles settled only in abundance on bare surfaces. Barnacle colonization was followed by hydrozoan and bryozoan colonization. The presence of hydrozoans and bryozoans enhanced settlement of tunicates. Tunicates subsequently dominated the community until unknown activities or methodologies ultimately rid turtles of their epibiotic community. These observed patterns of colonization suggest that tunicates (*Molgula manhattensis*) are the climax species within the carapace epibiont community on loggerheads in Georgia, and that the epibiotic community may climax in approximately 56–70 days after initial colonization by the pioneer species (*C. testudinaria*). Future studies, which investigate the growth rates of turtle barnacles in Georgia, would help to clarify the life span of a turtle's epibiotic community.

Other fouling community studies (on fixed substrata) report that tunicate colonization following hydroid colonization frequently results in the colonization and subsequent dominance (climax) of mussels within the community (Dean, 1981). On the turtles observed in this study, scorched mussels (*Brachidontes exustus*) did begin to appear following tunicate colonization but they did not dominate the community before turnover occurred. Sutherland and Karlson (1977) reported similar periods of catastrophic mortality (referred to as 'slough-offs') in fouling communities dominated by tunicates. Slough-offs are believed to be a result of spatial competition within the observed fouling community. Yet, it is possible that the observed epibiont communities were removed prematurely by the host turtles or by predators inadvertently 'grooming' the turtles. Based upon the extent of epibiotic colonization of the carapace prior to turnover, it is our belief that the slough-offs observed from loggerheads in Georgia occurred as a result of spatial competition within the epibiotic community. In further support, the largest turtles surveyed for this study hosted the oldest communities. This suggests that the more space available for community development, the longer the community can persist. Spatial competition amongst members of the epibiotic community obviously helps to rid sea turtles of excessive epibiont loads, which could adversely effect the hydrodynamics of

the turtle's carapace (Logan and Morreale, 1994). Yet, the possibility exists that since the overall community was eventually replaced by soft bodied tunicates the turtle host would have had a much easier time removing the epibiont community via scratching on hard surfaces underwater or with the front flippers. Live barnacles would be much more difficult to remove, especially types specialized solely as sea turtle commensals (*C. testudinaria*; Caine, 1986).

Obviously there are many more epibiont species present within the epibiotic community than identified within the successional pattern described above. However, we only focused on the most common and most visible sessile organisms frequently observed as epibionts on loggerheads. It is possible that smaller, motile forms do influence patterns of epibiotic succession. Although, increased settlement is generally attributed to the presence of sessile organisms and motile organisms are not considered to be 'long term' residents of the fouling community (Dean, 1981).

A number of turtles initially surveyed for our study were either not seen again for the remainder of the nesting season, seen irregularly throughout the season, or found nesting on beaches well away from the study area (two individuals as far north as northern North Carolina). These turtles and their epibiota were not used to investigate patterns of epibiont community succession since it would be hard or impossible to map successional patterns from these individuals. However, the data collected from the aforementioned turtles was compared to the data obtained from the site fidelity nesters in this study.

Ten percent of all the turtles initially surveyed (10% = 5 turtles) nested in early May (first week) with excessive epibiotic loads similar to those described for turtles observed ~56 days after the initial nesting observation. Dense aggregations of *M. manhattensis* on the carapaces of nesting loggerheads in early May, suggests that these turtles may have entered the nearshore coastal waters off their respective nesting beaches or nesting area at least 56 days prior (early March) to their first nest of the season. Based upon the seasonality and distribution of *M. manhattensis*, the nesting area in question would be the coastal waters between Cape Canaveral, Florida and Cape Romaine, South Carolina (the Georgia Bight; Ruppert and Fox, 1993).

The arrival of adult female nesters, into the Georgia Bight, in March would coincide with courtship and mating observations for this area during the same time period (Caldwell, 1959; Frick *et al.*, 2000). A mated turtle within the Georgia Bight in March could be heavily encrusted by *Molgula* by the time she deposited her first nest. Turtles that began their nesting cycle relatively free of epibiota may have either just arrived to the area or experienced a slough-off of the epibiotic community. An epibiont community slough-off prior to first nesting would indicate coastal residency in the Georgia Bight at least 70-80 days prior to first nesting. Individual loggerheads that migrate through-

out the southeast, depositing their nests in various locations within a season, would probably not host quite an extensive epibiont community and appear epibiont free every time they were observed. Since the study of sea turtle epibiota is still very much in its infancy, more comprehensive studies regarding the colonizing ability of animals that occur as sea turtle epibionts will undoubtedly help in our overall understanding of sea turtle populations in the southeastern U.S.

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Habitat Use, Movements, and Diving Behavior of Pelagic Juvenile Loggerhead Sea Turtles

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Large numbers of juvenile loggerhead sea turtles, *Caretta caretta*, inhabit the pelagic eddies and meanders that diverge from the North Atlantic gyre system near the Azores Islands, Portugal. The objectives of our study are to analyze the habitat use, movements, and diving behavior of these loggerheads through the use of satellite-linked data recorders and remote sensing imagery. We hypothesize that pelagic juvenile loggerheads utilize a 'float-and-wait' strategy that puts them in contact with potentially productive oceanographic regions such as fronts and convergence zones and minimizes energy expenditure. To test this hypothesis we will determine whether turtles are randomly distributed or are associated with oceanographic features identified from satellite images of chlorophyll concentration and sea surface temperature. We will also determine whether diving behavior correlates with habitat

type. We will determine whether turtles are passive or active in their choice of an environment by comparing turtle movements with the speeds and directions of surface currents estimated from altimetry and wind satellite imagery. In this presentation, we report our initial findings. Our results suggest that diving behavior varies with movement patterns, which in turn may correlate with habitat type. Diving behavior was also analyzed to detect temporal cycles and to determine whether variation in diving can be explained by body size. Interpretation of juvenile loggerhead habitat use and diving behavior will promote an understanding of the ecology of the pelagic life stage, allow the development of more accurate demographic and bioenergetic models, and facilitate the development of more effective protected areas.

Marine Behavior of Leatherback Turtles Nesting in French Guiana for Conservation Strategy

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INTRODUCTION

The Yalimapo nesting colony of leatherback turtles, *Dermochelys coriacea*, located along the north coast of French Guiana and extending into southern Suriname is the largest in the world (Spotila *et al.*, 1996). Since 1992, however, the primary French Guiana nesting beach has shown an alarming decline (Chevalier *et al.*, 1999) despite conservation efforts for many years resulting in lowered land-based threats (Fretey and Lescure, 1998). Two possible reasons (which are not mutually exclusive) for this decline are the shifting of nesting from Yalimapo to other beaches and a declining population. Because such a rapid decrease in leatherback population has been attributed to increased fishing mortality in other populations (Eckert and Sarti, 1997), we felt it important to investigate where female leatherbacks reside offshore within and between nesting seasons.

METHODS

To determine internesting and post-nesting movements of turtles from the Yalimapo nesting colony, we

attached Argos monitored satellite transmitters (prepared by Sirtrack based on Telonics model ST-10 components) to nesting female leatherbacks in June and July of 1999. Transmitters were secured to a custom-designed harness and placed on the turtles during egg laying. The harness system has been used with success in other studies of leatherback movements (Eckert *et al.*, 1989; Chan *et al.*, 1990).

RESULTS

Leatherbacks ranged up to 80 km along the nesting beach and 80 km offshore during the internesting interval (Fig. 1). This is an area of intense trawl fishing as well as an area where drift-nets are regularly observed.

After completion of the nesting season (Fig. 2), one turtle moved east for three months traveling approximately 3200 km to the Cape Verde Archipelago where it remained for two more months after which time no more transmissions were detected. The second turtle moved north along the outside of the Caribbean Archipelago and ended up off the coast of Florida five months later.

DISCUSSION

This was the first time that leatherbacks of French Guiana were tracked during interesting intervals. Based on our preliminary data, the area covered at sea by Yalimapo turtles overlaps that covered by nesting leatherbacks off the Malaysian zone (Chan *et al.*, 1990).

The postnesting destinations of two turtles (i.e. Cape Verde and Florida) are near previous captures of tagged individuals (Pritchard, 1976; Girondot and Fretey, 1996). The first few weeks of the route taken by the turtle now in Florida also accords with a previous three-week tracking (Duron-Dufrenne, 1987).

CONCLUSION

These preliminary Argos tracking data indicate that leatherbacks at the nesting colony in Yalimapo frequent areas where they may be subject to incidental mortality in commercial fishing operations. These areas include, but are not limited to, the nearshore waters of French Guiana and Suriname as well as the eastern coast of Florida, which has recently experienced an increase in leatherback mortality by shrimp trawlers. The study also demonstrates the value of using satellite telemetry as a means for determining where turtles may be at risk so that preventive efforts can be undertaken.

ACKNOWLEDGMENTS

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Fig. 1. Three interesting movements of a leatherback turtle indicated by Argos position fixes. The continuous line shows the limit trawl-fishers should stay beyond. For Suriname, there is a fishing limit only 15 km off Galibi Reserve.

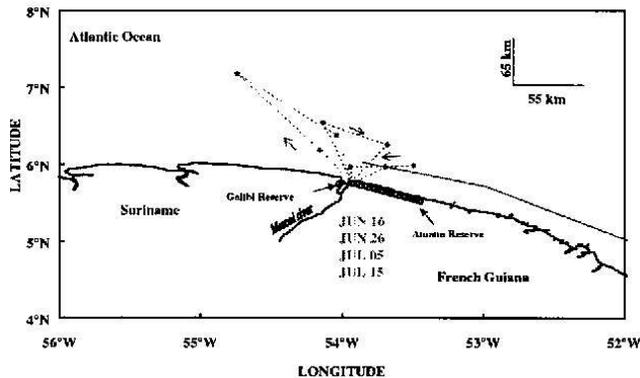
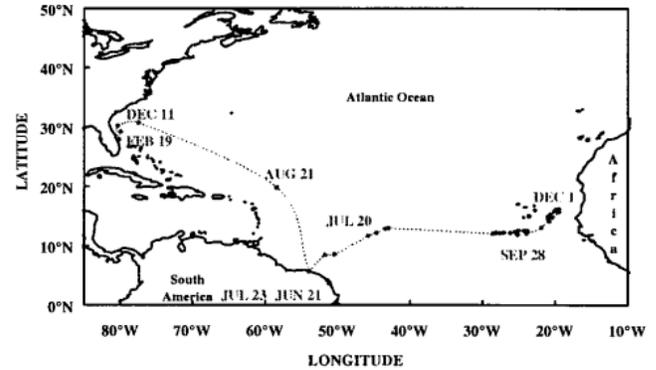


Fig. 2. Postnesting movements of two leatherbacks. The points are the position fixes.



Habitat Use of Mixohaline Fish Ponds by Green Turtles at Kiholo Bay, Hawaii

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Kiholo Bay on the Kona Coast on the Island of Hawaii is located at 19°52'N, 155°55'W (Kay *et al.*, 1977). This area has been studied regularly since 1987 and over 300 green turtles (*Chelonia mydas*) have been captured and tagged there (Balazs *et al.*, 2000). Kiholo Bay represents an important foraging and resting area for immature green and, to a lesser extent, hawksbill turtles. The primary resting area is Wainanali'i lagoon, but recent observations have shown that turtles are resting in mixohaline ponds that were previously little used. Turtles can now be seen entering and exiting these ancient Hawaiian fish ponds on a daily basis through a 50 m long channel (awai). Freshwater supplied by underground springs continually mixes with saltwater brought into the ponds with the tides through the awai and as tidal ground water. Nothing has been reported elsewhere about turtle behavior and ecology in similar brackish water environments (Lutz and Musick, 1996). The purpose of our study was to determine which turtles used the ponds, the times they entered and departed, their size distribution, and movements relative to tides and time of day. We additionally observed habitat usage and specific behaviors within the ponds.

METHODS

A Sony TRV-10 Digital Video camera connected to a TV monitor and VCR was used to record turtles entering and exiting the mixohaline ponds through the awai. A total of 149 hour of observations were recorded between April 1999 and January 2000. Individual turtles were carefully hand captured using scoop nets. The turtles were measured,

weighed, PIT tagged, and lightly inscribed on the left and right second lateral scute for visual identification (Balazs, 1995). The deep body temperature (T_b) was taken with a Cole-Parmer Digi-Sense thermister thermometer (model 8522-10). A lubricated, flexible probe was inserted at least 15 cm through the cloaca into the colon to reach the deep body regions. Time, identifying number, and behavior were recorded for any turtles observed in the ponds. Water temperature and salinity were taken at various locations within the ponds and awai. Water temperature was taken at the surface and at 1 m depth using a hand held thermometer. Salinity was measured with a refractometer. Current flow was measured by allowing a surface drogue to float a measured distance (10 m) and timing it. Algae samples were collected in feeding areas and stored in 10% formalin for identification.

RESULTS AND DISCUSSION

A total of 42 turtles were captured. All of the turtles captured and tagged in the ponds were immature. Seventy-nine percent of the captured turtles had a curved carapace length between 40 cm and 60 cm. Eighty-two percent of the captured turtles weighed between 10 kg and 25 kg. Turtles in the ponds were generally observed to be resting, feeding, or basking out of the water. Turtles usually rested in the shallows (depth <0.5 m) near the edge of the pond. Larger turtles were also observed resting on the bottom within the deep sediment of the pond floor (1.5 m deep). Due to the warmer water at the bottom of the ponds, it is likely that resting in the sediment on the pond floor has thermal

benefits, but greater analysis of this behavior would have to be done. Individual turtles (as identified by their carapace numbers) were frequently observed resting in the same locations or home site. Turtles were also observed feeding on algae in and near the pond entrance. Analysis of algae samples taken revealed over 99% *Cladophora hemisphaerica*. Turtles were observed basking in four primary areas. The same turtles consistently basked at the same location. For example, #36 was observed basking on 11/2/99 at 1743 hours and then observed basking at the same site on 1/14/00 at 1455 hours. Many of the numbered pond turtles were observed outside the ponds as well, mainly in the lagoon. For example, on November 1, 1999, turtle 19 was recorded leaving the mixohaline ponds at 0611 hour and was then observed basking in the lagoon later that afternoon at 1457 hour. On 1/15/00, turtle 45 was seen basking in the lagoon and was captured the next day exiting the ponds at 0635 hours (Rice *et al.*, This volume). Tides appeared to be the determining factor for turtles entering the ponds. Numerous turtles were observed attempting to enter the ponds, but currents from the falling tides prevented them from doing so. Current flow measured in the awai during a falling tide was 0.6 m/second in the widest part of the awai and one meter per second in the narrowest part of the awai. Often turtles managed to swim part way up the awai before currents proved too strong and they were forced to abandon efforts to enter the ponds. No turtles entered the ponds when tides were below 0.2 m. However, turtles did not appear to be restricted by tides when exiting the ponds. Turtles left the ponds periodically, but 82% of the turtles observed exiting the ponds left between 0500 hours and 0900 hours, presumably to forage in the adjacent bay outside the ponds. Deep body temperatures (T_b) taken from turtles both entering and then exiting the ponds showed a decrease in temperature for pond residency. The average T_b of the eight turtles captured entering the ponds was 24.8°C. The average T_b for the ten turtles captured exiting the ponds was 21.9°C, an average drop in deep body temperature of 2.9°C. Water temperatures were taken in the ponds at both the top and bottom. The range of water temperatures in the ponds was 20°C to 23°C near the surface, while the bottom was much warmer with a range of 24°C to 26.5°C (depth = 1 m) Salinity measurements were taken at the same time. In pond one, surface readings gave a salinity of five parts per thousand (ppt) and the bottom was 33 ppt. In pond two, surface measurements showed a

salinity of 0 ppt and a salinity of 21 ppt at the bottom. The slightly higher salinities in pond 1 are most likely due to the infusion of salt water brought into the ponds through the awai with the tides. The results of this study depict the ponds as an important resting habitat for the green turtles residing there. In the past, the ponds were not used at the current high level, but now turtles can be seen entering and exiting the ponds on a daily basis. Over fifty turtles were observed entering the ponds in a single 24-hour period. All of the turtles using the ponds were immature. The turtles usually left the ponds for at least a few hours each day, presumably to forage in the bay. Turtles were seen foraging and basking in the ponds, but the ponds appear to be principally a resting area. The ponds likely offer protection and safety from predators in the bay as well. Lower deep body temperatures observed in turtles exiting the ponds would lower their metabolism, perhaps resulting in an energy savings. The overall use of the ponds is primarily that of a resting habitat for immature turtles.

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Movements of Loggerheads Around the Canary Islands (Northeastern Atlantic)

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We present the first data on movements of loggerheads (*Caretta caretta*) in the Canary Islands (Northeast Atlantic), the commonest species in this area, where there is a developmental habitat. They seem to belong to the

nesting population from the southeastern United States, and live around the archipelago as immature stages before returning to natal beaches. Body size ranges from 20 to 70 cm of curve carapace length (CCL), being occasionally

larger. Since November 1998, eight individuals of *Caretta caretta* have been tagged using Platform Transmitter Terminals (PTT's): seven in the Canary Islands, and one in the Strait of Gibraltar, both areas included in migratory routes described for this species in the North Atlantic. Seven transmitters still work, the last three were released very recently and the data are still poor. The first PTT deployed was transmitting for five months before the batteries ran out. The routes followed by the turtles are different: the one from the Strait of Gibraltar and the one from the Canary Islands appear to swim towards the

Western Atlantic; two other turtles went to the Northeast Atlantic and stand close to Moroccan coast; one individual was around the archipelago since its release ten months ago; and the last three tagged animals still remain in the release area. There may be a relationship between body size and direction of movements, since the two larger individuals swam towards the Western Atlantic, and the smaller ones remained close to archipelago. Data provided by these turtles, and those obtained from animals tagged in a near future, will allow us to discuss this hypothesis.

Changing the Landscape: Evidence for Detrimental Impacts to Coral Reefs by Hawaiian Marine Turtles

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HOME SWEET HOME

Site fidelity to a particular stretch of coastal waters is a recognized characteristic of the Hawaiian green turtle, or honu (Balazs, 1980; Bennett *et. al.*, This volume; Keuper-Bennett and Bennett, This volume). The turtles living at Honokowai, West Maui, Hawaii are also dedicated "reef potatoes." Through benign observations using photographs and videotape, conducted during July and August each year from 1989 to 1999, we have shown that turtles from all post-pelagic size classes have called Honokowai home for many years (Keuper-Bennett and Bennett, This volume).

Further, we have discovered that the honu are faithful not just to a general area such as the Honokowai reef system, but also to specific places on the reef. We have documented numerous areas that individual turtles regard as "private" resting sites. These are specific ledges, shelves, and depressions that become "home" to one turtle. The same animal can occupy its private space for years and will defend it stubbornly from intrusion by other honu.

CONSEQUENCES OF THIS FIXITY

The consequences of such site-specific residency are clearly visible on the reef. Turtles engage in three types of activities causing three forms of destruction. Finger corals are broken and trampled, plate and lobe corals are ground smooth, and large coral heads are split asunder.

The area we call the Turtle House was a mound of thriving corals in 1989. A decade later, these corals are unrecognizable, having been pummeled into rubble or ground down to their rock base. A colony of honu can indeed change the landscape-and do so dramatically!

Whether it's a case of many turtles huddled around a shared piece of habitat (such as a scratch post) or that of an

individual turtle calling a ledge home, the results are the same. As these hard-shelled creatures come and go for daily foraging and resting, the environment bears testimony to their long-term presence.

THREE TYPES OF DESTRUCTIVE ACTIVITIES

Landing/Resting/Leaving

The effect of 100 kg turtles taking off and landing atop corals leaves little to the imagination, but honu can do damage even when resting. Fragile finger corals (*Porites compressa*) are major victims. Their remains litter the "floors" of most Honokowai resting places. We call these sites "Turtle Tramples" because that's exactly what the turtles do, even during the course of such an innocent activity as resting. They trample and grind the corals into rubble simply by physical contact.

Scratching

Generally speaking, an "itchy" plastron is the easiest itch to satisfy. A honu simply needs to drag itself over a section of coral using its front flippers to move itself back and forth. If an "armpit" or abdominal region is itchy, a turtle can find relief on any handy piece of coral; however, a coral head that offers top-quality easy access for armpit/abdominal scratching becomes a shared resource. Over time it can be worn to a point, thus making it an even more effective itch "satisfier."

While scratching plastron and soft body parts is easily accomplished, there is a logistical problem with an itchy carapace, since a turtle can't (or won't) roll over. To satisfy this kind of itch requires some overhanging structure. For small turtles, any ledge or coral "lip" works well. Large turtles, however, require suitably sized overhangs of either rock or durable coral-and therein lies the problem.

Honokowai offers few coral structures of the necessary size, and the few that exist attract intensive and prolonged bouts of scratching. During our decade of observations we've determined that no corals are durable enough to withstand the relentless carapace rubbing and scraping inflicted on them by large and powerful itchy honu. Three of Honokowai's five most prominent and "popular" scratch posts have split and collapsed—one in 1991 and the other two in 1998-99.

Foraging

We have occasionally documented green turtles foraging for sponges growing among corals. To get at these morsels, a turtle will use its flippers to pry away coral projections. In 1999, we were fortunate to witness the foraging habits of two Hawaiian hawksbills (honu'ea). These turtles flail their flippers with even more enthusiasm than their larger honu brethren. The two species exhibit interesting differences in sponge foraging behaviour. Green turtles work the perimeters of Honokowai reef systems, while the hawksbills will turn their attention anywhere they sense a sponge might be located. As a result, the honu and honu'ea leave somewhat different "calling cards" of damage around their Honokowai reef homes.

THREE TYPES OF DESTRUCTION

Erosion

This type of damage is subtle and is done mostly to large corals, such as lobe corals (*Porites lobata*). Years of plastron-rubbing have ground portions of these coral heads smooth. In 1989, when we first discovered the Turtle House, the portion of it that we called The Depression showed enough erosion to suggest that turtles had already used it as a resting area for years. The number of turtles has increased, however, and the corals at The Depression haven't stood a chance. They've been ground down, smoothed, and eroded more between 1996-99 than in all previous years under observations.

Breaking/Snapping/Trampling

This is the most extensive form of reef damage at Honokowai. Foraging or arriving and departing can be the cause, but it primarily results from movements while resting on the corals. Because the Turtle House was "established" first as a honu cleaning station and rest site, the once flourishing corals of 1989 (mostly *P. compressa*) are barely recognizable today. A decade of honu presence in this area gives it a look similar to the break-and-scatter damage wreaked by a hurricane.

Structural Collapse

This type of damage is the most pronounced. Massive coral structures sheer and collapse as a result of the honu's

need to satisfy carapace itches. The Keyound—a carapace scratch post at the Turtle House—was sheared in half between 1990 and 1991. East House, a prominent lobe coral structure at Reef 2, collapsed in 1999. Both structures almost certainly fell victim to large adults doing "push ups" from underneath in order to drag and scrape their shells along the coral overhang.

CONCLUSIONS AND CONUNDRUMS

The condition of the corals at the Turtle House in 1989 suggests that honu were not established in significant numbers at that time. Retrospective video analysis demonstrates that most Honokowai coral destruction is recent, occurring only in the last decade and largely attributable to honu activity.

The obliteration of corals has affected other marine inhabitants that lived at the Turtle House before honu colonization. For example, review of video of the Rest Site, a severely trampled area just east of the Turtle House, shows fewer fish in 1999 than in 1989 footage.

We are left to wonder what happens when portions of reefs are turned into rubble. Will the honu move to alternate locations? We already seem to have evidence of that happening with newly discovered congregation areas such as North House, approximately 250 m northeast of the Turtle House.

What consequences, if any, might the destruction of corals and other honu-induced effects on habitat have on the course/expression of fibropapilloma disease within this population?

Last, can the corals ever recover in the daily presence of so many of Hawaii's splendid and charismatic turtles?

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Remigration and Residency of Hawaiian Green Turtles in Coastal Waters of Honokowai, West Maui, Hawaii

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During the period 1989-1999, five adult females (U521, F765, U359, 122C, and A240) have made nesting migrations to French Frigate Shoals (FFS) and returned to Honokowai. Three of these females (U521, F765, and U359) have made two or more migrations during this period. This involves a round-trip swimming voyage of at least 2000 km. Tutu (U521), first identified by photograph in 1990, completed her fourth documented migration during this time.

Three of the five females (F765, U359 and 122C) were sub-adults (65-85 cm carapace length) when first sighted, and subsequently matured at Honokowai. They migrated to FFS where they were issued their first set of flipper tags. Observations at Honokowai, captured on photographs and videotape, provided a historical record of these turtles before they were tagged, an unusual circumstance. The combined National Marine Fisheries Service (NMFS) and Honokowai records are shown in Tables 1-5.

The reproductive behaviour of the three honu suggests that young females on their first migration return to the place where they spent their late developmental years. For example, we recorded Tiamat for six consecutive years at Honokowai before she made her first documented FFS nesting migration in 1997, when she was issued tag 122C. In 1998 and again in 1999 she was regularly present at Honokowai.

Two turtles already had tags when first sighted. If these two turtles are like the three younger females, it is highly probable that Tutu (U521) and Shredder (A240) lived at Honokowai when they migrated/nested for the first time. Considering the powerful site fidelity of female honu to their resting/foraging grounds, it is possible that all five of these females have spent all their post-pelagic years in this small area of West Maui (approximately 25 hectares). As a result, there exists the romantic possibility that some honu spend their entire lives within the same reef system.

IMPLICATIONS OF FIXITY IN HONU

This fixity makes honu vulnerable to persistent pollution sources and other anthropogenic assaults. It therefore follows that it is imperative that humans do all they can to keep sea turtle habitat, and the ocean in general, clean.

Of the five females, three have had fibropapilloma (FP) tumours and regressed. In 1999, we documented tumours

for the first time in a fourth, Shredder (A240).

Honu fixity and tameness offers unique opportunities for researchers to study the etiology of FP in free-ranging turtles living in the same habitat over many years. With such impressive long-term residency, no other sea turtles in the world have offered such a "window" into their private lives, a window that might well remain open for decades!

EXAMPLE OF FIXITY FOR A HONOKOWAI FEMALE

In June 1998, Mendelbrot was sighted on East Island laying her eggs. She is U359 and the good people monitoring turtles there took a picture of her. This makes Mendelbrot the first Honokowai turtle for which we have a photographic history in both nesting and foraging habitat.

This is one of those rare occasions where a turtle seems more beautiful on land than in water. This is also the first time in FFS history that a turtle at East Island has been matched to her foraging grounds by her facial markings. In addition, she is the first honu with a documented history prior to having received tags.

CONCLUSION

Hawaiian green turtles nest at the French Frigate Shoals every two to three years, a fact based on twenty-nine years of annual monitoring at FFS by NMFS. The Honokowai females follow this cycle. When egg-laying is complete, all five have reliably returned to the same home foraging grounds until their next urge to reproduce.

These records significantly contribute to continuing research in Hawaii suggesting that at least some green turtles demonstrate the same high degree of fidelity to certain coastal waters as they do to their distant nesting beaches.

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Table 1. Annual records for Tutu, U521. All evaluations of tumour severity and overall turtle condition conducted according to Work and Balazs (1999).

Year	Comments
1990	First sighted at the Turtle House. Tagged female. Tumors on both eyes and one tumor near tag on right front flipper. Overall Tumor Score Light
1991	Nesting, French Frigate Shoals. 6/1/91, 6/2/91, 6/16/91, 6/18/91, 7/1/91, 7/3/91, 7/4/91, 7/15/91, 7/16/91, 7/29/91, 8/12/91, 8/13/91
1992	Resighted at the Turtle House. All tumors improved. Fist Honokowai regression case.
1993	Resighted at the Turtle House. Read one tag for the first time. Regression continues.
1994	Nesting, French Frigate Shoals. 6/25/94. Nesting, but resighted at Honokowai on August 25 th . Eye tumors completely gone. Tumor on right front flipper barely noticeable. Regression continues.
1995	Resighted on second dive. Accepted our presence easily. Regression complete, no visible tumors. New tags read July 15. She is turtle U521 (left rear tag).
1996	Nesting, French Frigate Shoals. 6/15/96, 7/1/96, 7/2/96
1997	Resighted quickly as fourth turtle of the summer. Regression holds.
1998	Resighted July 3 rd dive. Several white blemishes on neck and shoulders. Fear of FP relapse!
1999	Nesting, French Frigate Shoals. 6/8/99, 6/21/99, 6/23/99

Table 3. Annual records for McTaggart, F765. All evaluations of tumour severity and overall turtle condition conducted according to Work and Balazs (1999).

Year	Comments
1990	---
1991	---
1992	Nothing more than a left profile in a poor photo, but enough for identification.
1993	First time. Nesting, French Frigate Shoals. 6/3/93.
1994	Regular visitor to the Turtle House. Named McTaggart in honor of new tags – F765. Tolerant of approach. No visible tumors.
1995	Resighted at the Turtle House. Infrequent visitor this year.
1996	Not sighted at Honokowai, not reported at French Frigate Shoals. Only female ever to go AWOL!
1997	Resighted on afternoon dive of July 3 rd . Increasing in girth and regular visitor this summer. No visible tumors.
1998	Resighted July 9 th at the Rock. Only seen twice. No visible tumors.
1999	Nesting, French Frigate Shoals. 6/21/99

Table 5. Annual records for Shredder, A240. All evaluations of tumour severity and overall turtle condition conducted according to Work and Balazs (1999).

Year	Comments
1990	---
1991	Nesting, French Frigate Shoals. 5/26/91, 5/27/91, 5/28/91, 6/11/91, 6/24/91, 7/6/91, 7/7/91, 7/20/91, 8/1/91
1992	---
1993	Nesting, French Frigate Shoals. 6/15/93, 6/16/93, 6/17/93, 6/29/93
1994	---
1995	Extremely shy turtle, easily identified by mangled hind flippers. Finally let us get close enough to record her facial markings, our only way for a positive identification.
1996	Nesting, French Frigate Shoals. 6/9/96, 6/21/96, 6/22/96, 7/3/96, 7/4/96
1997	Still shy, but allows us to read tags: A240 and A241
1998	Nesting, French Frigate Shoals. 6/7/98, 6/8/98, 6/9/98, 6/21/98
1999	Resighted August 26 th dive near North House. Only one resighting. Small tumor growing in posterior of each eye.

Table 2. Annual records for Tiamat, 122C. All evaluations of tumour severity and overall turtle condition conducted according to Work and Balazs (1999).

Year	Comments
1990	---
1991	Retrospective analysis of videotape shows Tiamat resting at the Turtle House.
1992	A photograph shows Tiamat swimming in the distance.
1993	Resighted at the Turtle House several times this summer. Acclimated somewhat. Small tumor beginning in right eye. Overall Tumor Score Light.
1994	Resighted at the Turtle House and Reef 2. Tumors growing on neck, shoulders, and in both eyes and mouth. Overall Tumor Score Moderate.
1995	Resighted at the Turtle House. Eye tumors shrunken, mouth tumors nearly gone. Becoming fully acclimated. Possible regression. Overall Tumor Score Light.
1996	Resighted at Resting Site and accepted us immediately. All tumors gone. Regression confirmed. To celebrate we named her Tiamat.
1997	First time. Nesting, French Frigate Shoals. 5/30/97, 6/13/97, 6/15/97, 6/16/97
1998	Resighted on our first dive. June 29 th . New tags – 122C, and “V 40” is engraved in the right hind portion of her carapace. NMFS notified. Regression holding.
1999	Resighted Tiamat during first week’s diving. Judging by her girth, things are going well. Regression holding.

Table 4. Annual records for Mendelbrot, U359. All evaluations of tumour severity and overall turtle condition conducted according to Work and Balazs (1999).

Year	Comments
1990	---
1991	---
1992	---
1993	First sighting: July 18 th . Rest Site. Early FP in both eyes, several neck/shoulder tumors, cantaloupe-sized under right front flipper. Named Mendelbrot.
1994	First Time. Nesting, French Frigate Shoals, 6/12/94, 6/13/94, 6/25/94, 7/7/94
1995	Resighted at Rest Site with shiny new tags. Regression confirmed. Eyes tumor-free, large tumor under her right front flipper is shrunken and gray. Did not read tags.
1996	Nesting, French Frigate Shoals. 6/11/96, 6/12/96, 6/22/96, 6/23/96, 6/25/96, 6/26/96
1997	Resighted July 27 th . “Armpit” tumor had shrunken further. Regression continues. Read tag U359. NMFS records show Mendelbrot nested in June ‘94, June ‘96.
1998	Nesting, French Frigate Shoals. 6/5/98, 6/6/98, 6/18/98, 6/19/98. June 29 th . NMFS confirms Mendelbrot nested at French Frigate Shoals. August 16 th , sighted at Reef 2, D62 painted on right rear carapace. Still regressing.
1999	Resighted July 22 nd at her preferred spot on Reef 2. Seen later at the Turtle House. Tumor under right front flipper continues to shrink. Still regressing.

Hatching Success of Olive Ridley Sea Turtles (*Lepidochelys olivacea*) in La Flor, Nicaragua

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La Flor beach is one of two major nesting sites for Olive Ridleys in Nicaragua. This site is a protected area under guard by both the military and personnel of the ministry of the environment. Recent management of the beach has involved a six month open season when arrivadas are small and all eggs are taken by local people. The arrivadas are officially protected during the other six months. Nevertheless, 10-20% of the eggs deposited during those "closed" months are also given to local inhabitants to eat or sell. Because land in the vicinity of the reserve is too dry and rocky for farming, many people are economically dependent on income from the eggs.

In this context, the present study set out to determine the most biologically rational management strategy. As a first step, we have tried to identify predictive parameters for determining which nests may best survive. We have done this by selecting nests at random during arrivadas, measuring the exact positions using triangulation, and excavating each nest after hatching, to determine how many eggs fail to hatch and how many hatchlings fail to emerge.

While we have witnessed losses of eggs low on the

beach on some occasions, this was not a factor in the data that we have analysed thus far. The study is still ongoing and we hope to have relevant quantitative data on this factor in the near future.

The major predictive factor appears to be whether a second turtle digs on top of a previously existing nest. In addition to eggs that are expelled from the nest, the mortality of eggs remaining in the sand from both the first nest and the second nest suffer a nearly 50% increase in mortality.

Further implications from this work are that overall hatching success on the beach can also be increased by removal of these nests to prevent undue buildup of pathogens in the sand. Another related effect which may explain the very high hatching success at La Flor beach (approx. 66%) compared to nearby beaches in Costa Rica (1%-8%) is the fact that at LaFlor, all eggs are removed from the beach for six months of every year and thus the sand is cleansed. This idea is speculative and will also be the subject of further investigation.

Evaluation of Factors Affecting Hatch Success of Loggerhead Nests on Pritchards Island, South Carolina, USA

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INTRODUCTION

Pritchards Island is a 2.5 mi long pristine barrier island located between Little Capers Island and Fripp Island, South Carolina. The Center for Coastal Ecology, operated by the University of South Carolina-Beaufort, has been maintaining the Sea Turtle Conservation Project on Pritchards Island for the past six years. The University has been conducting loggerhead (*Caretta caretta*) sea turtle protection programs on Pritchards Island for seventeen years (Table 1). The main goal of the project is to assist in the conservation of the loggerhead by protecting the nests and increasing the hatchling survival rate on land. As part of a statewide effort, coordinated by the South Carolina Department of Natural Resources (SCDNR), the Pritchards Island project is also inline with regional conservation efforts. In conjunction with conservation, this project serves as an educational tool to increase public awareness of local threatened and endangered species and the need for habitat protection. During the 1999 sea turtle season,

Pritchards Island had over 800 program volunteers visit the island to assist with protecting 134 loggerhead sea turtle nests. The Pritchards Island Sea Turtle Conservation Project is one of 20 projects on the coast of South Carolina that utilizes volunteers. The objective of research conducted during the 1999 nesting season was to determine if specific management practices negatively or positively affect hatch success. Comparisons were made with regards to where clutches were located during their incubation period. The variables include *in situ* nests, individual nests relocated to a safe location and screened on the beach, nests relocated to hatcheries that have been used in previous years, and nests relocated to hatcheries being used for the first time.

METHODS

The 1999 Loggerhead Sea Turtle Conservation Project began with patrols on May 10 and continued through August

15. Assisted by a maximum of nine volunteers, one of four trained conservation staff successively led nightly beach patrols on foot. Patrols were conducted from the North end of the island to the end of the overwash area twice per night in order to find nests within the six-hour period recommended for nest relocation. An early morning patrol of the entire beach, was conducted on a bicycle or all terrain vehicle (ATV) to find any nests missed during the night. Once the nest was located, eggs were carefully removed with an effort not to change polar orientation. Volunteers, under staff supervision, were allowed to help in egg removal from the original cavity. Before eggs were removed from the chamber, sand directly from the top of the chamber was placed approximately 1-2 in deep in the bucket. Eggs were counted as they were placed in the bucket and then recounted as they were placed into the new cavity. Nest reconstruction and reburial was limited to conservation staff. Procedures for nest relocation were consistent with those outlined by SCDNR. The island's beachfront is divided into five zones based on beach characteristics. This zonation is designated by physical characteristics; thus, divisions are not equal in distance. Zone 3 is an overwash area in the middle of the island with approximately a 400 yd stretch of dunes. This area contains the most suitable nesting habitat for loggerhead sea turtles. However, the number of suitable locations in the dunes for hatchery sites is so small that the Pritchards Island Sea Turtle Conservation Project has reused hatchery sites from season to season. Due to the possibility that reusing hatchery sites might be causing a low hatch success rate, the 1999 season staff put in two new hatchery sites as well as relocated nests individually. One of the purposes of the 1999 work was to evaluate if hatch success was dependent on parameters such as hatchery reuse and relocation of nests versus those left *in situ*. Hatch success was determined by taking the number of hatched eggs in a nest, dividing by the total number of eggs laid, and multiplying by one hundred. Statistical analysis was accomplished by performing a z-test that compared two sample hatch success means with different variances. The tests were performed at the 95% confidence level.

RESULTS

Analyses of the data collected during the 1999 nesting season on Pritchards Island are presented in Figure 1.

DISCUSSION

Despite the visual differences between the means of some of the variables, z-test analysis did not indicate any significant differences between any of the variables. One

concern in this process is that adequate sample sizes were not available for all of the variables used in these comparisons. The 1999 season research started 51 days after the first loggerhead nested on Pritchards Island, which caused the sample sizes to be small. To ensure that the conclusions drawn from the preliminary results of this data are completely valid it is recommended that the staff start the study at the beginning of the season in order to obtain larger sample sizes. The continued improvement in training and equipment in the seasons to follow will provide Pritchards Island with an advanced research program as well as an excellent education program. Pritchards Island's Barrier Island Research Facility has recently acquired a computerized weather station and GPS unit which will assist in continued research efforts. This new technology will aid the project staff in keeping detailed information on nest and crawl locations, nest characteristics, and environmental factors. Thanks to these tools, information gathered in the future seasons will add useful information to the data collected during the 1999 season. The 1999 research data provides important information that will act as a foundation for further research. With successive years of study, questions about the affect of management practices on the loggerhead sea turtle nests can be answered. The Pritchards Island Sea Turtle Conservation Project continues to rely on consistent procedures, scientific methods, thorough data collection, and detailed season reports to excel in the field of sea turtle conservation.

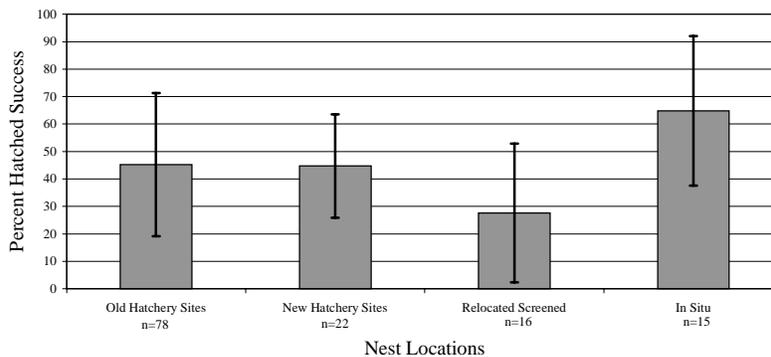
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Table 1. Loggerhead sea turtle nesting data for Pritchards Island from 1982-1999.

Year	No. nests	No. eggs	Ave. clutch	% hatched	False crawls	First nest	Last Nest	Hatchlings
82	50	5618	112	78.8	110	5/25	8/4	4427
83	74	8393	113	69.3	309	5/20	8/6	5816
84	103	9466	109	80.7	321	5/19	8/17	7639
85	69	7320	106	79.5	316	5/23	8/5	5819
86	113	11714	104	87.4	547	5/17	8/7	10238
87	57	6159	108	86.2	71	5/24	7/31	5309
88	176	21120	120	85	237	5/18	8/6	17952
89	103	12273	119	81.2	144	5/15	8/13	9666
90	174	20570	118	83.3	263	5/15	8/9	17135
91	121	13915	121	80.3		5/17	8/5	11132
92	118	13064	118	71.7	179	5/20	8/5	9366
93	41	5366	131	71	138	5/25	7/24	3810
94	67	7421	110	77.9	191	5/13	7/26	5784
95	113	12479	121	65.1	114	5/15	8/14	8124
96	142	16794	118	77.6	110	5/13	8/8	13032
97	53	6272	118.3	79.2	118	5/21	8/12	4967
98	168	20423	122.2	77.8	200	5/13	8/8	15961
99	134	16746	125.9	44.6	236	5/10	8/1	8019

Fig. 1. Percent hatched success for the different incubation locations.



Touching Eggs of *In Situ* Nests May Not Affect Hatch Success

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INTRODUCTION

Since 1976, Boca Raton's Sea Turtle Protection Program has used cages in order to mark and protect nests from depredation. After a predation study in 1996 demonstrated that cages actually attract predators, Boca Raton changed its procedure to adopt both caging and double staking (nest and dune stakes) methods. Now caging partially occurs only in areas of high predation or naïve human activity. Although caging has been used for many years in Boca Raton, its effect on hatch success, due to the required touching of in situ eggs to verify nest location, has

not yet been evaluated. Does touching an egg, possibly contaminating the clutch, affect the fate of the nest? Using a representative zone (INBS zone D), the hatch success of caged nests and staked nests was compared. From 1993 to 1999, 277 undisturbed loggerhead (*Caretta caretta*) nests were laid in this zone, of which 161 were caged and 116 were staked. No significant difference in the overall percent hatched of caged versus staked nests was demonstrated nor was there a difference during the 1998 and 1999 season when both cages and stakes were used in this zone. In fact, caged nests had a slightly higher percent hatch overall indicating that touching eggs in a nest does not apparently affect hatch success.

METHODS

From 1993 to 1996, all sea turtle nests laid in Boca Raton had been screened with 2 ft x 2 ft self releasing cages. After a predation study indicated cages may actually attract predators, Boca Raton began using only the double stake method (nest and dune stakes) to mark its sea turtle nests during the 1997 nesting season. Significant changes in predation activity occurred. Now cages are only used on every other nest in areas of high predation or high traffic (INBS zones D, E, F, and H). Caging procedures follow the guidelines described by the Florida Fish and Wildlife Commission. The cage is constructed of 2 in x 4 in wire mesh, and is marked with flagging tape and a nest sign. Cages are centered exactly over the egg chamber and should not compromise the viability of the nest in any way.

INBS zone D is 1/2 mi long located between latitudes 22° 22' 04" and 26° 22' 24" at longitude 80° 04' 03". All but 300 yd of this zone is occupied by city owned Red Reef Park. This is considered to be a high predation, high traffic area, and, for the purposes of this study, is a representative zone. Since 1993, all undisturbed nests (ones that had not been relocated or predated) in this zone were considered for this study. As per Florida Fish and Wildlife Commission regulations, nest contents were surveyed 72 hour after first emergence. From these data, percent hatch and hatch success can be determined.

RESULTS AND DISCUSSION

While the average percent hatch varied over the seven years, the caged and staked averages remained very close in value (77.5% for staked and 79.5% for caged) (Table 1). During the 1999 and 1998 seasons, when both stakes and cages were used, no significant difference in hatch success

was observed (82.9% for staked and 80.3% for caged in 1999; 66.8% for staked and 63.9% for caged in 1998).

Although double staking methods changed the pattern of predation on Boca Raton's beaches, they did not affect percent hatch or hatch success. However, natural yearly variances in hatch success were reflected equally in both caged and staked nests. Due to an exceptionally hot and dry summer in 1998, the average whole beach percent hatch for Boca Raton dropped from in 1997 84.2% to 55.1% in 1998. This drop was seen in both caged and staked nests.

Although it is always desirable to leave nests as natural as possible, nest location must be verified by touch to correctly utilize the caging method. Touching an egg in the clutch to confirm chamber location before caging does not reduce the viability of the clutch. While caging should not be used in every situation, where necessary, caging appears to be a safe protective method.

Table 1. Zone D hatch success.

Year	Staked	Caged
1993		79.6
1994		94.5
1995		82.4
1996		82.5
1997	89.4	
1998	66.8	63.9
1999	82.9	80.3
Average	77.5	79.5

Emergence Success and Nest Environment of Natural and Hatchery Nests of the Leatherback Turtle at Playa Grande, Costa Rica, 1998-1999

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In 1997-98 nesting season at Playa Grande, Costa Rica there was a 20% emergence success of leatherback turtle (*Dermochelys coriacea*) nests. Previous mean emergence success ranged from 48-53%. We hypothesized that high tides may have caused this extremely low nest survival. Most of the nests laid in October and November failed to hatch. Therefore, in the 1998-99 nesting season we established a hatchery in the high beach zone safe from tidal inundation and tested the emergence success of nests in the

hatchery versus natural nests. We also measured O₂ and CO₂ in the nests to determine if lack of O₂ or high CO₂ affected emergence success. We collected eggs during oviposition, transported and buried them in the hatchery within six hours after oviposition. We placed gas sampling devices in nests during October through January. We took gas samples every three days during incubation. The emergence success for hatchery and beach nests was 54% and 52%, respectively and was not significantly different. There was

a statistically significant difference in the emergence success between nests put into the hatchery from October to December and laid on the beach from November to January. There was a significant difference in emergence success between 31 females that laid three or more clutches. There was no significant difference in emergence success between nests with yolkless eggs removed and other nests laid by the same females ($n = 12$). There was a significant relationship between emergence success and high $CO_2\%$ and low $O_2\%$ in 56 hatchery nests but no significant relationship for 32 beach nests. Gas concentrations in the nest were not good indicators to predict emergence success. Gas production from decay and metabolism could not be distinguished in the nest environment. The hatchery produced 5768 hatchlings and

proved to be an excellent conservation strategy at Playa Grande, which can contribute to the recovery of this population.

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Influence of Filtered Roadway Lighting on the Seaward Orientation of Hatchling Sea Turtles

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Sea turtle hatchlings emerge from their nests at night and use visual cues to crawl toward the sea. Artificial lighting, such as street lights on coastal roadways, disrupts their seafinding orientation. Streetlights on coastal roadways are often responsible for these behavioral abnormalities. In most areas, these lights must be left on for roadway safety. How can hatchlings that emerge from nests near roadways be protected from these light sources?

Here, we investigate one possibility: the use of “high pass” light filters. These filters exclude the shorter light wavelengths that hatchlings are sensitive to, but transmit longer wavelengths that illuminate the roadway. We used arena experiments (staged emergences) to assay hatchling responses to a filter (Acrylic #2422) now being used in coastal roadways. Loggerhead hatchlings were unaffected by either unfiltered or filtered (70W, high-pressure sodium) lighting whereas green turtle and leatherback orientation was disrupted by filtered lighting. Differences among the species probably reflect their unique spectral and perceptual visual capacities. We conclude that filtered roadway lighting is probably ignored by loggerheads but that further testing with new filters will be needed to protect all species.

INTRODUCTION

Sea turtle hatchlings emerge from their nests at night (Witherington *et al.*, 1990) and crawl directly towards the sea (Mrosovsky, 1967). This “seafinding” orientation is based upon visual cues. Hatchlings crawl away from high, dark silhouettes (such as those of vegetation growing on a dune behind the beach), and toward brighter, lower, and less complex horizons characteristic of the view toward the

ocean (Limpus, 1971; Salmon *et al.*, 1992; Witherington, 1992a).

Artificial lighting interferes with the ability of nocturnally active animals to respond normally to visual cues in their surroundings (Verheijen, 1958 and 1985). Hatchling sea turtles are no exception, as their ability to sea find is severely disrupted by artificial lighting at the nesting beach (review: Witherington and Martin, 1996). Hatchlings may crawl on straight paths but toward light sources, (“misorientation”; Verheijen, 1985), or they may be incapable of crawling on straight paths (“disorientation”; Verheijen, 1985).

These problems might be solved by turning off the lights, by reducing their intensity, by lowering the lights, or by shielding the fixtures to reduce the spread of light to nesting beaches (Witherington and Martin, 1996). But on coastal roadways, another possibility is to take advantage of differences in visual perceptual between humans and turtles. It has been known for many years that sea turtles are behaviorally less sensitive to longer wavelengths of the visual spectrum. For example, hatchlings of several species crawl toward the shorter wavelengths, but not toward (i.e., are “indifferent” to) the longer wavelengths (Witherington and Bjorndal, 1991).

These results prompted the Florida Power and Light Company, in collaboration with the General Electric Corporation, to design a “high pass” filter that excludes the shorter wavelengths of light attractive to sea turtle hatchlings (violet, blue, green), but transmits the longer wavelengths (yellow, orange, red). One such filter (Acrylic #2422) excludes all wavelengths below 530 nm, but permits over 90 % transmission of wavelengths above 600 nm. This filter is inserted between the bulb and the lens of the street light.

Our purpose in this study was to evaluate the efficacy of this filter under “real world” conditions, that is, at sea turtle nesting beaches. We exposed hatchlings to the lights, then tested their orientation responses in “staged emergences” (arena experiments). These tests were performed when the roadway lights were off (controls), and when they were fitted with the filters (experiments). We used hatchlings of three species: loggerheads (*Caretta caretta*), leatherbacks (*Dermochelys coriacea*), and green turtles (*Chelonia mydas*).

METHODS

Study Sites

Experiments were performed at two sites (Woolbright Road and Carlin Park) in Palm Beach County, Florida, USA. At each location a roadway, with streetlights, was immediately west of the beach. The two sites differed in topography and in exposure to other sources of artificial lighting, but both areas were otherwise “natural” nesting beaches.

The Woolbright Road site was located in a relatively dark, residential neighborhood, but was exposed to sky glow from adjacent cities (Boynton Beach to the North; Delray Beach to the South). The beach was shielded from landward (West) residential lighting by a tall vegetation barrier (seagrape, *Collocobus fervix*), 3-4 m high. At our test location, two street light fixtures were visible from the beach. These lights were elevated by 9.1 m on poles on the East side of the road. The straight-line distance between the test site and each fixture was: North light, 29 m; and South light, 36 m. By selecting a test location at an angle to the poles, both lights were visible to the turtles.

The Carlin Park site had a minimal vegetation barrier between the highway (A1A) and the beach. Four highway lights were located on the West side of the road, also elevated on poles at a height of 9.1 m, with their fixtures facing East (toward the beach). Experiments were performed 30 m to the east of one pole.

Arena Assays (Staged Emergences)

At each site, tests were carried out within a 4-m diameter circular arena, drawn in the sand at the same location each evening. The sand inside the arena was cleaned and smoothed, and a shallow (2-3 cm deep) depression was dug in the arena center. In each trial 4-6 turtles were placed in the depression. They almost immediately crawled toward the arena boundary. Each turtle left tracks (flipper prints) in the sand, marking its crawl path. As hatchlings crossed the arena boundary, they were recaptured and released.

The track left in the sand by each turtle was drawn to scale on a data sheet, and the turtle's escape angle (vector from the arena center to the turtle's exit point at the arena boundary) was estimated with a compass. Another trial with 4-6 new turtles commenced immediately until all the

subjects had been tested.

During each trial, observers (2-3) lay prone and motionless on the beach, facing the arena center from several directions outside its boundary. All equipment was placed flat on the beach, and well away from the arena.

Background Lighting Measurements

Lamps used were 70 watt, high-pressure sodium (HPS) luminaires. Light reaching the beach was measured at night from the center of the testing arena as irradiance (in lumens/m²) using a Minolta Illuminance meter (Model T-1). The measurements were made with the lights turned off or on. An initial measurement was made directly under each light to determine irradiance levels near the source.

Additional light measurements were made on the evening of each trial. Irradiance levels were measured from the arena (a) towards the street light, (b) at the arena center, just above the sand surface, and (c) directly overhead (toward the sky).

Hatchlings

The majority of the loggerhead hatchlings used in these experiments were taken from nests relocated to a hatchery beach at Hillsboro Beach, Broward County, Florida, USA. The hatchlings were removed from their nests in the afternoon of the evening they were scheduled to emerge. Captured hatchlings from each nest were stored in separate, light-proof styrofoam coolers filled with several centimeter of moist sand, and kept in a dark room until evening when they were taken to the beach and used for the tests. A few hatchlings were obtained from another hatchery site, located in Dade County.

The green turtle and leatherback hatchlings were obtained on the night they emerged from natural nests at Juno Beach. The turtles were used for assays that evening or the evening that followed. As assays were completed, the hatchlings were released. No turtle was used for more than one trial.

Controls and Experiments

All assays done at Woolbright Road were performed with loggerhead hatchlings on moonless evenings. Experiments were done when the street lights were off (control), and when they were turned on with a clear lens (unfiltered light) or with the filter installed (filtered light).

Assays were done with three species of hatchlings at Carlin Park, under two conditions: lights off (control) or lights on with the filter in place (experimental treatment).

Data Analysis, Statistics, and Interpretation of the Data

Exit angles for each experiment were used to calculate a group mean angle and dispersion (r-vector). R-vector values range from 0 (random dispersal) to 1 (mean angles of all animals used in a test are identical). Rayleigh tests (Zar, 1984) were used to determine if each experiment resulted in significant orientation (p 0.05). Most species, with the

exception of some green turtles, showed seaward orientation making it difficult to distinguish between performance on that basis. We therefore combined statistics with subjective comparisons between the control and experimental groups. These comparisons centered upon two behavioral attributes: scatter (variation among individuals in escape angle) and crawl paths (normally straight but under abnormal conditions, curved or “looped”).

RESULTS

Light Measurements

When the street lights were turned off, background (sky measurement) light levels at Woolbright Road were higher than those at the Carlin Park site. When the street lights were on, turtles at the Carlin Park site were exposed to higher light levels at the arena center than those at Woolbright Road. More light was reflected from the sand at Carlin Park than at Woolbright Road.

Hatchling Orientation at Woolbright Road

A total of 114 hatchling loggerheads were tested, and all showed significant seaward orientation. Control turtles showed mean vectors of 87°, 97° and 98°, and r-vectors of 0.88, 0.88 and 0.98. Tracks were generally seaward (sea located at 103°), but the turtles on average oriented slightly north of the most direct route. When hatchlings were exposed to filtered or unfiltered light, their orientation was similar in mean angle (filtered 82° and 86°, unfiltered 94° and 97°) and scatter (filtered $r = 0.99$ and 0.86 , unfiltered $r = 0.93$ and 0.85) to the control tests. In all tests, the turtles showed significant orientation (Rayleigh $p < 0.05$).

Hatchling Orientation at Carlin Park

Seventy-two loggerhead hatchlings were tested. The control turtles showed mean vectors of 67° and 74°, and r-vectors of 0.66 and 0.85. In both control tests the turtles had an orientation north of the seaward direction (89°). Hatchlings in Group A showed greater scatter than Group B. When exposed to filtered light, hatchlings orientation was similar in mean angle (69°) and scatter ($r = 0.65$) to the controls.

Sixty-five leatherback hatchlings were tested. The control turtles showed a mean vector of 92° and an r-vector of 0.98. In the control test most turtles oriented slightly south of the seaward vector. When hatchlings were exposed to filtered light their orientation was similar in mean angle (93°, 92°, and 102°) but hatchlings exhibited more scatter ($r = 0.85, 0.88, 0.55$) and looping than during the control tests. A few (six experimental turtles) crawled away from the ocean. This trial was performed with no moon present (new moon phase). The two other experimental trials were done under a full moon. However, all groups showed significant orientation (Rayleigh $p < 0.05$).

Ninety-four green turtles were tested. The control

hatchlings oriented seaward at angles of 79°, 79° and 129°. The control turtles in two groups were well oriented, but a third group showed poor seaward orientation. When hatchlings were exposed to filtered light, mean angles were toward land (213° and 263°). With the exception of Groups C and D, the turtles showed significant group orientation (Rayleigh $p < 0.05$).

DISCUSSION AND CONCLUSIONS

Loggerheads at Woolbright Road and Carlin Park did not appear to be influenced by the street lights. There was no significant difference in orientation between the turtles exposed to filtered and unfiltered lighting at either site. However turtles tested at Carlin Park under all conditions showed more scatter in orientation than those at Woolbright Road. These differences may be related to the presence of a higher, and darker, background of sea grapes along the landward horizon at Woolbright Road than at Carlin Park. These cues toward land apparently had more of an influence on hatchling orientation than the street lights, which were relatively dim (70w).

Filtering the lights further reduces their intensity while illuminating roadways. Thus even though our results fail to show a difference between how loggerheads respond to filtered and unfiltered lighting, that might not be true in the absence of landward vegetation. Thus we suggest that these filters should always be used with low wattage (70w HPS) luminaires near loggerhead nesting sites—that is, in cases where the street lights must be left on.

Leatherback hatchlings were affected by exposure to filter lighting. In contrast to loggerheads, leatherback orientation was affected by exposure to filtered lighting. The extent of that effect was correlated with background illumination provided by the moon. In the absence of moonlight, orientation was most seriously affected. The presence of lunar illumination increases background light levels, and thus weakens or eliminates responses to street lighting (Salmon and Witherington, 1995).

Green turtle hatchlings exposed to the filtered light were in some cases attracted toward the light source. Green turtles are attracted to monochromatic light sources between 350-600 nm; as wavelength increases from 600 nm to 650 nm, their attraction gradually changes to “indifference” (Witherington and Bjorndal, 1991). The Acrylic #2422 filter transmits more light as wavelength increases from 540-600 nm; at wavelengths above 600 nm, it allows most (90%) of the light energy to pass to the environment.

Taken together, the data show that the filtered light does not protect leatherback and green turtle hatchlings. The green turtles showed a considerable decrease in their ability to orient toward the sea and were attracted towards the filtered light. The leatherbacks were less affected, but some individuals also crawled toward the filtered light.

More tests with new filters are necessary to protect sea

turtle hatchlings other than the loggerhead. Loggerheads are probably not good “models” for the other hatchling species, as they are less sensitive to the longer light wavelengths (Witherington, 1992).

Use of the Acrylic #2422 filter where other species of sea turtle nest cannot (at present) be justified! General Electric Corporation is currently selling the Acrylic #2422 filter for use on coastal beaches internationally, even though there is no data that proof its effectiveness for any species other than the loggerhead. Thus, the use of these filters without testing could have disastrous effects upon sea turtles hatchlings, worldwide.

ACKNOWLEDGMENTS

The Florida Department of Transportation supported this project. In addition, it would not have been possible without the cooperation of the Florida Power and Light Company, which graciously provided the personnel each evening to install the street light filters and to turn the lights on and off.

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Potential Effect of Long-term Upland Sand Deposition on Florida High-density Nesting Beaches

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INTRODUCTION

Traditional borrow sites (i.e., submarine sand) for beach nourishment are becoming increasingly difficult to locate and extract economically (Stauble, 1991; Scott, 1980; Finkl, 1993), so that non-traditional borrow sites, like upland or imported, are being evaluated for alternative sand sources (Olsen, 1991; Williams, 1995; Cummings, 1997). Consequently, questions may be raised about how long-term deposition of non-traditional sand could negatively affect beach environment, and ultimately nesting marine turtles.

This study was specifically designed to quantify the physical attributes of a high-density nesting beach, which

was renourished with upland sand. During the winter 1996-97, 200,000 yd³ of sand was obtained from an upland borrow site located on the Atlantic Coastal Ridge, and placed on eroded beaches of Sebastian Inlet, Florida. Monitoring was initiated one year prior to nourishment (1996) and undertaken during three consecutive post-nourishment years (1997-1999). The 1996-98 data was already reported by Magron *et al.* (1999) and it indicated strong significant differences in 1997 immediately after nourishment. In 1998, most of the significant differences remained but their magnitude decreased, which then suggested initial stages of convergence towards pre-nourishment conditions. The study is now complete with the collection of the 1999 data, so in this paper we will (1)

review the results of 1999 data, (2) evaluate the four-year impact assessment, and finally (3) discuss the potential effect that long-term upland sand deposition may have on Florida high-density nesting beaches.

METHODS

Physical monitoring of the beach was conducted monthly during each nesting season (May through October). Assessment of the beach physical environment consisted of surveying different physical attributes, to influence the marine turtle nesting sequence (Table 1). Each beach study site was monitored along four alongshore transects and sampled at three crossshore stations: (1) toe of the dune, (2) mid-backshore, and (3) spring high water level. For each station, two samples were collected respectively at 30 cm and 60 cm from which a single mean value was calculated to represent the station.

The data was subject to a BACI statistical method (Before and After Control/Impact) for impact assessment (Underwood, 1991). Differences of means between the Control and Impact beaches were compared for each pre- and post-nourishment monitoring interval (1996 vs. 1997, 1996 vs. 1998, and 1996 vs. 1999). An alteration of the physical attributes is determined whenever a post-nourishment data set deviates significantly from the pre-nourishment data set.

RESULTS AND DISCUSSION

When looking at the statistical results, the 1999 physical conditions of the nourished beach are nearly similar to the 1996 pre-nourishment conditions (Table 2). The 1999 data sets for shear resistance, relative density, grain size, carbonate content, and temperature are not significantly different from pre-nourishment values. Even though relative moisture and mud content are significantly different, a closer look at Figure 2 reveals the magnitude of the 1999 difference of means to be relatively similar to pre-nourishment values.

The BACI statistical results (Table 2) corroborate the 1996-1999 graphical analysis (Fig. 1). Indeed, the initial alterations of 1997 on the nourished beach gradually decreased over the three post-nourishment years. The degree of significance declined and the magnitudes of the differences of means converged to pre-nourishment conditions until nearly recovery in 1999. During the 1998 nesting-season, Magron *et al.* (1999) identified the first recovery at the seaward crossshore stations (Spring-High Tide), and by the 1999-nesting season, the recovery was detected on all crossshore stations. This recovery process was easily explained by the evolution of the nourished beach profile (Fig. 2), which resulted in landward retreat and elevation lowering so that the 1999 sampling moved into pre-nourishment sand. The nourishment berm had been

gradually adjusted not only by wave and tide forces, but also by mechanical grading and tilling prior to the 1998 nesting season. In due course, barely all of the nourishment material had been removed and assimilated within the beach environment during the three-post nourishment years. Erosion of the nourished profile also accounts for the better-sorted sand in 1999.

CONCLUSION

This study documented a three year recovery, which is consistent with other programs (Steinitz *et al.*, 1996). An inspection of beach profile indicates that recovery has occurred along profile adjustments through mechanical action and erosion. Consequently, the use of the upland borrow site on the Atlantic Coastal Ridge for beach nourishment at Sebastian Inlet appeared to be an acceptable alternative sand source. The potential effect of long-term upland sand deposition on Florida high-density nesting beaches may be minimized as long as the selection, placement, and post-nourishment management of the upland sand follows the directions of this project at Sebastian Inlet. Nourishment frequency, though, needs to be further investigated.

Casual observations of the biological data (obtained by a collaborative team from UCF) suggested the altered physical parameters had apparently no biological significance on hatching success or incubation length. Only nesting success was considerably reduced in 1997 due to scarping formations. Unfortunately no sampling design was developed to measure scarping frequency in order to conduct valid statistical analysis.

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Table 1. Synopsis of the beach physical attributes monitored in this study and their known influences on the four phases of the marine turtle nesting sequence

Physical attributes	Marine turtle nesting sequence			
	Phase 1	Phase 2	Phase 3	Phase 4
	Female emergence and nest site selection	Nest excavation and egg deposition	Nest incubation and embryonic development	Egg hatching and hatching emergence
Beach profile	X		X	X
Shear resistance		X		
Relative density		X	X	
Relative moisture content		X	X	X
Sand texture		X	X	
Sand composition			X	
Sand temperature	X		X	X
References	Raymond, 1984; Nelson <i>et al.</i> , 1987,1988; Ehrhart, 1994; Rimkus <i>et al.</i> , 1995; Wood, 1998; Mortimer, 1980; Stoneburner <i>et al.</i> , 1981	Ackerman, 1980,1981; Raymond, 1984; Nelson, 1987,1991; Nelson <i>et al.</i> , 1988; Mortimer, 1990; Lutz <i>et al.</i> , 1991; Ehrhart, 1994; Ryder, 1992; Rimkus <i>et al.</i> , 1997	Crain <i>et al.</i> , 1995; Carthy, 1994; McGehee, 1978; Mrosovsky <i>et al.</i> , 1980; Limpus, 1983; Miller, 1985; Witherington, 1990; Cheeks, 1997; Ackerman, 1980,1981,1991; Mortimer, 1981; Milton <i>et al.</i> , 1997; Mann, 1977; Packard <i>et al.</i> , 1977; Bustard <i>et al.</i> , 1967	Carthy, 1994; Witherington <i>et al.</i> , 1990; Ehrhart, 1998; McGehee, 1990

Table 2. Summary of the BACI statistical results on the physical attributes for each pre- and post-nourishment monitoring interval. The differences of means are presented along with the degree of statistical significances (ns = not significant, * =95% confidence limit, ** =99% confidence limit, *** = 99.9% confidence limit). A collaborative team from UCF provided the biological data of each nesting-season. Note that casual observations on scarping are presented but they have no applicability to the BACI analysis. Temperature was the only physical attribute to be not impacted during the entire study.

Beach physical attributes	Pre-nourishment		Post-nourishment				Biological observation
	1996	1997	1998	1999	1998	1999	
Scarping presence (field observations, no analysis)	None	Permanent scarping on impact beach	None	Late-season scarping on both beaches			1997: scarping altered nest-site selection and nesting success. Higher nest destructions (washed out or depredated) and greater non-digging false crawls. 1998-1999: scarp was leveled down resulting in no further alterations on nest-site selection and nesting success.
Shear resistance (psi)	8	145 **	148 **	54 ns			1997-1998: harder substrate accounted for misshapen egg chambers, shallower nests, which in turn resulted in higher nest depredation. However, no increase in abandoned body pit/egg cavity type of false crawls. 1999: no alteration on nesting success
Relative bulk density (%)	-9.70	1.4 *	3.8 ns	-11.60 ns			
Relative moisture content (%)	0.20	8.4 ***	7.5 ***	2.10 *			
Mud content (%)	0.00	0.50 ***	0.50 ***	0.03 **			
Mean grain size (phi size)	0.48	0.87 ***	0.74 ***	0.60 ns			1997-1999: no alteration on incubation length, nor hatching success. No monitoring was conducted on sex ratio.
Mean grain size (mm)	-0.16	-0.23	-0.19	-0.16			
Sorting (phi size)	-0.01	0.09 ns	0.09 *	-0.12 **			
Carbonate content (%)	-18.60	-37.9 ***	-30.20 ***	-20.10 ns			
Temperature (°C)	-0.60	-0.90 ns	-0.80 ns	-0.60 ns			1997-1999: no alteration on incubation length. No monitoring was conducted on sex ratio.

Fig. 1. “Impact minus Control” differences of means for each physical attribute during 1996-1999 monitoring program. Concave trend reflects initial impact to all physical attributes, followed by a gradual convergence to pre-nourishment conditions. The horizontal line represents the differences of means prior to nourishment; any post-nourishment deviation above or below that line respectively means an increase or a decrease due to the nourishment. Error bar is one standard deviation and the gray arrow represents the nourishment disturbance.

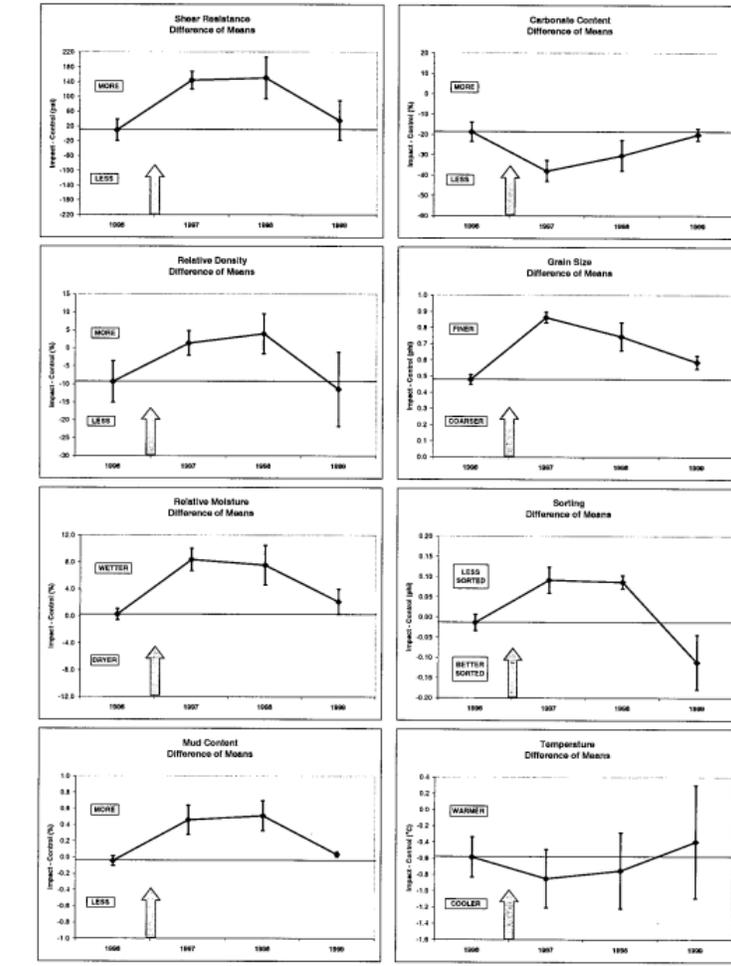
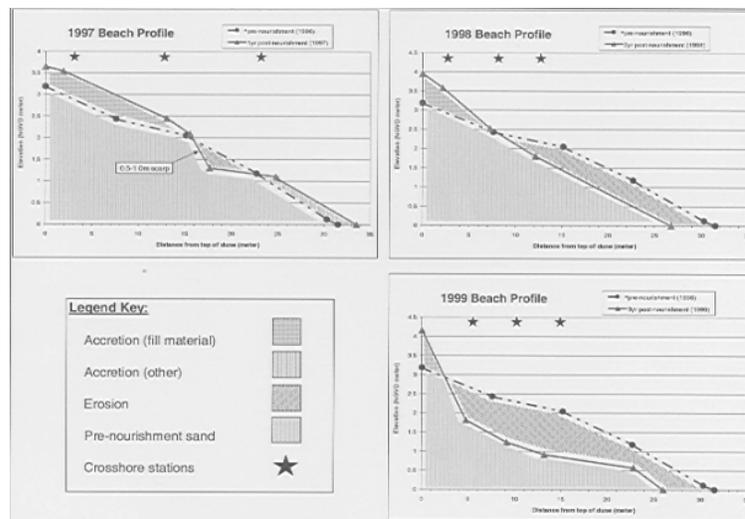


Fig. 2. Comparison of the Impact beach post-nourishment (1997-99) versus pre-nourishment (1996) profiles. Natural forces (i.e., waves and tides) undertook the adjustments of the nourished profile, but they were also supplemented by mechanical action. In 1998, bulldozers pushed the sand down to the sea (grading and tilling) in order to knock down scarp formations. This explains the recovery rates of the physical data as sampling was gradually done within pre-nourishment sand. The profiles were averaged from May to October of each nesting-season.



The Sea Turtles of Suriname, 1999 Project: Research for Conservation

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As a part of "The Sea Turtles of Suriname", 1999-project, that was carried out by Biotopic, several aspects of the nesting ecology leatherbacks (*Dermochelys coriacea*) and green turtles (*Chelonia mydas*) were studied in the Galibi Nature Reserve. The main goal of this study is to develop a better nest relocation method. The effects of abiotic factors on emergence success of leatherback and green turtle nests were investigated. In May, June and July, several leatherback and green turtle nests that were laid on 2.3 km of the main nesting beach were localized and

recorded. Results of a study carried out in 1997 in the same area show that nests laid below 2 m below the Spring Tide Line are doomed. Doomed nests and nests threatened by poaching were localized and replaced to a hatchery. After the incubation period, all nests were excavated, the emergence success, predation rate amongst others were determined. A comparison of emergence success has been made between natural and relocated. Relocation methods, predation, inundation and rainfall seem to determine the differences in emergence success.

Magnetic Field Distortions Produced by Wire Nest Cages II: An Update With New Data

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INTRODUCTION

Loggerhead sea turtles return to their natal beach region to mate or nest (Encalada *et al.*, 1998). The sensory basis of this homing is not known. One hypothesis is that hatchlings imprint on magnetic features of the natal beach and use them in homing (Lohmann and Lohmann, 1996, 1994). If such imprinting occurs, however, turtles that experience an unnatural field during development may have difficulty navigating back to the appropriate region.

A common conservation practice is to enclose turtle nests in galvanized wire mesh cages to protect eggs from raccoons, foxes and other predators. Two cage designs, a cube and a dome, are often used. We investigated whether these protective cages altered the local magnetic field at the position of the developing eggs. Specifically we asked:

1. Do nest cages distort the local magnetic field?
2. Is there a difference in field distortion at different levels or between different cage designs?
3. What are the geographical equivalents of these distortions that might cause navigational errors if sea turtles are homing using these cues?

METHODS

Ten cube-shaped and ten dome-shaped galvanized steel wire cages were tested. Each cage was placed in an area with good uniformity of the Earth's magnetic field. The cube cages were similar in design to a popular design (Addison, 1997) with dimensions approximately 60 cm x 60 cm x 60 cm. The dome cages were of prototype design with

dimensions roughly 90 cm x 90 cm x 45 cm. All cages were previously used on south Florida beaches.

Measurements of the magnetic field were made immediately beneath and 25 cm below each cage at nine different points: center, each corner, and each side midpoint. Cages were aligned with one side parallel to the north-south axis of the local magnetic field. The change in horizontal and vertical components of the magnetic field due to a cage were measured using an Applied Physics System 520 triaxial digital fluxgate magnetometer.

From these measurements, the change in total field intensity and inclination angle were calculated. The magnitude of the changes at each point was averaged for each distance, and this "plane average" was used for comparison. Statistical analysis of the distortion differences between each cage type at the same level and between different levels for the same cage type were made using a t-test.

RESULTS

The local magnetic field within the test area had an intensity of 39.7:T and an inclination angle of 58.7°. All 18 points measured for all 20 cages altered the local field in some way. Distortions ranged widely but were clearly less dramatic with increasing distance from a cage. For both cage designs the magnitude of distortions of both intensity and angle were significantly greater immediately beneath the cages than 25 cm below ($p < 0.001$, t-Test). Both intensity and angle distortions were significantly greater close to the cube type cages than close to the dome type

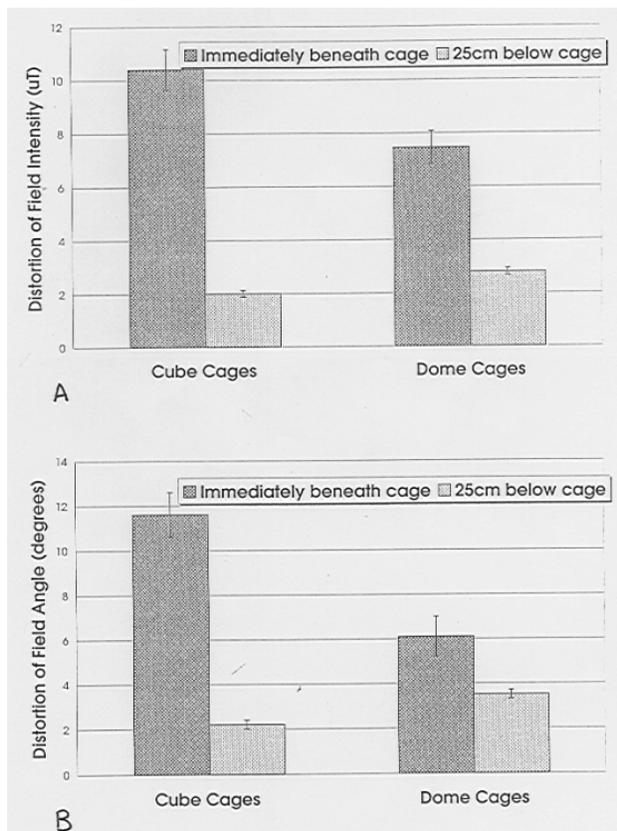
cages ($p < 0.001$, t-Test), but were both significantly greater 25 cm from the dome cages than 25 cm from the cube cages ($p < 0.001$, t-Test). A summary of measurements is presented in Figure 1.

DISCUSSION

Each cage measurably altered the inclination angle and intensity of the magnetic field beneath it, but the magnitude of field distortions decreased with distance below the cage (Fig. 1). Thus, the field change that developing eggs will experience depends on their position relative to the cage. Distortions caused by the dome cages appear more severe at each level than those of the cube-shaped cages. Since the magnitude and direction of distortions varied widely, and individual cages are likely to differ greatly there is no way to predict the field deviations at any specific location.

Though the geographical distance corresponding to changes in magnetic field parameters of this magnitude vary with location, there is no way to predict what effects these alterations may have on the homing ability of individual turtles. Using current geomagnetic maps and the data obtained with the cages tested, hypothetical geomagnetic positional displacement was calculated for a typical

Fig. 1. Comparisons between cage types and measurement levels. The average distortion at each level for each cage type is indicated. A. Distortion in local field intensity. B. Distortion in local field angle.



loggerhead nesting area near Boca Raton, Florida (Fig. 2).

Because nest depth and cage position relative to the eggs may vary, the averages calculated should be used only as relative comparisons between depths and between cage designs. We emphasize that, at present, no direct experimental evidence exists to support or refute the magnetic imprinting hypothesis. Thus, the potential risk of disrupting magnetic navigation must be weighed against the very real threat of nest depredation. Appropriate choices of construction material and cage design can minimize effects of field distortion in areas where cages are needed.

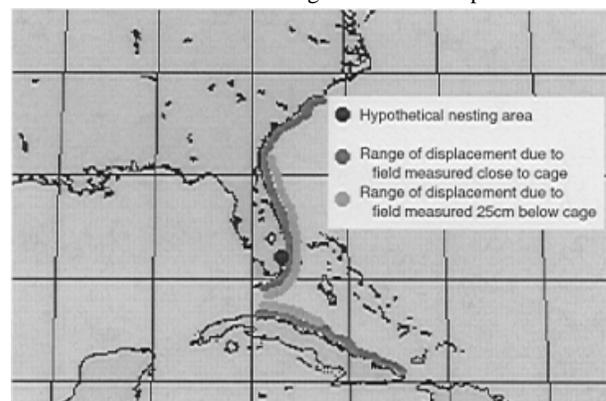
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Fig. 2. Possible navigational errors caused by field distortions. For this example, the geographic range of the shoreline equivalent to the inclination angle measurements made below the dome cage is shown. If turtles imprint on inclination angle at their natal beach and use this information for homing, they may return to a different region along the coast. Other ways of using the geomagnetic information could lead to either larger or smaller displacements.



Documented Effects of Coastal Armoring Structures on Sea Turtle Nesting Behavior

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INTRODUCTION

As do other sandy beaches around the world, the ocean beaches of Florida erode and accrete. During the erosion phase of this cycle, man-made structures built close to the beach become threatened. In response to this threat many property owners in Florida have built coastal armoring structures to protect their upland property from erosion. The number of these armoring structures in Florida is increasing (Schmahl and Conklin, 1991). Superimposed upon the value of Florida's beaches to coastal property owners is the importance of Florida beaches to nesting sea turtles. Florida beaches host approximately 95% of all the sea turtle nesting in the continental United States (Turtle Expert Working Group, 1998).

In a study of the impact of coastal armoring structures on sea turtle nesting behavior, seawalls were shown to have had detrimental effects on sea turtle nesting (Mosier, 1998). Results showed that fewer turtles emerged onto beaches in front of seawalls than onto adjacent, non-walled beaches, and of those that did emerge in front of seawalls, more turtles returned to the water without nesting. The threat for nesting sea turtles posed by seawalls may lie in a reduction of nesting habitat, in an elevation of the physiological cost of nesting, and in displacement of turtles into nesting habitat that is sub-optimal (e.g., a lower beach elevation where eggs would drown; Murphy, 1985).

There are few data available that examine potential effects from beach armoring on nest site choice in sea turtles. Consequently, coastal resource managers are left with few details on how differently constructed and positioned armoring structures affect sea turtle nesting. This means that there are no appropriate definitions for coastal armoring from a nesting sea turtle perspective.

In response to the need for such a definition, a follow-up study was conducted during the 1999 nesting season comparing the effects of different types of armoring structures, placed on various parts of the beach. A central goal of the analysis was to define coastal armoring from the perspective of effects on sea turtle nesting. Our objectives were to map and characterize the dune (vegetation, armoring structures, topography) on a two-mile stretch of nesting beach in order to analyze the nesting attempts by loggerhead turtles. These data were used to test the hypotheses that predict nest-site choice and nesting behavior dependence upon dune character (e.g., the presence of armoring).

METHODS

Study Area

The study area was a two-mile stretch of beach at Jupiter Island on the southern Atlantic coast of Florida. Bordered by St. Lucie Inlet to the north and Jupiter Inlet to the south, the island has experienced chronic erosion problems that threaten the private property of its coastal residents (Clark, 1989). In response to erosion threats, approximately 80% of the shoreline on Jupiter Island is protected by varying types of coastal armoring (Aubrey, 1995).

Jupiter Island is also a critically important nesting beach for sea turtles. Density of loggerhead (*Caretta caretta*) nesting is particularly high, with the number of nests per mile ranging from 200 to greater than 1300 (Steinitz, 1994), which is one of the highest densities in the state (Conley and Hoffman, 1986, Meylan *et. al.*, 1995). Additionally, Jupiter Island is part of Florida's Index Nesting Beach Survey program and is represented by ten years of detailed nesting data.

Mapping Dune Character

We mapped and characterized all structures on the beach and primary dune that had the potential to significantly affect the nesting behavior of sea turtles including; 1) all man-made structures greater than one meter in continuous breadth that might be a physical barrier to nesting turtles attempting to access the sandy dune or 2) structures that are greater than one meter in continuous breadth and that visually subtend a vertical angle of 30° or greater from the perspective of an observer looking landward at the base of the dune (or structure). All position data was collected using a Trimble differential correction Global Positioning System (DGPS). We mapped armoring structures by recording beginning and end (e.g., north and south) points at individual structures and by assigning them to discreet categories. We used seven categories which included: vertical seawall; vertical seawall with dune in front; vertical seawall with rocks in front; revetment wall; revetment wall with dune in front; natural dune, and natural dune with rocks in front.

Mapping and Characterizing Sea Turtle Nesting Attempts

Evidence of sea turtle nesting attempts was judged by the track and nest sign left in the sand the morning following nightly sea turtle nesting attempts. Each location where a nesting attempt had been made was identified to species

(principally loggerhead and green turtle, *Chelonia mydas*) and categorized as 1) track only; 2) track and abandoned primary body pit with no nest; and 3) a nest. A DGPS position was taken at each nesting attempt at the point where the turtle turned toward the surf to return to the sea (which for a successful nesting attempt is nearly always the position of the nest itself). To reinforce the linkage of nesting data to mapped dune-character data, we recorded the character of dune (or armoring) immediately landward of each of the nesting-attempt positions.

RESULTS

A total of 989 loggerhead emergences were recorded along the two mile stretch of study area. There were 444 nests and 545 non-nesting emergences (false crawls). Turtle emergences were not evenly distributed between the different stretches of beach. There were more emergences reported on those stretches of beach that had dunes present than on the beaches that did not have dunes ($P = 0.02742$). There were also differences in the nesting success on the beaches with walls and no walls ($P < 0.0001$).

DISCUSSION

Similar to the findings in the previous coastal armoring study (Mosier, 1998), overall, there were fewer successful nesting emergences in front of the various armoring structures than in the non-walled "natural" areas (the high nesting success of the sloped revetment wall was most likely an artifact of the low sample size in that area) (Fig. 1). Unlike the previous study, this study offered the opportunity to explore differences between different types of coastal armoring structures in addition to comparisons between armored and non-armored beaches. There appeared to be an increase in the number of emergences in front of structures with dunes in their characterization ($P = 0.027$) (Fig. 2). These results suggest that turtles may have used the dune profile as a visual cue in the emergence decision making process. However, despite the increase in emergences in front of structures with dunes, there were fewer nesting successes on those stretches of beach than on the non-armored beach, suggesting that there are still other confounding cues to the nest site selection process.

CONCLUSION

These data, along with nesting behavior studies, nesting population biology and life history studies, coastal erosion studies, and coastal engineering studies indicate that the armoring of Florida's shoreline poses a significant threat to sea turtle populations. But the problems associated with coastal armoring are complex and span many disciplines of knowledge, all of which must be integrated in order to

create changes. Meanwhile, turtle nesting habitat continues to be replaced by walls.

In the interest of time, turtles and economics, data must be strategically collected. In order to reach the final goal of protecting turtle nesting habitat from coastal armoring influences, current regulatory policies must be changed. These changes cannot take place without help from the public, whose support is dependent on their perceptions of the problem. The turtle biologist must now either wear additional hats as sociologist, psychologist, economic and political analyst or integrate research efforts with the experts in these disciplines. Above all, we must keep the final goal in the forefront when developing our research plans.

ACKNOWLEDGMENTS

We wish to thank Sarah Dobsa, a graduate of Fairleigh Dickinson College who collected all of the nesting data for this study while working as an intern for the Florida Marine Research Institute. We also thank Chris Koepfel for assisting in the field work, and the Bureau of Protected Species Management for reviewing the study design to ensure optimal management applications.

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Fig. 1.

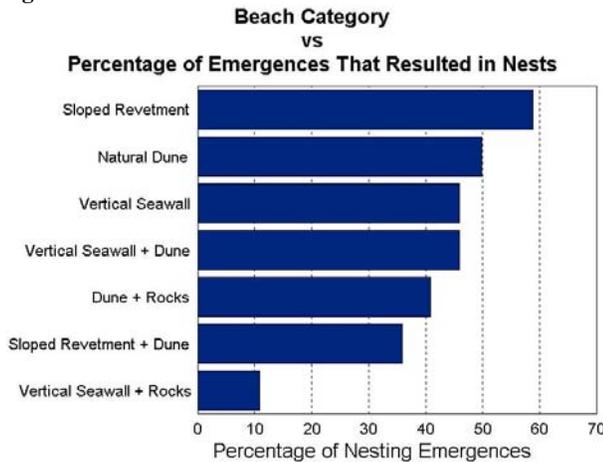
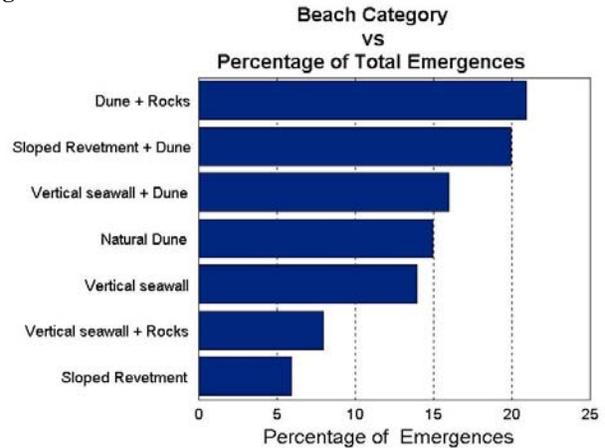


Fig. 2.



An Alternative Nest Marking System for Populated Beaches with a History of Poaching

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INTRODUCTION

Many beaches have sea turtle projects devoted to the protection and monitoring of sea turtles. The collection of hatching data requires nests to be marked on beaches where nests are not relocated to hatcheries. Wooden stakes have been the preferred nest marker for the Jekyll Island Sea Turtle Project. One method of marking nests with wooden stakes is to place three or four stakes around the nest and flagging tape around the stakes. Along with public education, marking nests in this way is effective for alerting beach goers to the presence of sea turtle nests. However, this method also gives the exact location of the nest to would-be poachers. In areas such as Coastal Georgia, the consumption of sea turtle eggs has been a part of cultural diet for hundreds of years. Despite current laws, some people find it hard to give up such aspects of their culture. Factors such as this reinforce the illegal taking of sea turtle eggs. When evidence of poaching came to light on the beaches of Jekyll Island, technicians altered their nest marking system. In an effort to make the exact location of nests less obvious, technicians began using a single stake, placed one stake's length above each nest. Poaching continued to take its toll on Jekyll as poachers soon figured

out how to find the nests. Populated beaches with a history of poaching need nest marking systems with multiple and variable aspects to decrease poaching.

METHODS

In 1998, experimentation with alternative nest marking on Jekyll Island reduced the percent of nest poached. The nest marking system we offer was developed on Jekyll Island in 1998 and used during the 1999 season. Three basic aspects are employed in this method. First, two stakes are used to mark each nest. Second, each stake is placed in variable positions relative to the nest. Finally, compass bearings are taken for the nest's relative position.

The exact location of the nest chamber must be found for this method to be effective. Each stake used should have the nest's number written on it. A standardized mark indicating north for one stake and south for the other stake should also be written on each stake respectively. The second aspect of this method utilizes three different lengths of rope, such as 4 ft, 6 ft, and 10 ft. These ropes can be color-coded to aid in quick identification. Each rope should have a loop on one end. Two different lengths of rope

will determine the distance each stake is placed from the nest. Hold the open end of one rope over the nest chamber. Put a stake through the loop on the other end and extend the rope to the north of the nest (Fig. 1). Repeat this process with the other rope and stake but extending them south of the nest (Fig. 2). Variability of stake placement should be increased by randomly altering the east/west placement of each stake. Finally, use a compass to take bearings from each stake to the nest. Compass bearings can be used to replace pulled stakes or to locate nests in the event a hatching is missed. Once the nest is marked, the nest site must be made less conspicuous by smoothing out the body pit and obliterating the crawl.

RESULTS AND DISCUSSION

In 1997, 25% of the nests were poached on Jekyll. Altering the nest marking system in 1998 reduced the number of nests poached to 6%. The 1999 implementation of the system previously described further reduced the number of nests poached to 3%. Many stakes are pulled by uninformed beachgoers; therefore, having two stakes reduces the chances of losing a nest's location on populated beaches. Individuals not directly involved with monitoring nest activities should remain uninformed regarding the details of the marking system in use. Marking nests at night will decrease the chances of a would-be poacher discovering particulars of the system, which could aid in finding nests. This system would be most effective on portions of the beach with low natural predation, such as the

middle and south end of Jekyll Island. Predator control efforts such as screening would negate the ability to use a discrete marking system.

Fig. 1. The first step in marking a nest.

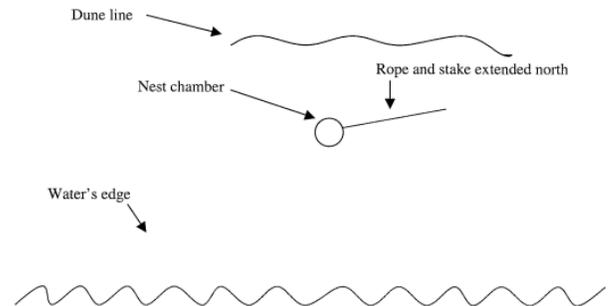
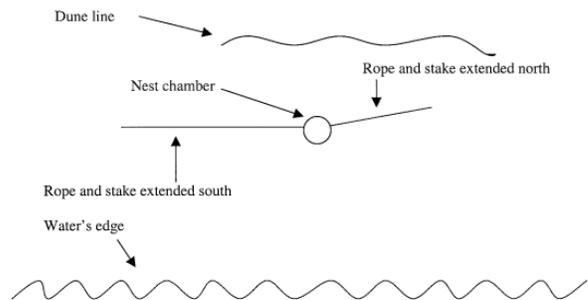


Fig. 2. The second step in marking a nest.



Statistical Power and Sample Size Determination - Know Before You Go

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Statistical testing is commonly used in the biological sciences to identify relationships or to test for differences (or similarities) among the variables of interest. An enormous amount of time, money and effort is spent collecting data to test a particular hypothesis. Unfortunately, often times insufficient effort is allocated to determining the usefulness of that data to answer the research question with statistical confidence. Sometimes sample size alone can determine the outcome of a study before it is actually carried out. For example, a sample size that is too small can result in failing to detect biologically meaningful results and incorrect conclusions can be drawn. In contrast, with a exceedingly large sample size, any

statistical test can show a significant difference even when it may be biologically meaningless. Statistical power relates to the confidence in the conclusions of hypothesis testing. Power is dependent on the sample size, variability in the data, the desired size of the detectable difference, and the type of error one is willing to make. Today there are tools readily available for researchers to accurately determine the sample sizes needed to conduct a statistically sound experiment. The purpose of this article is to emphasize these concepts, the tools for sample size determination, and to provide examples related to sea turtle research.

Sand Dune Restoration Behind the Nesting Beaches of Lakonikos Bay, Greece

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The coastline of the Evrotas delta and the nearby beaches are the fourth largest nesting rookery in Greece for the loggerhead sea turtle (*Caretta caretta*), hosting an average of 183 nests annually. The extensive sand dunes that once lay between the beach and the low-lying wetlands are now greatly reduced in area by agricultural conversion, and degraded by numerous damaging activities. Channelization of the Evrotas River has also led to severe coastal erosion. Sand dunes are a protected habitat under the EU Habitats Directive, they also fulfill a vital role in maintaining the beaches and protecting the coastal zone. Under the LIFE-Nature project, Archelon, in cooperation with local authorities, carried out several projects aimed at the protection of these dunes and restoration of damaged and degraded areas. Several different types of sand-trapping fences were built to determine effectiveness, then two larger areas were selected for pilot projects. Monitoring showed high rates of sand accumulation in some areas, up to 50 cm over nine months. Once a good dune profile is achieved, transplanting of native Marram grass will restore the natural functioning of the dune system. In the management plan prepared by Archelon-STPS and the Hellenic Ornithological Society, other sites along the nesting beaches are identified where dune restoration and protection works are necessary. Combined with proposals for the re-creation of other areas of coastal wetlands and the reformation of the river, the natural function of a coastal delta may be recovered, so protecting the nesting beaches.

INTRODUCTION

Lakonikos Bay is found at the southern tip of the Peloponnese, Greece. The five separate nesting beaches have been monitored by the Sea Turtle Protection Society of Greece since 1985. Totaling 23.5 km, they host on average 183 loggerhead sea turtle (*Caretta caretta*) nests each year. The works described in this paper were concentrated on the main beach of either side of the mouth of the Evrotas River. Sand dunes exist behind much of the 15 km of the Evrotas nesting beach. According to the classifications defined in the European Union Habitats Directive (92/43), three types of dunes are found in the area: Mediterranean embryonic shifting dunes (2110); shifting (White) dunes along the shoreline with *Ammophila arenaria* (2120); and fixed dunes with herbaceous vegetation (2130). The endangered sea daffodil (*Pancratium maritimum*) occurs extensively and is indicative of the rich flora of the area. The nearby coastal wetlands are important habitats for migratory birds, being the first stopover opportunity on the European mainland along this flyway. Extensive beds of seagrass (*Posidonia oceanica*) are found

offshore. Due to its important habitats and species, the Evrotas Delta has been included in the Natura 2000 network of proposed protected sites. The current LIFE-funded project operated by Archelon-STPS is designed to continue monitoring and baseline data collection, to prepare a management plan, and to develop and implement conservation management programs.

Land Use Changes

Analysis of aerial photographs showed that there have been dramatic changes in the Evrotas Delta over the last decades (Fig. 1). Conversion of wetlands and sand dunes to agricultural fields was in line with national priorities and policies of the day. Since 1945 the area of dunes has been reduced by 76%, and coastal wetlands by 47%. Prior to 1945, 3,700 ha of citrus and olive groves already existed. Another significant change was the channelization of the Evrotas river, resulting in severe beach erosion and coastline regression 2.5 km either side the river mouth. It is estimated that the coastline has retreated 175 m at the worst point. Erosion has slowed to 1m/year. Other activities which destroy and degrade these dunes are sand extraction, road-building, vehicular access, rubbish dumping, afforestation, and the construction of illegal beach homes.

Rationale

Management practices on the beach itself are well established, and include in situ nest protection and transfers. Extending management to the sand dunes was deemed important for several reasons: buffer zone. It has been observed in many of the nesting areas in Greece, that once the sand dunes are destroyed, severe and usually irreversible impacts will soon follow. Management of the dunes, both protection and restoration, will help preserve this buffer zone behind the beach.

Land Ownership

Under existing Greek land law, sand dunes can be classified as 'forestland' and therefore come under public ownership. Some dune areas are privately owned, and in many areas private ownership is claimed, but awaiting court decisions. Once dunes are converted to agricultural use, ownership effectively defaults to the farmer, since the state has no definitive register of public lands. Any dune management activities funded by the state and EU, both reduces the risk of illegal land appropriation, and helps establish the states' claim of ownership.

Coastal Processes

Sand dunes are an integral part of sedimentary coastlines, acting as a vast natural bank of sediment.

Erosion and deposition continually takes place across the land-sea interface, alternating over time and location. When sand dunes remain intact behind beaches, these natural coastal processes have little or no long-term impact. Without sand from the dunes to replace material eroded, beaches can disappear, and coastlines regress inland.

Light Barrier

The higher relief of sand dunes behind nesting beaches acts to block light from nearby roads and developments. Preserving even a narrow foredune ridge will result in a significantly darker beach, with fewer problems of disturbance and disorientation

Active Management

There are very few examples of environmental management for habitat restoration in Greece. Involving local communities and government in these simple management activities educates them as to the importance of the beach-dune system, and shows to them that effective results can be obtained by relatively inexpensive, but well-planned activities. It can serve as a example to others seeking to involve locals in protected area management.

METHODS

Experiments showed that a double layer of plastic netting was the most effective sand-trapping fencing material (Fig. 2). The 50 cm high fence was stabilized by wooden poles and galvanized wire. Accumulation rates varied greatly, with a maximum of 45 cm in one month (wintertime). If there was no sand accumulation after 12 months the fence was removed. Fencing only works when there is a sufficient supply of wind-blown sand. The cost is \$1/m. Wooden pathways were constructed from local sawmill offcuts, attached on the underside by galvanized wire. Five meter sections can easily be carried to the site, unrolled and fixed in place by wooden stakes at each end. The flexible nature of the path means that if covered by windblown sand, it can simply be lifted, shaken and the replaced back on the surface. The cost is \$2/m. Replanting of the restored dune is done using Marram grass transplants taken locally. Applications of slow release fertilizer ensure rapid growth and good coverage. All work is done using volunteer labor. After a new forestry road was constructed through the dunes, the local Forestry Department planted 10,000 trees along 5 km of dunes. They included Pine, Oleander, Acacia, Eucalyptus and Tamarisk. The management plan identifies this afforestation as a major threat to the dune-beach system, and makes specific recommendations for the removal of all these trees. The management plan also includes many proposals that use the techniques outlined above for dune restoration and reconstruction projects on a larger scale in the area. Proposals are also made regarding reducing the impact of public access to the

beach and dunes system. The conversion of an old schoolhouse to the Evrotas Delta Environmental Education and Information Station (now complete), and appropriate signage and public awareness will facilitate conservation efforts.

CONCLUSION

With the objective of improving protection of the Loggerhead sea turtle nesting beaches of Lakonikos, Archelon-STPS are turning their attention farther afield. The management activities in the dunes, as described here, are ongoing, and will serve as valuable preparation once the protected area is established. The management plan proposes many expanded actions to restore and rehabilitate the sand dune system. It is hoped, that by involving local communities in nature conservation management at this early stage, with proven results, that this will greatly facilitate the operation and acceptance of a future protected area in the Evrotas Delta.

Fig. 1. Land use changes in Lakonikos Bay 1945-1989.

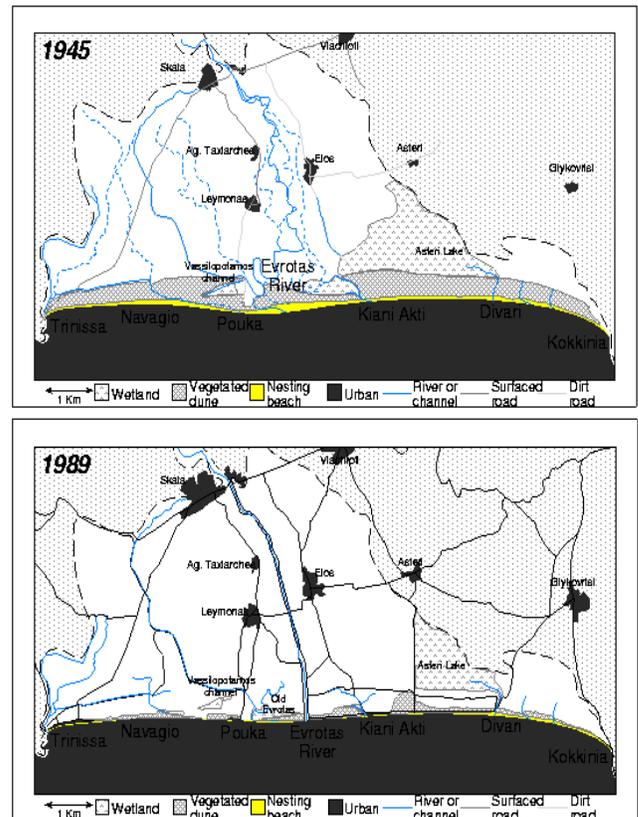
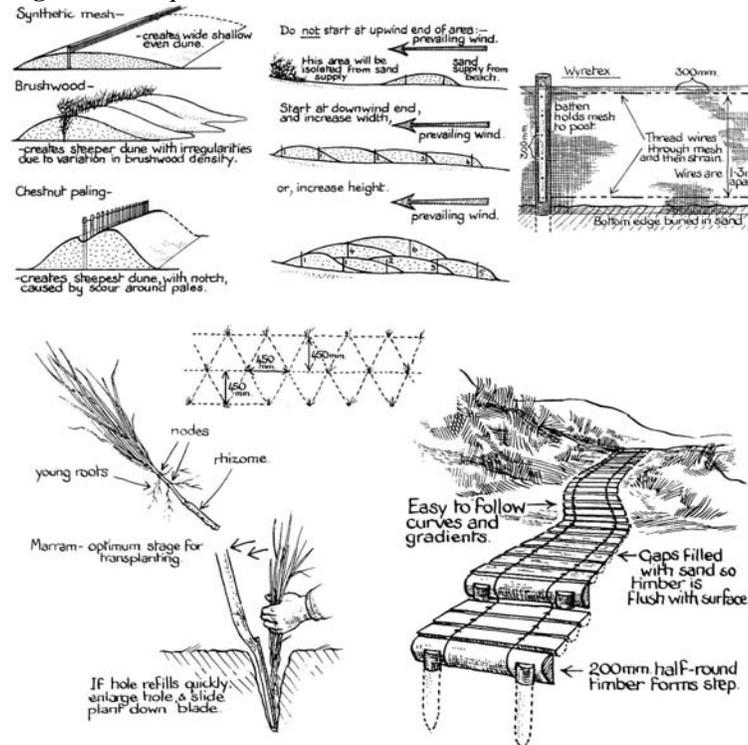


Fig. 2. Techniques used for sand dune restoration.



A Prefabricated Box for Restraining Sea Turtles on Nesting Beaches

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INTRODUCTION

Transporting a pre-assembled wooden box for temporarily restraining post-nesting sea turtles in order to attach telemetry tags can be problematic if the beach is remote or lacks convenient access points. Using screws or nails to assemble a prefabricated restraining box on the beach takes some time and requires that a few more tools be included along with all the other “stuff” that is needed to affix a transmitter to a turtle. Using a prefabricated wooden box with the four sides held together by short lengths of rebar fitted through outside braces has proven to be a viable alternative to the other methods. The design resulted in a restraining device that could be easily assembled on site without tools and could also be adjusted to some extent to fit the size of the turtle. The parts can be carried without great difficulty by two people or, preferably, the pieces can be laid flat on the rear of an all-terrain vehicle for transport. The design also saves considerable storage space if there is a need to transport the parts for long distances aboard a boat. To date, it has been used successfully for restraining loggerhead turtles on remote beaches on Key Island, Florida and on the islands of the Cay Sal Bank, Bahamas.

METHODS

The sides should be formed using 3/8-in exterior grade plywood. Lengthwise, the dimensions should measure 48 in x 21 in while the front end and back ends should be cut to be 31 in x 24 in and 31 in x 15 in, respectively. The lower height of the rear section makes for easier access to the posterior margin of the carapace in order to attach a tether and/or a sonic tag. The outside braces are made from 2 in x 2 in-lengths of pressure treated pine. Pressure treated pine makes stronger joints and is much less apt to split under stress than ordinary white pine, for example. The placement of the outside bracing is depicted in Figure 1. In order to provide a means to adjust the width of the box, the outside braces from the front and rear should be cut so they extend 5 in beyond the ends of the plywood on each side. To adjust the length of the box, the side braces should be cut to extend 4 in beyond the rear end of the sides. The side braces should also extend 3 in beyond the ends on the front portion so the holes for the rebar can be lined up with the holes in the braces for the fronting piece. The holes in the braces

need to be uniformly spaced along the protruding ends of the braces and slightly larger than ½ in diameter so ½ in lengths rebar can easily slide through them. The lengths of rebar needs to be about 38 in long so they can be bent into a J-shape at one end and still be long enough to be pushed into the sand to hold the box in place. Keep in mind that these dimensions were predicated on the fact that we were working with loggerhead turtles. Different dimensions might be more appropriate for other species.

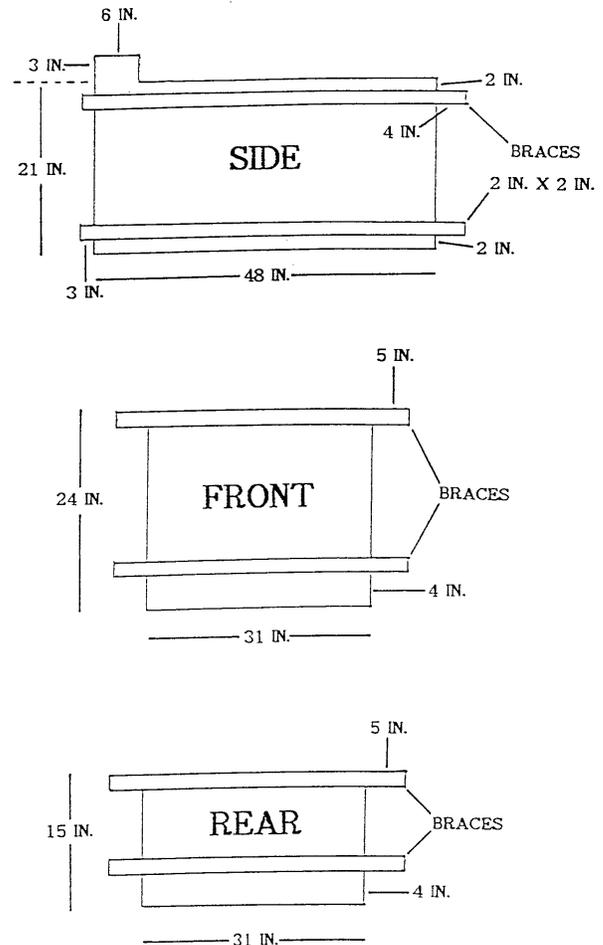
The box is assembled while nesting is in progress. Placing the box over a turtle requires two people. In picking it up, the rebar at both ends must be held so it doesn't slide through the holes in the braces. Once in place, the rebar is pushed into the sand. Some care is needed during this procedure as the turtle's flippers may (will) get in the way. The width of the box can then be adjusted so the turtle can't turn around. This is accomplished by adjusting the rear width of the box. On Key Island, no additional support for the box was used after the turtle was restrained; however, piling sand around the outside of the box is advisable. This step provides more stability and peace of mind, especially if the animal is a robust specimen. If the turtle is going to be held through the night, a section of window screen should be placed over the box to provide the turtle with some protection from biting insects. The screen can be held in place by fastening the screening to the rebar with nylon wire ties. When tag attachment is complete, remove the rebar from the braces and watch her regain her dignity once she enters the water.

ACKNOWLEDGMENTS

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Jim Gore, Tracy Grazia, Markus Henig, Kristen Nelson, Jennifer (Jo) Opdyke, Heather Ross, Nicole Ryan, Dawn Soles, Shelly Steele, and Kathy Worley.

Fig. 1. Dimensions of sides, front, and rear sections of prefabricated box.



A Photographic Documentation of Aborted Nesting Attempts Due to Lounge Chairs

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During the 1998 nesting season, volunteers from the Sea Turtle Conservation League of Singer Island took photographs of nesting attempts believed aborted because of the placement of wooden lounge chairs on a 1.5 mi section of critical nesting habitat on Singer Island, in easternmost Palm Beach County, Florida. Heavy wooden lounge chairs interfered with nesting attempts in 64 sea turtle emergences, resulting in 52 false crawls and 12 nests.

By documenting this on-going problem, it is hoped that new guidelines will be established to safeguard sea turtle nesting habitat around the state.

ACKNOWLEDGMENTS

Thank you to the volunteers from the Sea Turtle Conservation League of Singer Island for photographing and reporting these incidents. Special thanks also to Andrea Mosier, Environmental Specialist at FWC in St. Petersburg, Florida for her encouragement and assistance with the creation of this poster presentation.

Argos: The Mission Continues

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The Argos System is the satellite telemetry system of choice for biologists worldwide. Although the system was initially designed to provide *in situ* data from the earth's oceans and atmosphere, this now 21-year-old system was discovered by the biological community in the early 1980's. In fact, species monitoring and Argos technology have grown together. The demands of collecting sensor data and locating animals in wide-ranging, and remote and hostile environments have continuously pushed Argos to improve the on-board and ground based systems to satisfy these needs. Today, biology applications are the fastest growing of all the monitoring and protection programs in the Argos System. System enhancements, both underway and planned for the near-term, will provide a number of advantages to biologists, such as increased sensitivity and broadening of the bandwidth. Efforts are underway to "channelize" the bandwidth in order to allow low-power transmitters to operate in a dedicated area of the spectrum. In the future, the sensitivity and the bandwidth will be increased again. A downlink capability will also be added to allow users to turn transmitters on/off, download orbital parameters, or modify the characteristics of the sensors or transmitter. All of these improvements will greatly benefit those involved in wildlife management.

ARGOS SYSTEM OVERVIEW

Advances in space technology allow new observational strategies, as satellites provide unrivaled advantages for observing the Earth. The challenge of tracking remote mobile platforms and collecting sensor data was first met in 1978 by the Argos Satellite Data Collection and Location System. Since then, over 20,000 transmitters have been deployed, with more than 7,000 operational today. Much of the worldwide environmental data collected through the Argos System would not be possible to obtain any other way.

The Argos System is dedicated to environmental observation and protection. Today, Argos is the only fully integrated global system that can locate a transmitter and relay the sensor data from anywhere in the world to a user's desktop anywhere else in the world.

Argos instrument packages are currently flown on National Oceanic and Atmospheric Administration (NOAA) polar-orbiting environmental satellites (POES). The orbits are circular and sun-synchronous, and thus each provides daily worldwide coverage. NOAA maintains two satellites in operation, plus one or more in standby, resulting in at least 10 passes per day at mid-latitudes and more than 20 in the polar regions.

Argos-generated positioning information and sensor data are updated after every pass of the satellites for users

to access or receive automatically via telecommunication networks. These data are also archived at the Argos processing centers and made available on floppy disk or CD-ROM.

Two Global Processing Centers, in Toulouse, France, and Largo, Maryland, USA, are fully redundant to maximize reliability. More than 45 countries use Argos for a wide variety of applications.

Argos Unique Capabilities

The Argos System was developed to meet certain global environmental data collection requirements, and therefore possesses many unique capabilities.

On-board Receiver Sensitivity

The high sensitivity of the Argos on-board receiver is a key capability of the system. The uplink data rate (400 bits/sec), a "clean" frequency band (401,650 MHz), remote area operation (without electromagnetic interference) coupled with the high satellite receiver sensitivity provide the unique capability to operate with small, lightweight, and very low power transmitters. The low power consumption of Argos transmitters contributes to platform longevity.

Transmitters

Intelligent Transmitters can be equipped with microcomputers which have sophisticated duty cycles so that data is collected at pre-selected times. Intelligent also means transmitting only when a satellite is overhead. To achieve this, the transmitter can be linked to a receiver tuned to the satellite VHF downlink frequency. The transmitter then comes on only when it detects that signal, resulting in a net benefit to the power budget.

Miniaturized. Very small, very low-power transmitters continue to open up a range of new applications, especially in animal tracking. Some transmitters now weigh as little as 15g, including the electronics, batteries and antenna, and consume as little as 20 to 40 mW.

Argos Doppler and GPS

Argos location capability (based on Doppler effect) continues to be an important characteristic of the system. Argos uses a global network of reference platforms to enhance the Doppler location capability. Doppler location also contributes to simple, low-power platform operation, as the calculation is performed at the Global Processing Centers.

Global Positioning System (GPS) positions are also transmitted through the Argos System. As GPS receivers continuously recalculate position fixes, higher temporal resolution is possible. For example, samples taken every

15 minutes can now be associated with a location. The results are integrated with other Argos data; GPS and Argos locations are presented in the same format (a flag indicates whether the location is Argos or GPS based). Transmitters with built-in GPS receiver electronics are available from most Argos certified manufacturers worldwide.

Worldwide Data Distribution

Automatic Distribution System (ADS). ADS is an Argos developed data distribution system that supplies results automatically, either at fixed times, or whenever new data become available. The User specifies the most appropriate distribution method. For example, in the U.S., many users employ the Internet to receive their data. There is no need to interrogate Argos on-line, as data can be delivered directly to the user's desktop.

Global and Regional Processing Centers

The Argos Global Processing Centers in Largo, Maryland, USA, and Toulouse, France, are operated around-the-clock, seven days a week. Operators and engineers are continuously available for problem solving, or to immediately alert users of transmitter alarms, or other anomalous situations. There are also five Argos User Offices around the world to help users with routine matters such as data processing modifications, or to assist them with data sharing arrangements with colleagues.

Real-time and Stored Data

Timeliness is often critical in environmental studies. Today, over 68% of data processed at the Argos Global Processing Centers is done in near real-time, thanks to data reception through 18 regional receiving stations. When the satellite is in view of a ground receiving station, it will instantly rebroadcast any message for subsequent transfer for processing at one of the Argos Global Processing Centers. In areas served by near real-time coverage, 30% of results are available in less than 15 minutes, and 90% within an hour. Service Argos continues to extend near real-time coverage by adding regional receiving stations.

International Cooperation

Argos' orientation to serve the environmental science community results from the system's government origins. Because of its unique history and position in this community, the Argos System serves as a catalyst for the formation of many international scientific agreements. To date, this has involved some 45 countries. Agreements have extended beyond data telemetry to include other aspects of data collection activity such as platform design and construction, platform deployment, and shared post-processing of data obtained via Argos.

ARGOS: THE FUTURE

The Argos System has evolved along with the

requirements of its User Community. Plans include additional satellites, increased data throughput, higher receiver sensitivity, and the addition of a downlink messaging function (two-way capability). Implementation of these enhancements will be oriented to the requirements of the Argos User Community and thereby, further add to the unique capabilities of Argos.

Together with NOAA, Argos has been making plans for future programs, and is taking its system users' comments into account. For example, beginning with the 1998 launch of NOAA - K, the Argos on-board processing units were doubled. This had the effect of nearly quadrupling the number of platforms able to be received at the same time.

Other significant changes to the instrument on this spacecraft include increasing the bandwidth from 24KHz to 80 kHz, to increase data volume and also to allow the frequency band to be apportioned among platforms having different transmission characteristics (e.g., low power, normal, and short period) and increasing the signal reception sensitivity by three dBm to allow the possibility that weak or environmentally constrained platforms will be received by the satellite, or to permit transmissions at a lower power level (one-half the power in some cases).

Expanding the Satellite Constellation

Beyond the instrument enhancements scheduled, Argos now has an agreement with Japan to fly an expanded instrument on ADEOS II. This instrument will have a downlink messaging capability to allow users to modify the characteristics of their platforms. This new instrument will transform Argos into a two-way communications system. Additionally, an understanding has been negotiated to include Argos on EUMETSAT's METOP 1 and METOP 2 satellites, which are scheduled for launch in the early to mid 2000's.

The downlink messaging capability will be added to the Argos-2 instrument on the Japanese satellite, ADEOS II, in 2001. For the European METOP-1 satellite and NOAA-N', plans are underway for Argos-3, which will incorporate further enhancements, such as another increase of the sensitivity. Plans are also being discussed to allow "channeling" of the bandwidth into sub-bands which could be allocated to different types of applications. For example, different channels of the bandwidth could be used for low-power applications, high data rate applications, or high sensitivity applications. "Channelization" will enable Argos to serve diverse user applications in a more specialized way, and thereby improve results for the user community in general.

THE MISSION CONTINUES

Argos has been serving the scientific community for more than 20 years, in a spirit of worldwide cooperation. The best example of this is the way the system continues to evolve as a partnership between its users and operators. As

in the past, Argos System users are urged to participate in discussions with Argos management to provide input as to program requirements. The enhancements described will allow the user community to satisfy increasingly difficult data relay needs. With a proven, reliable and robust data collection system, Argos continues its observation and monitoring mission well into the next century.

Table 1. Argos enhancements

Enhancement	Operational from
Increased on-board sensitivity	Now (with NOAA-K)
Extended bandwidth	Now (with NOAA-K)
Bandwidth channeling	Mid 2000
Web interface/database management system	Mid 2000
Three times greater system capacity with two satellites	Mid 2000 (NOAA-L)
Downlink messaging (two-way capability)	End 2001 (ADEOS-II)
4.8 kbps high data rate channel	2003 (METOP1)

Fig. 1. Argos system components.

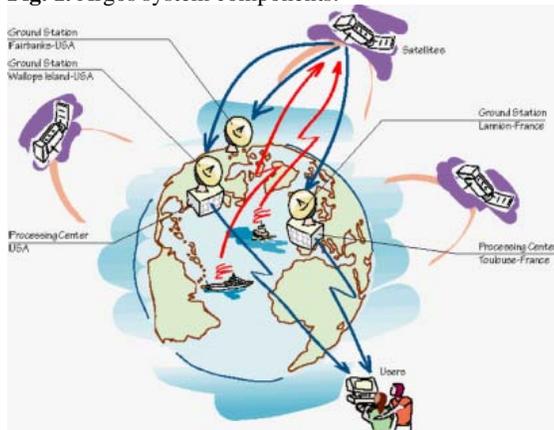
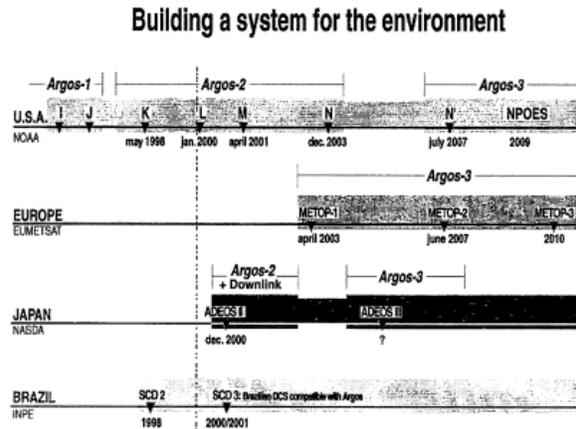


Fig. 2. Argos launch manifest.



A Decade of Land Acquisition to Protect the Archie Carr National Wildlife Refuge, Florida, USA

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INTRODUCTION

In 1989, an unprecedented partnership for conservation and land acquisition evolved in response to: scientific concerns for Florida's threatened and endangered sea turtles; recognition of the global significance of the sea turtle nesting beaches of Brevard and Indian River Counties, Florida; and Congressional dedication of the Archie Carr National Wildlife Refuge (ACNWR). The initial vision for the refuge, as established by the U.S. Fish and Wildlife Service (USFWS), was to acquire four areas

of contiguous beachfront properties representing approximately nine miles of oceanfront and additional non-contiguous vacant lands between these four core conservation zones. In response to this vision, the State of Florida, Brevard County, Indian River County, The Nature Conservancy, The Conservation Fund, and the Richard King Mellon Foundation implemented aggressive local land acquisition initiatives and expanded the Congressionally identified boundary of the ACNWR to include significant natural areas associated with the ACNWR to protect the natural integrity of the barrier island ecosystem.

METHODS

This poster presentation presents the first synthesis of land acquisition data for the past ten years of the ACNWR land acquisition effort. Data were analyzed from information provided by USFWS, Brevard County, Indian River County and the Richard King Mellon Foundation. Analyses presented herein were dependent upon the use of GIS maps, aerial photography, real estate acquisition data, and field observations. A number of discrepancies among the data provided by the land acquisition partners suggests that these findings should be considered preliminary until more complete analyses and verifications of original land sale documentation and property surveys are completed.

RESULTS

The success of a decade-long multi-agency initiative to acquire lands within and around the Archie Carr National Wildlife Refuge in east central Florida is due to an unprecedented partnership among agencies from federal, state and local government and not-for-profit conservation organizations. Successful land acquisitions have occurred within and between each of the four core segments of the Archie Carr National Wildlife Refuge (Table 1). Additional land acquisitions were completed by the non-federal partners west of the formal ACNWR boundaries to create four significant Atlantic Ocean-to-Indian River Lagoon conservation areas that span from east to west across the barrier island ecosystem. These lands provide significant benefit to the ACNWR by reducing lighting impacts, reducing direct and indirect public-use impacts, and providing an ocean to river natural corridor. Land acquisition opportunities within ACNWR designated segments, between ACNWR designated segments and outside of the ACNWR boundary continue to exist. These privately-owned properties (both inholdings and additions) can provide significant conservation benefits to the ACNWR if acquired for conservation, resource management, and public use.

CONCLUSIONS

The success of land acquisition activities in the Archie Carr National Wildlife Refuge was a result of significant partnership programs and economic commitments from the State of Florida, Brevard County, Indian River County and the Richard King Mellon Foundation. These collective partner efforts have greatly exceeded the overall economic expenditures of USFWS.

Numerous parcels of vacant land within USFWS designated segments, between USFWS designated segments, and west of Highway A1A remain as potential public acquisitions. Many of these privately owned “in-holdings

and additions” are essential for long-term resource management and are threatened by immediate development pressures.

Current levels of federal funding are insufficient to effectively respond to the remaining land acquisition opportunities and long-term management responsibilities in the ACNWR.

Large acreage parcels located west of Highway A1A in Brevard County (between Segments 2 and 3 and adjacent to Segment 3) and Indian River County (associated with the Pelican Island National Wildlife Refuge) present immediate opportunities to provide significant conservation benefits to the ACNWR.

Changes in vacant land availability, land seller expectations, and economics have made it more difficult for the ACNWR conservation partners to negotiate successful land acquisitions with willing sellers.

A lack of funding and program support for comprehensive management plan development and implementation represents a on-going concern among the ACNWR partners and a significant threat to long-term conservation efforts within the refuge and the associated natural area network.

RECOMMENDATIONS

Increase federal funding to acquire remaining ACNWR properties from willing sellers and to support long-term ACNWR management needs. Focus non-federal land acquisition dollars on large tracts of vacant land west of the congressional boundary of the ACNWR to complete ocean to river natural corridors across the barrier island.

Re-dedicate state efforts and staff at the Florida Conservation and Recreational Lands (CARL) Program and Florida Division of State Lands to contact land owners within and associated with the ACNWR boundary to identify willing sellers and leverage remaining Florida Preservation 2000 funds and future Florida Forever funds..

Prioritize remaining properties for acquisition to provide the greatest biological and economic benefit to the ACNWR and the barrier island ecosystem.

Immediately begin the complex process of multi-agency land management planning by convening a conference to identify and provide data (i.e., land acquisition, social, economic, recreation, geological, ecological, et. al.) required by barrier island and ACNWR land management planners.

ACKNOWLEDGMENTS

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Program (FDEP); Anne Birch, Brevard County EEL Program; Dan Bellucci, real estate representative for the Richard King Mellon Foundation; Indian River County; Brevard County Office of Natural Resources Management; and Ron Johns, Sebastian Inlet State Recreation Area.

Table 1. Approximate levels of completion within ACNWR (based on map analysis). Success levels were estimated based on the number of miles of oceanfront property acquired vs. the number of miles of undeveloped oceanfront property.

Segment	Length (miles)	Miles acquired	% completed	% success	Comments
1	3.2	2.45	77	96	five ocean parcels remain; one tract west of A1A remains
2	0.5	0.47	76	97	1 parcel remains
3	2.5	1.0	45	62	33 ocean parcels remain; numerous parcels west of A1A remain
4	2.8	1.2	33	50	multiple ocean parcels remain; numerous tracts west of A1A remain to provide a link to Pelican Island NWR

The Study and Control of a Beetle (*Omorgus suberosus fabricius*) That Destroys the Eggs of Olive Ridley Sea Turtles (*Lepidochelys olivacea*) at La Escobilla, Oaxaca, Mexico

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During the nesting season 1987, at Escobilla beach were found a small beetle inside the *Lepidochelys olivacea* nests, until 1990 were discovered that this coleopteran destroyed the eggs eating them. Doing an effort to control the beetle population, starting at 1993 were used plastic traps with sugar. Later were used excrement of fatten chicken and it give us good results. But during 1999-2000 season were used decomposition carcass fish which is more efficient than the others because it was possible captured the double amount of beetles. So far they have

been captured more than 7,000,000 of beetles in five months. During the last two years it was observed that this beetle prefers the wet zone than the dry. A high capture were noticed at the zones which the arrivals were concentrate along the beach. On the other hand, traps have been placed at high altitude Cozoaltepec river areas in order to identify the presence of the beetle because our theory is that they arrived from the Oaxaca mountains probably at tree trunks. In addition here we present our results about the cycle of life of this beetle.

Remote Interactive Digital Imaging: Implementation of a SeaTurtleCam System in the Hawaiian Islands

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A NEW WAY TO VIEW SEA TURTLES

A strong motivation exists amongst many of us to observe and photograph sea turtles in the wild for research purposes. These activities often carry with them the desire to communicate to others what we have been fortunate to see and learn about these amazing animals. However, there are practical limits to the amount of time that can be spent in the field. Also, the potential influence of our direct presence on the turtles is always a consideration. In order

to expand our field of vision over the horizon, using new viewing technologies, the world's first camera system with real-time video linkage to the Internet is being implemented to watch turtles in the Hawaiian Islands. We predict that this network will usher in exciting new approaches to research, monitoring and conservation education.

The initial deployment of what we call the Hawaiian SeaTurtleCam System will take place shortly at Kiholo Bay on the Kona Coast of the island of Hawaii. Terrestrial

basking by juvenile and subadult green turtles commonly occurs along this out-of-the-way lava rock shoreline, making it an ideal setting for remote imaging (Balazs *et al.*, 2000; Harrington *et al.*, This volume; Rice and Balazs, 2000; Rice *et al.*, This volume). Placements of other portable cameras are also planned to watch turtles foraging in near shore habitats, and at underwater sites used for resting or visited by turtles for cleaning by fish. In addition, we intend to install infrared and visible light cameras on an existing 15 m pole at five-hectare East Island, French Frigate Shoals. These cameras will transmit digitized signals to orbiting satellites for relay to researchers in Honolulu and viewers worldwide. We will use the images to quantify seasonal nesting and basking by migrant green turtles at this important but isolated rookery in the Northwestern Hawaiian Islands (Wetherall *et al.*, 1998).

The present abundance of green turtles throughout the Hawaiian Islands, the relative tameness of the turtles, and the special behaviors they exhibit (Balazs, 1996) afford an array of opportunities for remote imaging research, as well as teaching and public viewing on the World Wide Web. To pursue these objectives, a working partnership has been formed involving the Hawaii Preparatory Academy, SeeMore Wildlife Systems, and the Marine Turtle Research Program of the Southwest Fisheries Science Center, Honolulu Laboratory, National Marine Fisheries Service.

The custom-built cameras to be used by SeeMore Wildlife Systems for the Hawaiian SeaTurtleCam will have pan, tilt, zoom, and audio capabilities. Powered by small solar-charged storage batteries, microwave signals of the images will be relayed to SeeMore Wildlife servers from remote sites using environmentally-friendly compact transmitters and antennas. All camera functions, including windshield washer and wiper to clear salt spray, will be remotely controlled with easily used web browser software. Images will be obtained as 80 Kbs full-stream video, or programmable as time-lapse tapes.

SYMPOSIUM POSTNOTE

The various conceptual elements of the Hawaiian SeaTurtleCam System, as described above, were illustrated in our poster paper at the Twentieth Symposium on Sea Turtle Biology and Conservation. On April 7, 2000, following the symposium, two cameras (given the Hawaiian

names of "Mele" and "Maka") were installed at Kiholo Bay with a microwave link 33 km to the Hawaii Preparatory Academy (Figs. 1 and 2). The units became operational on a limited-entry basis the following day (April 8) providing continuous images to the SeeMore Wildlife Systems website at <www.seemorewildlife.com>. On April 19th full-stream images of basking turtles on a daily basis were made available at this website for unrestricted free worldwide viewing. Hence, the first component of the multifaceted Hawaiian SeaTurtleCam System has been accomplished as planned.

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Fig. 1. The world's first SeaTurtleCam installed at Kiholo Bay providing real-time remote video images of basking green turtles to the World Wide Web (www.seemorewildlife.com). The SeeMore Wildlife camera named "Maka" (eye in Hawaiian) is located on the right. A small transmitter and other electronics are entirely concealed under the rocks.



Fig. 2. Close-up of the SeeMore Wildlife video camera named "Mele" (song in Hawaiian). Five basking green turtles rest on the rocks, at Kiholo Bay, unaware of their global exposure as Hawaiian Ambassadors for their species.



Criteria for Nest Relocation: The Underground Water Table During a High Tide Cycle

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It has been a standard procedure of the turtle patrol on Kiawah to identify the most landward extent of the *Spartina* debris (the wrack line) of the April spring tide and to mark this line with easily visible posts. The guideline for nesting patrols then is to relocate any nest laid seaward of this line. The wrack line is frequently the only identifiable feature parallel to the water line on which to base the judgement, even though, relative to the waveless high tide line, its position depends on the wave height during the spring tide and the local slope of the beach. Consequently, there has

been some uncertainty on the part of nesting patrols as to whether to relocate nests just at the wrack line.

Although there have been other, sometimes very sophisticated, studies of groundwater fluctuations at beaches (Emery and Foster, 1948; Dominick *et al.*, 1971; Pollack and Hammond, 1971; Harris *et al.*, 1971; and Fang *et al.*, 1972), there is some difficulty in relating these to the wrack line on the beach. To clarify the situation, we have undertaken simple experimental measurements and calculations specifically related to the wrack line.

Experimentally, a series of hollow vertical pipes were set in the sand to depths greater than that normally found for turtle nests. The pipes were in a line perpendicular to the water edge, at regular intervals extending both seaward and landward of the wrack line. Using indexed floats, the water level in each pipe was recorded at intervals over several hours around a spring high tide. The program encompassed spring tides during the summer months of two successive years.

Calculated water levels were made for each pipe using a very simple two-point model of underground water seepage from the sea, based on Darcy's law (Harr, 1962).

Over the limited expanse of our interest, a reasonable agreement is achieved between the mathematical model and the experimental results. We take this agreement to indicate that the groundwater rises and falls in response to the tidal fluctuations in the open sea. Wave action, which is not included in the model, plays little part in the groundwater level, although it is important in locating the wrack lines.

The results indicate that the likelihood of flooding at nest level is dependant upon the permeability of the sand and particularly upon the slope of the beach. For beach slopes such as we have measured at Kiawah Island (0.02 to 0.1) the survival of a nest located just at the wrack line is problematical. In the middle part of this range of slopes, at least part of a nest will be under water for as long as 1.5 to 2 hours. On a steeper sloping beach flooding is even more severe, whereas on a beach with a very low slope a nest just at the wrack line may experience no flooding at all.

Thus, the wrack line provides a reasonable but less than perfect criterion for nest relocation. This conclusion is

borne out by data on hatching success at Kiawah during the past season. Of fifteen nests which, for one reason or another, were left just at the wrack line.

The average hatching success was 50.4% compared with 71.9% for nests clearly more landward. Although eight of these marginal nests had hatching success greater than 70%, 6 others hatched with less than 20% success.

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Effect of Filtered Roadway Lighting on Nesting by Loggerhead Sea Turtles (*Caretta caretta* L.)

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INTRODUCTION

Sea turtles nest preferentially on dark beaches. In Florida, many nesting beaches are illuminated by the street lights of coastal roadways. These lights probably repel females. The purpose of this study was to determine how females responded to filtered roadway lighting. These filters reduce the amount of transmitted light and exclude the light wavelengths that females detect with greatest sensitivity.

METHODS

Experiments were carried out last summer in Jupiter, Florida. The beach was divided into a central experimental and two control zones of equal (425 m) length. Four street lights adjacent to the experimental beach were equipped with a 70w lamp and an amber (2422 acrylic) filter (excludes wavelengths <540 nm). Nesting attempts on each beach were counted during summer morning surveys. Proportions of nests to false crawls in 1999 were compared statistically to a mean Ahistorical@ proportion (past nine years with the lights turned off).

RESULTS AND DISCUSSION

There were 995 nesting attempts in 1999, compared to a historical average of 1258. There were no statistical differences between the 1999 and past proportions of nests to false crawls along the entire beach (~50:50 ratio). The proportion of nests placed in the experimental and in each control zone did not differ from previous years. The proportion of false crawls was higher in one control zone, lower in the other control zone, and showed no statistical differences in the experimental zone compared to previous years. These results suggest that at this site, the nesting choices of females are unaffected by filtered lighting.

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Improved Method of Displaying Sea Turtle Nesting Data in a GIS Format

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Sea turtle beach surveys involve the collection of data on nesting and non-nesting (false crawl) emergences. There is a need to display the spatial distribution of crawls along the surveyed beach. This is usually done by dividing the beach into several constant-length sections and counting the emergences in each. A bar chart or line graph is then created showing the number of nests and false crawls as a function of beach section. Valverde *et al.* (1997) used such an approach to show the effect of coastal development on the nesting population of green turtles at Tortuguero, Costa Rica. The present study provides an improved way to display this type of information in a Geographic Information System. A computer program was written to create a new

type of nesting graph that adjusts the x-axis to the shape of the shoreline and allows variable-length sections. The resulting shore-conforming chart can be overlaid on a map of the surveyed beach. The new mapping technique is demonstrated for several index nesting beaches in Florida.

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Unusual Nesting Patterns on a Renourished Beach

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INTRODUCTION

In early 1998, 1.5 mi of the northern area of Boca Raton's beach was renourished. During the 1998 sea turtle nesting season, nesting by loggerhead sea turtles (*Caretta caretta*) in the renourished area fell more than two-fold resulting in the lowest nesting recorded in this area in the last ten years. False crawls in zones within the project area exceeded nests by a ratio of more than seven to one even though the majority of the beach was free of berms and accessible to nesting females. Female turtles perturbed by the new sand in the renourished area apparently selected nesting sites within a mile north and south of the project area as nesting activity increased nearly twofold over average in these areas. Overall, the number of nests encompassing the project area plus a mile north and south of the project area resulted in a normal number of nests expected in this 3.5-mi area. Female turtles apparently avoided the project area, but ultimately nested close to it.

During the 1999-nesting season, the distribution of nesting throughout the areas affected during the 1998 season returned to normal levels and within the project area, the nest success ratio returned to the usual one false crawl per nest. Although nest viability (hatch success) was low in the project area during the first season of nourishment, similar low nest viability was seen throughout the five miles of Boca Raton's beaches reflecting unusually dry weather conditions in 1998. Overall, there was no detectable difference in nest viability in the project area compared to the whole beach. Additionally, nesting was apparently not deterred by sand compaction, as tilling did not occur in the project area until early June 1999 by which time many nests had been deposited in the project area. Hatch success was not significantly different between nests deposited before tilling (hard sand) and after tilling (softer sand) during the 1999 nesting season. Apparently whatever agent deterred nesting in 1998 had washed out of the beach by the 1999 season.

METHODS

All nesting and hatch success data was collected according to the Florida Fish and Wildlife Conservation Commission (FWC) guidelines provided to all Florida Sea Turtle permit holders. All zones referred to are approximately ½ mi in length. Zones B and C are fully contained within the nourishment project area.

RESULTS

Loggerhead nests in Zones B and C of the nourishment project area dropped to record low levels in 1998 (Fig. 1). Record high loggerhead nesting in 1998 was recorded in Zone D and Highland Beach Zone 1, both of these zones are immediately 0.5 mi north (Highland Beach Zone 1) and south (Zone D) of the nourishment project area. From 1990 to 1999, no lower or higher loggerhead nesting activity was recorded in these zones. These data indicate that although nesting was perturbed in the project area during the first year of nourishment (1998), nesting female loggerhead sea turtles chose to nest within 0.5 mi north and south of the project area. This may indicate that these nesting loggerheads were attempting to nest on or near their natal beach and after rejecting the project area in 1998, they nested as close to the project area as possible. The high numbers of false crawls per nest in the project area support this supposition as the number of false crawls per nest was 7.1:1 in Zone B and 7.6:1 in Zone C. This indicates that nesting loggerheads repeatedly attempted to nest in the project area, but rejected it for some unknown reason.

One possible reason for rejecting a preferred beach may be sand compaction. Penetrometer readings for the project area were high during the 1998 nesting season according to FWC guidelines. Figure 2 shows the hatch success results for combined Zones B and C over the years of 1996 to 1999. The hatch success of nests deposited in the project area during the 1998 season showed that lower levels of hatched eggs and higher levels of dead embryos and infertile eggs were observed in Zones B and C. However, the hatch success for the entire five miles of Boca Raton's beaches (n = 433) was almost identical to the hatch success results seen in the combined data from Zones B and C indicating that sand compaction had no influence on the lower hatch success numbers seen in the project area. During the 1998 season, extremely low levels of rainfall from April to the end of July caused many nests to desiccate, resulting in higher numbers of infertile and dead embryo eggs. During 1998, it was not unusual to excavate entire nests that had fewer than ten hatched eggs in all zones within Boca Raton.

During the 1999 nesting season, the beach in the project area was not tilled until June 9. By this time, about 50% of the year's loggerhead nests were deposited in the project area giving us the chance to examine the effect of tilling (reduced sand compaction) on the hatch success of project area loggerhead nests within the same year. The combined hatch success of project area zones B and C before and after tilling indicate that tilling had no influence

on the hatch success results during 1999 (Fig. 3). These data and the observation that approximately 50% of the loggerhead nests were deposited before and after tilling indicate that sand compaction was not a factor in either nest site selection or hatch success.

DISCUSSION

The data presented indicates that although loggerhead nesting was perturbed during the year of nourishment, nesting females simply avoided the project area after many attempts and nested as close to the project area as possible. If loggerhead nesting over the project area during 1998 is examined with the inclusion of one mile north and south of the project area, normal levels of nesting loggerheads are observed indicating that nesting females did not abandon their intended nesting sites, but simply moved north or south until they found a suitable nesting site. Loggerhead nesting in the project area was perturbed only during the first year of nourishment (1998) and nesting numbers returned to normal levels in 1999 despite high levels of sand compaction during both of these years before tilling. The hatch success of loggerhead nests within the project area was not different from the rest of the five miles of beach in Boca Raton during the project year (1998), nor was it different in 1996, 1997, and 1999. This indicates that something other than sand compaction influenced loggerhead nest site selection and subsequent hatch success in the project area. Perhaps the nesting loggerhead females were responding to chemical clues such as the amount of anoxic or other unpalatable material present in the freshly nourished sand which was washed out of the sand by the beginning of the 1999 season.

ACKNOWLEDGMENTS

My thanks to Boca Sea Turtle Specialists, Carly Pfistner, Ed de Maye, and Hillary Harder for their diligent field work. I also wish to thank Jose Echiverra and his team of hard-working volunteers in Highland Beach for providing us with data outside our survey area.

Fig. 1. Loggerhead nesting by year.

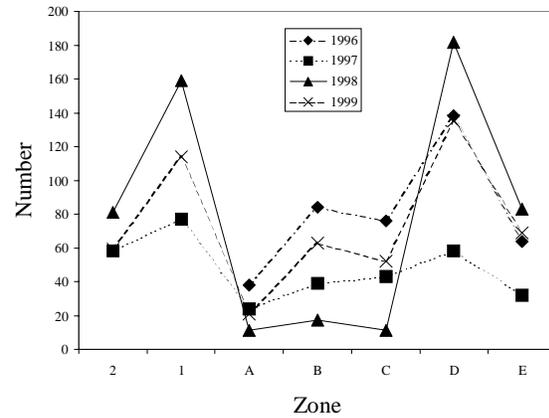


Fig. 2. Hatch success in combined Zones B and C.

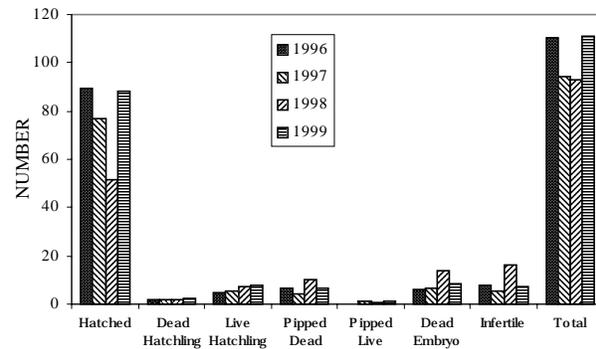
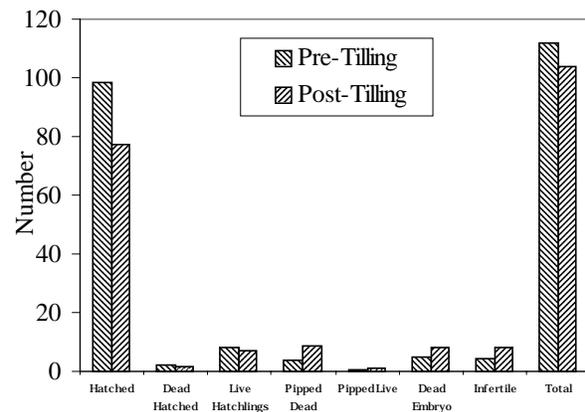


Fig. 3. Hatch success in combined Zones B and C before and after tilling in 1999.



An Analysis of Reported Disorientation Events in the State of Florida

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INTRODUCTION

Upon nocturnal emergence from the nest, hatchling sea turtles orient themselves toward the ocean using visual cues. They orient away from dark silhouettes such as dune vegetation and orient towards the brighter horizon over the open ocean (Witherington and Martin, 1996, Salmon *et al.*, 1992). On developed beaches, artificial lights can direct hatchlings inland, where they can perish from dehydration, predation from ghost crabs and fire ants, or cars on nearby roadways. This straight-line movement away from the ocean is called misorientation. Hatchlings may also become confused by the visual cues they are receiving and wander in circles. This is called disorientation. Artificial lights may deter adult female turtles from nesting, or in severe cases, cause them to disorient (Witherington and Martin, 1996). For this presentation, we use the term disorientation to generally describe all events where hatchlings or adults did not take a straight path to the ocean.

METHODS

Sea turtle disorientation events have been recorded and reported to the FWC since 1987. Adult sea turtle disorientation has been recorded since 1996. Disorientations are typically documented either while the disorientation is occurring, as concerned citizens contact the Commission, or during early morning surveys. Marine Turtle Permit Holders fill out a 'Disorientation Report Form' for each disorientation event discovered. One nest that emerges over several nights may have several disorientation events, since each night's event is reported separately. The form includes the location where the event occurred, the probable light source (if known), and an estimate of the number of hatchlings disoriented.

RESULTS AND DISCUSSION

1. Artificial lighting continues to affect thousands of hatchlings each year in Florida, and local, state, and federal governments should continue working with property owners to manage light pollution.

2. The increase in reported disorientation events may indicate heightened awareness of disorientations, more aggressive reporting, or an increase in coastal lighting (Fig 1).

3. Increased awareness and reporting has been

enhanced by the creation of a position at the FWC, funded by the U.S. Fish and Wildlife Service, to work on resolving lighting issues on Florida's nesting beaches.

4. The majority of the disorientation events in 1998 involved condominiums, streetlights, single family homes, and parking lot lights (Table 1).

5. Solutions to lighting problems are readily available in most cases if the responsible parties can be identified and are willing to make appropriate modifications.

ACKNOWLEDGMENTS

We would like to thank the many Marine Turtle Permit Holders and State Park Staff in the state of Florida who report disorientation events at their beach every year and who have also worked hard to reduce beachfront lighting. We would also like to thank the local code enforcement personnel from many communities who are working hard to protect marine turtles. This work was funded by a grant from the U.S. Fish and Wildlife Service.

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- Witherington, B.E., and R.E. Martin. 1996. Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches. Florida Marine Research Institute Technical Report TR-2.

Fig. 1. Reported disorientation events in the state of Florida

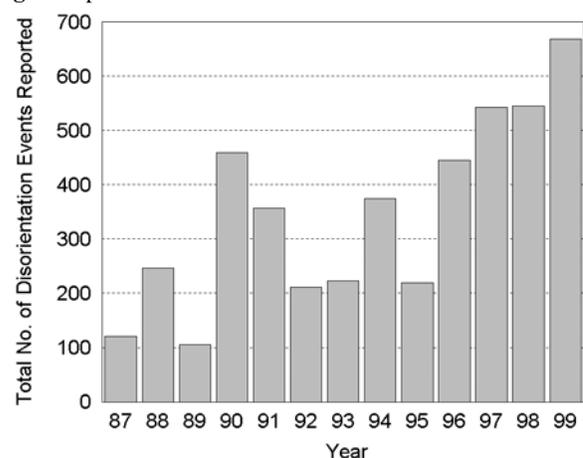


Table 1. Light sources contributing to reported disorientation events in Florida, 1998 (Data from 1999 are not yet available.)

Light Source	No. of Disorientations Reported	Percent of Total Disorientations Reported
Condominium	197	35.43%
Street Light	118	21.04%
Single Family Home	88	15.83%
Parking Lot	62	11.15%
Unknown	52	9.35%
Motel/Hotel	51	9.17%
Restaurant/Bar	35	6.29%
Naval Air Station	33	5.94%
Pier	30	5.40%
City Glow	20	3.60%
Pool	16	2.88%
Other	44	7.92%

Effect of Beach Nourishment on Sea Turtle Nesting on Panama City Beach, Florida (USA)

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One of the largest beach nourishment projects ever constructed in the United States was recently completed on Panama City Beach, located in Florida's panhandle on the Gulf of Mexico. During August 1998 to April 1999, the project pumped 8.3 million yd³ of sand from offshore borrow sites onto 17.5 mi of gulf beach. Panama City Beach supports a small but important nesting population of loggerhead turtles. Nourishment can alter beach characteristics in a way that decreases the reproductive success of sea turtles. We compared data for nest placement, nesting success (nests divided by total crawls), hatchling production, and incubation periods obtained prior to the nourishment project (1991-98) with post-nourishment data for the 1999 nesting season. Results showed that the nesting turtles did not utilize the wider, nourished beach. Instead, all nests were laid close to the water near an escarpment that formed along the shoreline. Nesting success dropped slightly but was within the normal variation for this beach, and hatchling production was well above normal. The average nest incubation period of 60 days was 10 days shorter than the eight year average for the pre-nourished beach. Multiple-variable regression analysis of the 1999 data showed a strong correlation between incubation period, air temperature, and sand luminance at the nest sites. The darker sands of the nourished beach likely contributed to the shorter incubation times, but the analysis showed that additional factors are involved.

INTRODUCTION

Panama City Beach in northwest Florida is a popular tourist destination, attracting over two million visitors

annually. This urban beach also supports a small but important population of threatened loggerhead turtles (*Caretta caretta*), with an average nesting density of 1.2/mi. Research has shown that loggerheads nesting on this beach are part of a genetically distinct group that nests in the Florida panhandle (Encalada *et al.*, 1997). Since 1991, a state-permitted monitoring program has protected loggerhead nests on Panama City Beach (Fig. 1). The entire 17.5 mi. survey area was nourished during the nine-month period from August 1998 to April 1999, finishing before the first documented nest of the 1999 nesting season. The project pumped 8.3 million yd³ of sand from offshore borrow sites onto the beach. This paper compares results for the 1999 nesting season with pre-nourishment data for the eight year period 1991-98.

METHODS

All nesting data in this paper are for loggerheads. No other turtle species are known to nest on Panama City Beach. The public was relied upon to report nests during 1991 and part of 1992. Beginning in 1993, a daily survey program counting nests and false crawls was conducted from May 1 through August 31. Nests in danger of tidal inundation or flooding by a storm drain were moved to a higher elevation within 12 hours of egg deposition. A wire cage was placed over each nest to contain light-disoriented hatchlings. Beginning on incubation day 50, the caged nests were checked for hatchlings three times daily: during the morning survey, in the late afternoon, and at night between 11 pm and 1 am. All marked nests were excavated to determine hatching success. The nesting and hatching data

were used to investigate potential nourishment effects as described below.

Spatial nest distribution

The nesting density in 1999 was too small to analyze statistically, so a qualitative approach was used to compare nest placement during the years before (1991-98) and after (1999) nourishment. Nest locations parallel to the beach (along-shore direction) were mapped on 0.5 mi sections. Nest locations perpendicular to the beach (cross-shore direction) were analyzed by comparing the percentage of nests relocated due to flooding danger from tides. Data for 1993 and 1998 were excluded, because in 1993 nests were moved on the basis of beachfront lighting concerns, and in 1998 nests were moved out of the anticipated construction area for the nourishment project.

Nesting success and emergence success

Nesting success is defined as the percentage of crawls resulting in nests. Post-nourishment data for 1999 were compared with the mean nesting success for the six year period 1993-98. The data for 1991 and 1992 were excluded from the statistical analysis, because daily surveys were not consistently performed during this period. Emergence success is defined as the number of hatchlings that escaped the nest divided by the number of eggs. The excavation data were compared for unhatched eggs, pipped live and pipped dead hatchlings, live and dead hatchlings in the nests, and hatchlings that escaped the nests.

Incubation period

The incubation period is defined as the number of days from when the nest was laid to the date of the largest hatchling emergence. Pre- and post-nourishment data for incubation periods were compared using the same statistical procedure described for nesting success. Multiple-variable regression analysis was performed on the 1999 data to correlate incubation period with air temperature and sand luminance. The average air temperature for each nest was computed for the first 50 days of incubation using data from a nearby weather station. Sand luminance was measured using an IL-1700 Research Radiometer manufactured by International Light. Luminance is a measurement of the visible reflectance of the sand, simulating the eye's response. Therefore, the measurement gives an indication of sand color. The units for luminance measurements are candelas per square meter.

RESULTS AND DISCUSSION

Spatial nest distribution

Figure 2 shows the along-shore distribution of nests. The pre-nourishment data shows that the highest nesting during 1991-98 occurred on the western portion of the survey area, which is less developed than the central and

eastern sections. This trend was reversed following nourishment. Of the 26 loggerhead nests identified in 1999, most were laid on the eastern part of the beach. The timing of the project may have contributed to this result, because the nourishment operation proceeded from east to west. Nourished beaches are intentionally overfilled and require time to achieve a natural profile. The eastern part of the survey area may have been more acceptable to nesting turtles, because it had more time to acquire a natural shape prior to the 1999 season. Regarding the cross-beach distribution of nests, Figure 3 and Table 1 show the number of nests relocated annually due to flooding danger from tides. The data show that 69% of the nests in 1999 were relocated to a higher elevation, a much higher percentage than the mean of 26% \pm 24%(S.E.) in the years before nourishment. In fact, none of the turtles took advantage of the wider, nourished beach. All of the nests were laid close to the water near an escarpment that formed after nourishment. The nests that were not relocated should have been moved but were found after the 12-hour relocation window had passed.

Nesting success and emergence success

Nesting success was 58% in 1999 (Fig. 3, Table 1), which is somewhat lower than the mean of 68% \pm 13% for the pre-nourished beach. However, the 1999 results are within the normal variation for this beach. Figure 4 compares pre- and post-nourishment excavation data. The combined emergence success in 1999 was 75% (25 nests), which compares to a value of 50% (130 nests) prior to nourishment. Tidal flooding from tropical storms and hurricanes during 1991-98 contributed to the low success rate on the pre-nourished beach. Nourishment appeared to have no adverse effects on hatchling production.

Incubation period

Figure 5 shows the annual mean incubation periods for 1991-99. The mean incubation period in 1999 was 60 days \pm 5 days, which compares to a mean of 70 days \pm 7 days for 1991-98. The nourished beach was darker than the natural beach, which may explain the record low incubation times in 1999. However, there is clearly some other factor involved, because the drop in incubation times also occurred in 1997 and 1998 before the nourishment project. Unusually warm nesting seasons in 1997-98 might explain the lower incubation times, but the air temperature data in Figure 5 do not support this theory.

The regression analysis showed a strong correlation between sand luminance, air temperature, and incubation period. The equation for the incubation period (P, days) is expressed as:

$$P = 2.836L + 0.6817T - 0.03529LT$$

where L is the luminance (candelas per square meter) of the top sand layer at the nest site, and T is the 50-day average air temperature (deg F) during the incubation

period. This equation predicts the incubation period to within a standard error of 2.39 days with an R-value of 0.941. Results are shown in Figure 6 for 21 hatched nests in 1999.

ACKNOWLEDGMENTS

Assistance was provided by Charles Peterson, Dean McCollum, and Steve Keehn of Coastal Planning and Engineering, Inc. We also thank volunteers with the Turtle Watch program on Panama City Beach who collected much of the nesting data presented in this paper.

Fig. 1. Map of Panama City Beach in northwest Florida. The survey area covers 17.5 mi of beach on the Gulf of Mexico.

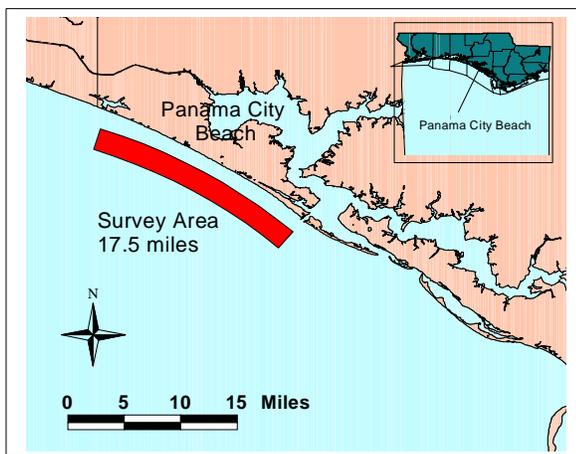
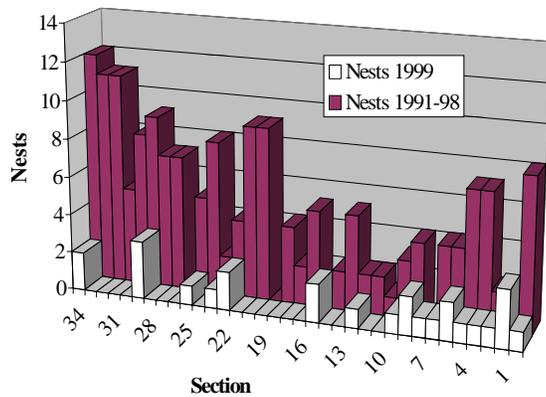


Fig. 2. Comparison of along-shore distribution of nests in 1991-98 (170 nests, pre-nourishment) and 1999 (26 nests, post-nourishment). Section widths are nominally 0.5 mi and are numbered east to west.



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Table 1. Annual totals for nests, nesting success, and nests relocated

Year	Nests	Nest Success (%)	Relocated Nests	Relocated Nests (%)
1991	19	76.0	3	15.8
1992	22	88.0	10	45.4
1993	9	75.0	0	0
1994	21	51.2	2	9.5
1995	24	70.6	1	4.2
1996	17	60.7	1	5.9
1997	33	89.2	10	30.3
1998	25	64.1	0	0
1999	26	57.8	18	69.2

Fig. 3. Annual totals for nesting success and nests relocated due to flooding danger from tides, 1991-99.

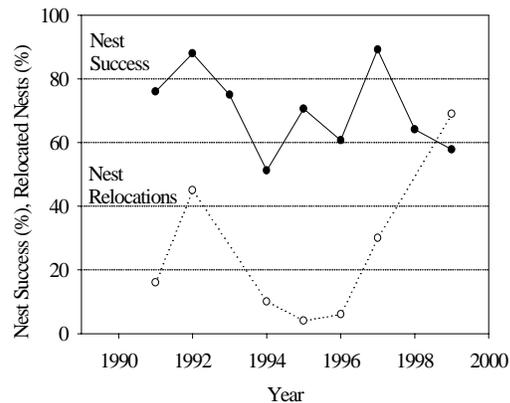


Fig. 4. Comparison of post-nourishment nest excavation data for 1999 (25 nests) with pre-nourishment data for 1991-98 (130 nests).

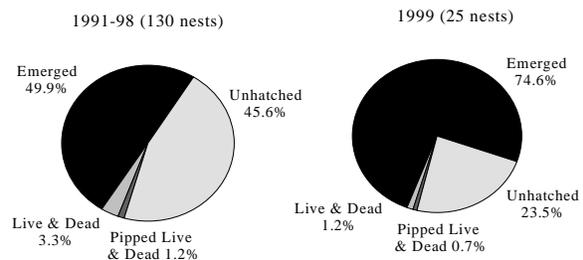


Fig. 5. Annual mean incubation periods and seasonal air temperatures during 1991-99. Bars represent one standard error of the mean. The air temperatures are the average of daily high/low values at a local weather station during June 1 to September 30.

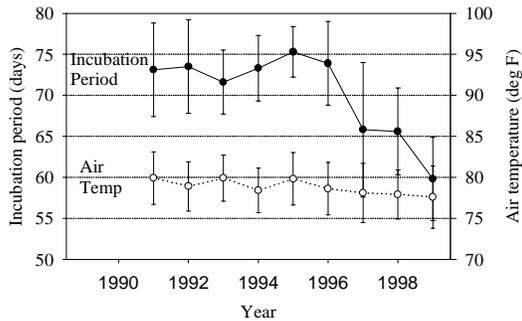
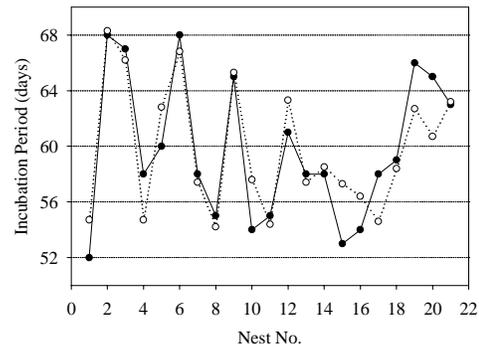


Fig. 6. Comparison of measured incubation periods during 1999 (21 nests) with predictions from a regression model. The data are predicted to within a standard error of 2.39 days and an R-value of 0.941. Nests are numbered east to west.



Effects of T-head Groins on Reproductive Success of Sea Turtles in Ocean Ridge, Florida: Preliminary Results

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INTRODUCTION

Coastal managers have shown renewed interest in using groins to address specific erosion problems in Florida. The shoreline in Ocean Ridge south of South Lake Worth Inlet (Boynton Inlet) was heavily armored with vertical seawalls, toe scour protection, revetments, non-functioning sheet pile groins and an intertidal sand bag sill. The T-head structures were designed to: replace the non-functioning groins and sand bag sill; minimize erosion stress immediately downdrift of the inlet; reduce the amount of sand entering the inlet; and, minimize burial of nearshore reefs by limiting beach fill near the inlet.

A groin field consisting of eight T-head groins was constructed in 1998 along 1,800 feet of beach as part of a beach nourishment project in Ocean Ridge, Florida. The approximate dimensions of the granite groins are: stem length, 110 feet; T-head length, 85 to 110 feet long; stem and T-head width, 20 feet; height, four feet NGVD; and, distance between groins, 220 feet. When all groin heads are exposed, 715 feet or 40% of the shoreline in the field is blocked by the structures.

The amount of sand remaining within the groin field is greater than expected. During nourishment, more fill material was placed in the south half of the groin field than designed. Additionally, the north half of the groin field receives sand from a permanent sand transfer plant which pumps a sand/water slurry onto the beach in the middle of the groin field when there is a south flowing nearshore current. The resultant beach is crenulate between the groins with the high water line at or slightly landward of the T-head. Most of the groin stems have remained buried with

the T-head usually exposed.

Sea turtles may be affected by groins by blocking nesting females from accessing the beach, preventing the deposition of nests, or trapping hatchlings that are crawling toward the ocean. This paper examines the effects of the groins on beach utilization by sea turtle by comparing pre-project nesting density, nesting success, hatching success and hatchling emergence success to post-project results.

METHODS

Once the potential for trapping hatchlings in the groin structure was recognized, two methods were used to reduce hatchling impacts. Low fabric fences were constructed on the landward side of groins in 1998 to redirect sea turtle hatchlings around the groins to the ocean. The fence was installed between groins and nests due to hatch. Fences were checked and repaired in the morning and the afternoon (depending upon sea conditions).

Restraining cages were used primarily in 1999 when beach conditions made fencing ineffective. Approximately half the nests in the vicinity of the groins were caged to prevent the hatchling entrapment in the groin structures. Selection criteria for caging was based on predicted hatchling crawl direction and likelihood of hatchlings encountering groins. The cages were self releasing during the day and closed at sunset, checked during the middle of the night and opened just prior to sunrise. At night, hatchlings were released adjacent to the cages and tracked to evaluate what may have occurred without the cages and to investigate the effects of nearby lighting on the ability to

predict hatchling crawl direction.

Nest relocation was considered as a management option but permitting agencies were not able to approve relocation since it had not been anticipated and addressed in the Biological Opinion for the project.

Data were collected on the number of nests and false crawls in the groin field, the number of adult/groin interactions, nest locations (using a differential Global Positioning System), the number of nests caged, nest emergence success, and the crawl direction of hatchlings at night.

RESULTS AND DISCUSSION

A summary of physical characteristics and sea turtle data is provided in Table 1. Beach width in the groin field is approximately 85 ft. wider than in 1997 when the beach was typically 0 to 35 ft. wide. The percent of shoreline with a structure within 25 ft. of the high water line has been reduced after groin field construction.

Nest density (nests/mile) for 1997, 1998 and 1999 was 89, 92 and 78, respectively. The average post-construction nest density was 85. Loggerheads accounted for the vast majority of crawls. Leatherbacks laid one nest in 1997 and two nests in 1999. There was one green turtle false crawl in 1998 and 1999.

Post-construction nest success is substantially less than in 1997. However, nest success was not a good measure of groin effects on this beach. Lowered nesting success was observed on other area beaches and appears to be related to a very hot and dry summer in 1998 and to the effects of beach nourishment in 1998 and 1999. The total number of crawls increased dramatically from 59 in 1997 to 142 in 1998 and 85 in 1999.

The effects of beach nourishment to the south and the increased beach width and elevation in the groin field appears to have increased the 'attractiveness' (as evidenced by increased total crawls) of the groin field beach to turtles, despite the presence of the T-head groins. However, the increased crawl activity created a greater likelihood of the groins affecting sea turtles by impeding nesting females accessing the beach and by trapping hatchlings.

Undoubtedly, some adults attempting to nest would have been blocked by the groins but, most of the time, any tracks seaward of the groin are covered at high tide making documentation of this effect impossible. In each year, there were only four observations of adults contacting the groins and, in most of those cases, the turtles crawled over the structure. This is considered to be a minor impact when compared to pre-project conditions when the beach was much narrower and contact with the existing seawalls and revetments was much more likely. Most of the nesting occurred in the south half of the groin field away from the inlet. All nests were laid landward of and, in some cases, very close to the structures.

The primary effect on sea turtles was the potential for

the groins to trap or block hatchlings crawling to the ocean. The project was designed to have a narrower fill section in the vicinity of the groins so that the shore parallel T-heads would be seaward of the high water line. As designed, it was expected hatchlings would encounter water before the T-head. However, the groin field contains more sand than expected and this has caused the high water line to be further seaward (near the T-head) increasing the chances of hatchlings encountering the groin before entering the water.

Fences were installed in 1998 adjacent to three of the five exposed groins when 16 nearby nests were expected to hatch. Approximately 12% of the hatchlings that would have been trapped by groins encountered the fences and were successfully redirected to the ocean. Seventy-three percent of the hatchlings entered the water directly; the remainder were disoriented toward lights (and rescued). No adults contacted the fence.

In 1999, eight groins were exposed and the in situ nests in the groin field were caged after considering the changes in the beach profile and the increased difficulty in maintaining fencing in the intertidal zone. A total of 16 nests were caged beginning 45 days after nest deposition. The inability to locate the egg chamber of one leatherback nest necessitated fencing one groin. Hatchling tracking results were very similar to 1998 except the number of disoriented hatchlings was reduced by half. If cages had not been used, 87 hatchlings may have been prevented from entering the water by the groins (5% of the 1754 estimated total number of hatchlings produced by all nests in the groin field).

Hatch success and emergence success (ES) was reduced after construction of the groins. The ES for in situ loggerhead nests for 1997, 1998 and 1999 was 0.90, 0.44, and 0.76, respectively. An unusually hot, dry summer was probably primarily responsible for this effect in 1998. This appears to be supported by data for relocated nests that were moved away from the influence of the groins.

Caging and fencing proved to be effective methods of protecting the hatchlings from encountering the groins. In both years slightly more than half of the nests laid in the groin field required some intervention (caged or fenced). Without cages or fences, ~13% of the hatchlings would have encountered the groins. Similar results can be expected on urban beaches with similar conditions. A narrower beach would reduce the impacts (because there may be less chance for hatchlings to contact groins) but would not eliminate the problem. The extent of the impact will be a function of nesting density, design and beach profile.

SUMMARY OF POTENTIAL MANAGEMENT METHODS

Caging

It is effective and can be used in all beach conditions. It eliminates loss due to disorientation and reduces

depredation. However, it stresses hatchlings, is labor intensive (checked 3 times per night), and may attract predator attention. It is also expensive (\$4,000).

Barrier Fencing

It is effective, less stressful for hatchlings, and less labor intensive (no night checks needed). However, it is difficult to maintain fencing in the intertidal zone during spring tides and high wave activity. Constant maintenance is also required and there is loss due to disorientation. It is also expensive (\$4,000).

Relocation

The new nest location could reduce risks of inundation and disorientation. It is less stressful for hatchlings and less labor intensive. However, there is an increased potential of reduced emergence success.

RECOMENDATIONS

1. Managers need to carefully consider sea turtle impacts and factor in long term monitoring costs (\$4,000/year in this case) when considering constructing groins.
2. Groins should be considered only on beaches with low nesting density and where environmental benefits of

the structures clearly outweigh the costs.

3. Groin design criteria should ensure that the low water line is landward of the T-head and could include:

- a. construction of the groin at a lower elevation to allow more sand burial of the structure;
- b. set stem crest lower than T-head crest; or
- c. eliminate the stem and/or include a gap or weir section in the stem.

4. Relocation should be considered on beaches with very low nesting density and where the emergence success of relocated nests is within 10% of the in situ emergence success.

5. At this beach, plans to extent the sand transfer plant discharge point further south should be accelerated to reduce the accumulation of sand in the groin field.

ACKNOWLEDGMENTS

We would like to thank all the people who put in many long hours wrestling with fences and cages including Allison and Mark Holzhausen, Jacey Biery, Sarah Tyrell, Charles Woodward, Reubin Bishop, Todd Mimnaugh, and Tricia Potter.

Table 1. Summary of structures and effects in Ocean Ridge groin field. Five derelict structures (including a shore parallel sand bag sill) were removed in 1997 and 1998. The groin field was built in 1998 and consists of eight T head groins; heads 85-110 ft (26-33 m) long and spaced ~220 ft (67 m) apart. The total length of the groin field is 1,800 ft (549 m) and includes vertical seawalls and revetments landward of the beach.

	1997		1998		1999	
	#	%	#	%	#	%
Structures						
Average beach width (feet)	35		110		97	
Percent of shoreline with structures within 25' of HWL		75		17		40
Number of groins exposed	5		3		8	
Adult/Nest Effects						
Nests	32		33		28	
False crawls	27		109		57	
Nest density per mile	89		92		78	
Nesting success		54		23		33
Adult/groin interactions	Unknown		4	12	4	14
Nests relocated	15	47	6	18	9	32
Nests fenced off from groin	0	0	16	48	1	4
Nests caged	0	0	2	6	16	57
Hatchling effects						
In situ emergence success		90		44		76
Relocated emergence success		75		40		50
Estimated hatchlings emerged per nest	82		42		63	
Estimated total hatchlings emerged from groin field ¹	2637		1392		1754	
Data from evaluated nests						
Number of hatchlings tracked	NA		342		663	
Entered water directly	NA		249	73	527	79
Contacted (or headed toward) fence	NA		41	12	3	0.5
Contacted (or headed toward) groins	NA		4	1	87	13
Hatchlings disoriented	10		98	29	117	18

¹Total hatchlings produced from groin field= (# in situ nests x avg # hatchlings/nest X avg in situ emergence success) + (# relocated nests x avg # hatchlings/nest x avg relocated emergence success).

A Preliminary Look at Sediment Re-compaction Throughout the Nesting Season on a Nourished Beach at Ocean Ridge, Palm Beach County, Florida, USA

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Beach nourishment is a common erosion management technique used on sea turtle nesting beaches in Florida. The sediments on a newly nourished beach are often very compact. In recent years it has become common practice to mechanically till (or loosen) the sediments prior to the sea turtle nesting season to mediate the negative effects of the compact sediments. Tilling is typically accomplished by pulling or pushing large spikes or tines through the sand with a bulldozer. Depending on the equipment used, compaction readings, as measured with a cone penetrometer, are usually significantly reduced. Often times this procedure must be repeated prior to subsequent nesting

seasons until the beach width is reduced to the point that natural re-working of the sediments by wave action can occur. Re-compaction of the nourished beach is taking place over a one year span; however, there appears to be little published information on the rate of re-compaction throughout a typical nesting season. We investigated beach re-compaction throughout the nesting season two years post-nourishment and found roughly a 20% increase, per month, in sediment compaction. These preliminary data suggest the need to evaluate the effects of re-compaction during the nesting season and to investigate ways to improve tilling methodology.

The Use of Directrices in the Localization of Sea Turtles Nests

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INTRODUCTION

During the activities of the protection of female sea turtles that go out to the beaches, one important job is to locate nests and to carry the eggs to a protected seminatural nest.

When the female is located depositing her eggs, is important with the purpose of avoiding interfering this part of the process. We propose a very simple technique that offers an advantage in the localization of the exact place of the nest entrance at the first attempt when the turtle has gone back to the sea, eliminating like this, the risk of the animal perturbation.

This technique offers a lot of help when some turtles are located simultaneously, or, when volunteers with few or not experience are participating in this activity.

METHODS

A thin stick is used it could be in wood, metal or any other similar material of about 60 cm of length with which two or three straight lines of 2.5 or 3 m length are drawn.

These lines set out from the nearest point of the nest entrance and that address to different points establishing among them from 45°-90°.

The length of these lines must guarantee that the most external part will not erase by the turtle elaborates the bed to hide the nest.

When has gone, it is enough to draw the lines again following the straight original trajectory being guided by the no erased part until they cross among them.

The nest is located exactly in the vertex.

Spatial and Temporal Models to Estimate the Likelihood of Encountering Turtles

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The likelihood of encountering sea turtles is important to consider when designing biological studies, when censusing populations, and when predicting possible impacts of potentially harmful activities. As a consequence of similarities in observed patterns of sea turtle movements and activity from year to year, it is possible to develop models to assign the likelihood of encountering turtles in

different habitats. Using biological data, mathematical models, and GIS models, predictions of sea turtle activity patterns were made for habitats along the Northeastern U.S. continental shelf. Spatial models also were developed to assign likelihood of occurrence of turtles within specific habitats in the New York Bight. Because such predictive models can be used to highlight coastal areas that are more

likely to support sea turtle populations, they can be used as guidelines to direct future studies. These spatial and temporal models also can be an important tool to direct

management schemes and to prevent undesired impacts from potentially harmful activities.

Loggerhead (*Caretta caretta*) Hatchling Reactions to Coastal Roadway Lighting and Lighting Modifications on the West Coast of Florida

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Mote Marine Laboratory personnel completed a coastal roadway lighting survey along the west coast of Florida during the spring of 1999 as part of a contract with the Florida Department of Transportation (FDOT) and Florida Atlantic University (FAU). During this survey, areas were identified in which street light modification could have a positive impact on the nesting habitat of marine turtles. Three experimental sites were chosen that typified these areas. Night-time hatchling 'arena' experiments were conducted at all three sites with street lighting as it currently existed, with the street lights modified, and with the street lights turned off. At Coquina Beach, an area where roadway lighting is the significant source of beach illumination, modification of streetlights with the use of filtered lenses resulted in a significant improvement in hatchling orientation. At Longboat Key and Lido Key, areas affected by roadway lighting and urban development, modification or removal of street lighting did not have a significant impact on hatchling orientation.

INTRODUCTION

When attempting to locate the ocean, a "hatchling turns to maximize the strength of visual input to multiple comparators in the retina of each eye. As a consequence, the hatchling orients toward the brightest direction" (Lohmann *et al.*, 1996). In a natural setting, this method of orientation results in orientation toward the ocean. However, in areas where artificial lighting exists, hatchlings may become misoriented (and travel in a relatively straight direction toward the light source) or disoriented (and demonstrate uncertainty in direction by frequently changing direction and circling; Witherington and Martin, 1996).

In an effort to reduce the number and severity of hatchling disorientation and misorientation events, Mote Marine Laboratory contracted with FAU and FDOT to establish guidelines for coastal roadway lighting on the west coast of Florida. One aspect of this study involved selecting three sites which: 1) demonstrated a lighting problem that was largely determined by roadway lighting conditions; 2) consisted of roadway configurations which

occur commonly in Florida; 3) were of major importance to sea turtle nesting; and 4) had previous reports of hatchling disorientation events.

Night-time hatchling arena experiments were performed at each of the study sites to measure changes in hatchling orientation when exposed to streetlight modification.

METHODS

Site Descriptions

All three study sites were located in Sarasota and Manatee counties, on the central gulf coast of Florida. Experiments were performed at each site under three different conditions: the streetlights left "as is", the streetlights modified with lenses or shields, and the streetlights turned off (Table 1).

Site #1: Coquina Beach, Manatee County, Florida

The lighting in this area is mostly from streetlights, with a few lights from single family homes. Gulf Drive, a two-lane roadway, is separated from the beach by a row of Australian pine trees (*Casuarina equisetifolia*), sea purselain (*Sesubium portulacastrum*), and sea oats (*Uniola paniculata*). This vegetation shields the beach from low-level lighting, but streetlights can be observed underneath the canopy of the trees.

Site #2: Longboat Key, Sarasota County, Florida

Gulf of Mexico Drive, a two-lane roadway, is separated from the beach by an intermittent row of 3' sea oats (*Uniola paniculata*). In addition to streetlights, headlights from cars traveling along the roadway can be seen directly on the beach. The lighting consists of entryway, security, and interior lights from multi-family residences along with commercial lighting.

Site #3: Lido Public Beach, Sarasota County, Florida

This site is the most highly developed of the three sites chosen for the studies. Ben Franklin Drive, a two-lane roadway, runs adjacent to the beach separated by a short cement wall and sparse vegetation. Lighting visible

from the beach includes shielded streetlights, car lights, interior/exterior hotel and condominium lights.

Arena Experiments

Loggerhead hatchlings (*Caretta caretta*), about to emerge from their nests, were captured during the daytime and kept in a light-proof Styrofoam cooler lined with moist sand until being transported to the study site later that same evening.

At each study site, an “arena” was created by drawing a 4 m circumference circle in the sand. A slight (2 to 3 in) depression was created in the center of the arena to represent natural emergence conditions. The area within the circle was smoothed by raking so the hatchlings and their tracks would be clearly visible. Approximately five minutes before placing hatchlings in the arena, the lid was removed from the Styrofoam cooler to allow exposure of the hatchlings to ambient lighting and temperature. While observers lay prone in the sand outside the arena, four to six hatchlings at a time were placed in the center and allowed to crawl undisturbed until they crossed the arena boundary. Each hatchling was only used once during the study. After exiting the arena, the hatchlings were recaptured and placed in a bucket to await release on a dark section of beach (Salmon and Witherington, 1995).

All arena experiments were performed on moonless nights. Because lighting modifications were done between each trial, all tests could not be performed on the same night. Although care was taken to provide similar conditions for each trial, slight changes in environment and in hatchling performance could not be avoided.

Data Analysis

The track of each hatchling was drawn on a circular diagram to document any circling or changes in travel direction. Each hatchling’s “mean angle of orientation” (arena center to the position where it left the arena) was recorded (Salmon and Witherington, 1995). Rayleigh tests were used to determine whether groups within each trial were significantly oriented. A Watson circular statistic test was used to determine whether differences among the trials were statistically significant (Zar, 1999).

CONCLUSIONS

Site #1: Coquina Beach

All modifications to streetlights at Coquina Beach resulted in significant improvements to hatchling orientation (lights on vs modified, $p = 0.00$, lights modified versus off, $p = 0.00$). Hatchlings which were exposed to existing streetlights headed east toward the roadway. When streetlights were modified by installing cobra cut-off fixtures with #2422 acrylic lenses, overall hatchling orientation showed a significant shift toward the northwest, with over half of the hatchlings heading toward the water.

When streetlights were turned off, all hatchlings headed directly toward the water (Table 2).

Site #2: Longboat Key

On Longboat Key, the mean angle of orientation for hatchlings exposed to existing streetlights and those exposed to streetlights modified by installing shields did not differ significantly ($p = 0.16$). Both sets of hatchlings showed an overall orientation toward the northeast. A significant number of hatchlings exhibited signs of disorientation before exiting the arena (“as is” - 4 of 24, “modified” - 5 of 24) (Table 2).

Site #3: Lido Public Beach

At Lido Beach, modifying or turning off the streetlights did not have a significant impact on hatchling orientation (lights on vs modified, $p = 0.92$; lights modified vs off, $p = 0.58$). Hatchlings headed east toward the roadway under all three lighting situations (Table 2).

It is important to note that modifications to the original streetlights on Longboat Key and Lido Public Beach, which resulted in a decrease in the number of hatchling disorientation events, had been implemented before the start of this study.

DISCUSSION

The effects of lighting modification varied at each site. At Coquina Beach, modification of streetlights resulted in a significant improvement in hatchling orientation. At Longboat Key and Lido Public Beach, modification or removal of street lighting did not have a significant impact on hatchling orientation.

At Coquina Beach, lighting due to development is minimal. While modifying the streetlights with #2422 acrylic lenses significantly improved hatchling orientation, the most advantageous situation for hatchling survival was provided by turning off the streetlights. However, complete elimination of roadway lighting may not be the most realistic solution. Additional modifications, such as tilting the streetlights or installing shields in addition to the lenses, may further improve hatchling orientation while allowing the roadway to remain lighted for pedestrians and motorists.

At Lido Public Beach and Longboat Key, modification of streetlights did not render the beach dark enough to significantly improve hatchling orientation. Because lighting from upland development and automobile headlights continue to illuminate the beach, a solution was not found by correcting the streetlights alone.

Optimal conditions are obtainable if streetlight modification is done in conjunction with corrections to lighting from upland development. Formation of an overall lighting plan for each area, including guidelines for roadway lighting and lighting from upland development (single and

multi-family residences, restaurants, etc.), is necessary to provide suitable habitat for nesting marine turtles and emerging hatchlings.

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Table 1. Lighting conditions at arena sites.

Site	"As is"	"Modified"	"Off"
Coquina Beach	•100W, HPS open bottom, unshielded	•70W, HPS, #2422 arylc flat lenses	Off
Longboat Key	•2-200W HPS shielded directional (north) •2-100W HPS painted open-bottom (south) •2-150W HPS painted cobra (east)	• 60 degree 6" to 8"X12" shields around cobra fixtures	N/A
Lido Key	•250W HPS Cobra w/6" 90° and 3" 180° shields	•250W HPS cobra with 8" to 10" 270 ° shields	Off

Table 2. Hatchling orientation in response to lighting situations.

Site description	Sample size	Mean angle of orientation	Direction to gulf	Rayleigh's r value
Coquina Beach lights on	24	73 degrees	260 degrees	0.83
Coquina Beach lights modified	24	334 degrees	260 degrees	0.54
Coquina Beach lights off	24	259 degrees	260 degrees	0.98
Longboat Key lights on	24	41 degrees	245 degrees	0.77
Longboat Key lights modified	24	22 degrees	245 degrees	0.78
Lido Beach lights on	24	82 degrees	240 degrees	0.86
Lido Beach lights modified	24	82 degrees	240 degrees	0.94
Lido Beach lights off	16	79 degrees	240 degrees	0.97

Evaluation of TED Opening Dimensions Relative to Size of Turtles Stranding in the Western North Atlantic

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Sizes of stranded loggerhead, Kemp's ridley and green sea turtles from 1986-1997 were compared with the minimum dimensions of turtle excluder device (TED) escape openings to determine what percentage of strandings may be too large to fit through currently mandated openings [Gulf of Mexico: 32 in (81.28 cm) wide by 10 in (25.40 cm) high; southeast U.S. Atlantic: 35 in (88.90 cm) wide by 12 in (30.48 cm) high]. Morphometric data, including carapace length, carapace width and body depth were collected on live or fresh dead turtles and regression analyses were performed to develop predictive regression equations for carapace width (when not actually measured) and body depth of stranded turtles. Loggerhead and green turtle strandings with carapace widths greater than the currently required minimum TED width openings have not exceeded 1-2% of the total measured strandings in

any year since 1986. Loggerhead turtle strandings with body depths greater than the currently required minimum TED height opening have ranged between 33-47% of the total measured strandings since 1986. Green turtle strandings with body depths greater than the currently required minimum TED height opening have ranged from 1-7% of total measured strandings since 1986. None of the Kemp's ridley strandings measured between 1986 and 1997 had carapace widths or body depths greater than the currently required minimum TED openings. In order to reduce trawl mortality of large turtles, the TED opening dimensions need to be increased in both the Gulf of Mexico and southeast U.S. Atlantic.

Complete text of this report can be found at http://www.nmfs.gov/prot_res/publicat.html.

A Windows-based Sea Turtle Database Management System Used by SEATRU

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Nesting, tagging and *in situ* hatching data have been collected at the turtle conservation beach in Chagar Hutang, Redang Island, Malaysia since the project began in 1993. This long-term program has generated large volumes of data requiring a computerised database system for management and analysis. Such a system has been developed under the Filemaker platform, a Windows-based data management software. The database management system was developed with little programming knowledge required. It allows data entry with layouts that can be printed for use in the field reducing the likelihood of errors. Different levels of user-password security for the database can be included. Information can be summarized and presented in various formats for analysis and up-to-date report generation. The database can be exported to other formats for further processing (like spreadsheets, statistical programs, etc.). The system was easily expanded to handle links to supply information for nest and turtle adoption schemes introduced by SEATRU in 1998 and 1999. The system can also handle shared local area network (LAN) access and internet access through a built-in WWW interface.

INTRODUCTION

Running a turtle research and conservation program often entails the collection of large volumes of data that need to be managed and analysed. Such demands arose when the Sea Turtle Research Unit (SEATRU) of Universiti Putra Malaysia Terengganu started a turtle nesting, tagging and *in situ* hatchery at Chagar Hutang, Redang Island, Terengganu, Malaysia in 1993. This poster demonstrates the application of the Filemaker Database Software in the management of sea turtle research and conservation data.

DATA COLLECTION

Data were collected in the field and recorded on forms with the same format structure as printed from the database program. This would minimize errors in the transfer of information from the field forms to the computerized database. Initially, two sets of database were created, one for tagging and nesting information and the other for the *in situ* hatchery. The type of data collected for the tagging and nesting information includes species of turtle, date and time of nesting activities, tagging information, size of the nesting turtle (CCL and CCW), number of eggs laid, nest number, location of the nest, depth of the nest, fate of the eggs, diameter of the eggs and other characteristics of the

turtle. Data collected for the *in situ* hatchery information includes nest number, date of hatching, number of empty egg shells, number of hatchlings stranded in the nest, number and condition of unhatched eggs and signs of predation. From the tag records, each nesting turtle can be identified and given a identification code or 'turtle I.D.' The turtle I.D. is indexed for cross-referencing and maintained permanently for the turtle even though the tags are changed. The nest number for each year is also indexed for cross referencing.

THE DATABASE SYSTEM

The computerized database management system was developed using the Filemaker Database Software. Though any other database software would perform just as well or better, the lack of expertise in computer programming prompted this selection due to its ease of use. Button menus could be easily created and the design of formats for data entry, listings, summaries and reports can be achieved with little programming proficiency. It also allows calculations from the database to be computed through the use of formulas. It also permits the import and export of data across different database and spreadsheet platforms for further analysis if necessary. Some of the output that can be generated from the Tagging and Nesting database includes the Turtle Identification Cards that would display the nesting chronology for each turtle; Turtle and Nest information listing for browsing through the database; summaries for daily egg production and landings; and overall summaries to date. Output from the Hatching database also has listings for browsing various hatchery information and summaries to date. These output formats allow rapid generation of information for reports and presentation.

EXPANSION OF THE DATABASE SYSTEM

In 1998, SEATRU introduced a number of public participation programs namely the Nest Adoption, Turtle Adoption and SEATRU Volunteers. New database to handle records of nest and turtle adoption information and the volunteers were created. These were linked to records from the previous two database for information pertaining to the nest or the turtles adopted to be dispatched to the sponsors concerned. Recent versions of Filemaker allow the database to be shared in a networking environment or through the internet in a web-based environment with user-password security access.

LIMITATIONS

There are limitations in this database system to perform certain analysis or to generate graphs and tables. However, these are common limitations of most database programs. Nevertheless, the data could be easily exported to various file formats like spreadsheets for further analysis and to generate the necessary tables, graphs or statistical analysis.

ACKNOWLEDGMENTS

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Turtle Excluder Device (TED) Development and Testing: 1999

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Small turtle testing and SCUBA diver evaluations of a fly net, flounder trawl and the leatherback modification for hard TEDs was conducted by the Harvesting Systems and Engineering Branch beginning June 3 and ending June 14, 1999. One hundred and sixty (160), two-year class loggerhead sea turtles with a mean carapace length of 34.5 cm were obtained from the National Marine Fisheries Service (NMFS) Galveston, Texas laboratory and were released into trawls equipped with TEDs.

TEST METHODS

Operations were conducted a board the R/V Georgia Bulldog, a 24 m, steel hull shrimping vessel operated by the University of Georgia, Marine Extension Service. The vessel was rigged to tow one trawl directly astern at 2.5 knots. Operations were conducted in the Gulf of Mexico, 0.25 mi offshore of Shell Island, Panama City Florida in a water depth of 7 m. Acclimation and conditioning of the turtles was conducted for four weeks prior to the tests in containment pens within St. Andrews Bay, adjacent to the NMFS Panama City laboratory. Care and maintenance of the test turtles was the responsibility of NMFS Galveston personnel throughout the project. All turtles were recaptured after being exposed to a candidate TED and returned to the containment pens at the end of the day. Recaptured turtles were allowed a recovery period of at least 48 hours before being used in another test/evaluation. Each candidate TED test required the exposure of a sample of turtles into a TED equipped trawl. Turtles were transferred from the surface to divers on the trawl via a stainless steel messenger wire, 30 mm in diameter, attached from the stern of the vessel to the trawl headrope. Turtles were placed inside a 63-cm x 63-cm mesh bag at the surface, attached to the messenger wire with a snap clip and sent underwater to divers on the trawl. Transit time for the turtle from the surface to the trawl was approximately one minute. Turtles were released from three different

positions on the trawl headrope to mitigate bias that might be associated with release position. Release positions on the trawl head-rope were determined by dividing the head-rope length into three equal length sections and determining the center point for each section. This method resulted in a center headrope release point and two side or 'wing' release points. Release position for each turtle was determined through random selection prior to initiating the test of a candidate TED. Three SCUBA divers monitored each test. Diver #1, released the turtle into the trawl, then took a position behind the TED in order to recapture the turtle. Diver #2, monitored the turtles passage through the net and recorded escape time and behavior data. Diver #3 recorded each test exposure using an underwater video camera. Upon release at the headrope, each turtle was allowed five minutes in which to escape through the TED. At the end of the five minute interval, if the turtle was still within the trawl, a diver removed it. If a turtle was determined to be stressed during the five-minute exposure period, it was removed from the trawl, returned to the vessel immediately, and not counted in the sample. Data obtained during each exposure included, a video record, total time in trawl (from release at head-rope to escape through TED or removal from trawl) and, turtle activity (very active, moderate, inactive). Recaptured turtles were not used in a certification test of a candidate TED. The relative efficiency of each candidate TED design was compared to that of a control TED tested under the same conditions and with the same year-group of turtles. A top-opening, curved-bar TED (Super Shooter TM) was selected as a control by a majority vote of the 1995 TED testing review committee (NMFS/SEFC report, April 1996). The control TED was installed at a 53E angle, and was fitted with an accelerator funnel and extended flap. A sample of 25 turtles were exposed to the control TED in order to establish a control data set. An outline of the statistical procedure used to obtain a decision rule for candidate TEDs is provided below.

1. A control TED is tested using a sample of 25 turtles.
2. Null Hypothesis (H_0) = exclusion rate of the candidate TED is greater than or equal to that of the control TED. Alternate hypothesis (H_a) = exclusion rate of the candidate TED is less than that of the control TED.
3. The number of turtle captures required to reject a candidate TED using a sample of 25 turtles is derived through assessment of the probabilities of committing Type I and Type II error. A Type I Error (α) is the rejection of a candidate TED which is as good or better than the control TED (risk of rejecting an acceptable TED). A Type II Error (β) is the acceptance of a candidate TED that is inferior to the control TED (risk of accepting an unacceptable TED).
4. Based on the performance of the control TED (0 captures in 25 releases) and maintaining a α at or below 22% (1995 TED Testing Committee Review, NMFS/SEFC report, April 1995) a decision rule was derived. Testing of a candidate TED could be terminated after it had failed to release one (1) turtle within the five minute exposure period. This capture rate corresponded to a 16% risk of rejecting a candidate TED that was as good as or better than the control TED.

FLYNET EVALUATIONS

Objectives

1. Determine if the large, front-end meshes of a flynet can cause turtle entanglement
2. Build and install a prototype TED for a flynet and,
3. Test a prototype fly net TED for turtle exclusion and ease of operation using a net reel.

METHODS

An 26 m head-rope length fly net was purchased from Wanchese Trawl Works in Wanchese, NC. The trawl was towed at 3.0 knots and had a front-end opening of 13 m wide by 7.7 m high. The fly net is designed for and was observed to fish hard on the bottom. The leading meshes of the trawl were 81 cm stretched length, with reducing mesh sizes of 40.6', 20.3', 10.1' and 7.6' cm mesh as the trawl tapered to the codend. Two and three year-class turtles were released in the trawl in order to observe entanglement. Turtles were released either by divers in a bottom wing position, or from a small boat, directly in front of the net. Using the latter method, turtles dove in front of the trawl and were overtaken, sometimes while lying on the bottom. This release method may simulate a more common turtle/trawl encounter.

RESULTS

Entanglement

Of 29 turtles released, seven escaped through the large 81 cm mesh of the trawl and three became entangled. The remaining 19 turtles either entangled briefly or got loose (remaining in the trawl) or had no encounter with the large mesh. Divers released all the turtles, which became entangled, immediately in front of the wing. None of the turtles released from the surface, in front of the trawl, became entangled. The low entanglement rate is due largely to the slow taper of the trawl (3:1) thereby creating a low angle of incidence between the trawl and direction of water flow. The trawl meshes were pulled tight, allowing turtles to push free of the webbing if they became entangled. Because of the large vertical opening at the trawl head-rope (7 m), we speculate that turtles overtaken by the trawl while foraging on the bottom are likely to encounter only the large meshes of the bottom belly or lower wing and free themselves by swimming upward. Further investigation on the range of flynet designs in the fishery is necessary to establish that all have similar low-angle tapers.

Prototype Flynet TED

In order to facilitate winding on the net reel, folding TED designs were constructed and tested. A bi-folding TED, consisting of two rectangular aluminum TED frames hinged together and a tri-folding TED (three smaller frames hinged together) were evaluated. Both designs were installed as top opening TEDs in a 9 cm mesh extension piece and inserted in the trawl ahead of the codend section. Both designs worked well for turtle exclusion with the following results: Bi-fold TED, $n = 25$ (one capture, 24 escapes), Tri-fold TED, $n = 10$ (0 captures). With the use of rib lines, the folding TEDs maintained their angle during fishing and presented no problems when winding on the net reel. The next step will be to evaluate these TEDs in the fishery aboard working boats.

FLOUNDER TRAWL EVALUATIONS

Objective

Using a 14-cm mesh flounder trawl equipped with a flounder TED, observe turtle encounters with the trawl webbing and determine where entanglement areas are located.

METHODS

A 15.8-m headrope length, 14-cm mesh flounder trawl (called a Yankee 52-ft.) was purchased from Wanchese Trawl Works and fitted with a top-opening flounder TED. The TED had two, 25.4-cm square openings at bottom of

frame. Two treatments of the gear were evaluated, Treatment #1: TED installed in a 14-cm mesh extension piece and Treatment #2: TED installed in a 8.9-cm mesh extension piece. The trawl was towed at 3.0 knots and had a front end opening of 9.4-m wide by 2.4-m high. All turtles were two-year class and were released from a wing position to create a 'worse case' encounter.

RESULTS

Treatment #1 (14-cm mesh extension.): n = 8

Four turtles entangled directly forward of the TED (did not escape within five minutes), one turtle entangled in mid-wing section of the trawl and, three escaped through the TED.

Treatment #2: (8.9-cm mesh ext.) n = 8

Six turtles escaped through the TED with no entanglement, one capture (lodged sideways between deflector bars), and one maneuvered through the 25.4-cm opening at the bottom of the TED frame (captured in the codend). These results clearly demonstrate that a 14 cm mesh TED extension piece can cause two-year class turtles to entangle and should be reduced in size within the fishery. Based on these results and our observations of turtles encountering 10-cm webbing in soft TEDs, we recommend a maximum size of 8.9 cm stretched mesh length in the TED extension of flounder trawls. Wing entanglement was observed in 1 of 16 turtles. Because of the slow trawl taper (4:1), entanglement in the forward section of the trawl may not be a significant problem in the fishery.

LEATHERBACK OPENING

Objective

1. Conduct a certification test of a bottom-opening and top-opening hard TED fitted with a leatherback escape opening to determine if two-year class turtles are prevented or inhibited from escaping with the long flap.
2. Assess the fishing configuration of the leatherback modification for shrimp retention.

METHODS

A control test was conducted using a top-opening mid-size Super Shooter with an extended flap, accelerator funnel and Gulf of Mexico escape opening dimensions (81.2 cm x 25.4 cm). The TED was installed in a 12.5-m mongoose shrimp trawl.

Treatment #1: 12.5 m mongoose shrimp trawl fitted with a bottom-opening, mid-size Super Shooter TED and leatherback opening modification (straight-line escape opening measurement 180 cm).

Treatment #2: 12.5 m mongoose trawl with top-opening TED and leatherback opening. Two-year class turtles were released from port wing, center and starboard wing positions on the trawl.

RESULTS

Control test: n = 25, 0 captures, 25 escapes. Treatment #1 (bottom opening): n = 25, 1 capture, 24 escapes. Treatment #2 (top opening): n = 25, 0 captures, 25 escapes. Mean escape times for each treatment were, Control = 1 minute, 36 seconds, Treatment #1 = 1 minute 16 seconds, Treatment #2 = 48 seconds. The extra width of the leatherback opening appeared to improve the escapement of turtles by providing more area for escape along the sides of the TED frame. This was especially evident with the bottom-opening TED. The flap length did not cause a problem with escapement in either the top or bottom configuration. As long as TED angle and flotation requirements are adhered to, the leatherback opening should only help escapement of both large and small turtles. With regard to the flap configuration, as a bottom opener, the leatherback flap a 1in gap was observed between the bottom of the TED frame and the flap. As a top opener, the flap had some slight folds, but was snug against the frame. Additional work is planned for the year 2000, which will examine the effect of knot orientation on flap configuration. Recent studies by fishing gear researchers have found that a piece of trawl netting may take a different shape depending on which way the knots are oriented with respect to the water flow. It is possible that orienting the TED flap piece differently will eliminate the observed 1in gap.

Sea Turtle Research and Conservation in Uruguay - Karumbé Group 1999

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INTRODUCTION

During 1998, a group of nine young biology students from the Facultad de Ciencias de la Universidad de la Republica del Uruguay and one education student start working in the sea turtle research and conservation stimulated from the experience they acquired in several projects in Brazil (Proyecto Tamar), Costa Rica (CCC) and Mexico (UNAM). Once established, the group visits the Laboratory of Vertebrate, and starts working with the current Professor M. in C. Federico Achaval (MTSG member). The name of the project, Karumbe, was chosen from the Indian language, and means "Turtle". This word was used in the past by the Guaraníes, who lived in our territory 500 years ago.

Due to the scarce information about Sea Turtles in Uruguay, there are just eleven works published- the group begins working at beaches and shores of our country. Trying to follow worldwide standards, we started the Karumbe project with two main goals: research and conservation.

RESEARCH

The research area focuses in the first place on getting knowledge of historical files, such as the Reptile Collection from Facultad de Ciencias and collections from state and private museums. We also keep a record of the immense number of animal remains (bones, carapaces, skulls) which are used as decorations in stores or private houses. Biometric data is taken from the samples, as well as information about connection, year of capture, cause of death. This job is complemented with a photographic register of each piece of the census. The aim of this work is to get to know the main problems of Uruguayan species as well as their virtual distribution and composition of turtle population.

A large number of turtles were affected in the last years by incidental capture, or they simply appeared stranded without reasonable explanation. During 1999, several field trip were made along the 320 km of Atlantic shore, with the aim of registering reports of stranded animals.

One special case was about seven turtles which were found stranded and dead in Punta Colorada, department of Maldonado, in May and September 1999. They were juveniles samples of green turtles (*Chelonia mydas*) (Table 1).

As a result of a first direct observation it was determined that all the samples were completely entangled in anglers' reel line, being that the possible cause of death. All the samples were in strong state of decomposition, which make the field work harder. There were also carried out necropsies in each piece, with no relevant outcomes, due to the state of the bodies.

In August we took notice of another stranded turtle at the beach of Punta Colorada. A sub-adult green turtle sample was found stranded alive at San Franciscos' beach, near to Punta Colorada. The turtle was 79 cm curved carapace length, the largest registered in our country. The Marine Fauna Rescue Center with site in Punta Colorada tried to rehabilitate it in captivity without success, for it died four days later. A later necropsy revealed tiny plastic pieces in its intestine, being that the possible cause of death.

A new experience was the necropsy we made at the Facultad de Ciencias' laboratories. Although the institution does count with two specialists on work with reptiles, there had not been carried out necropsies as practical classes for curricular subjects. The first necropsy was made on an exemplar donated by Pablo Etchegaray, director of the Museo del Mar, Maldonado.

The research on the consequences of the incidental capture in coast towns is other of the activities carried out, in collaboration with the research project of Profesor Federico Achaval and Institute National of Fishery (INAPE). Important data have been taken from this common activity, which refers to species loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*). This species are hard to investigate because of their pelagic habits.

CONSERVATION

On the conservation area, the work focuses particularly on fishermen and children. In order to make contact with fishermen, our technicians went to 15 different fish communities on four coastal departments (Montevideo, Canelones, Maldonado and Rocha). The work strategy to reach to fishermen was personal chat, which worked out to be effective. When noticing we were students, absolutely every fisherman collaborated. Fishermen and sea turtles live together day by day. All of the interviewed fishermen claimed to see them at fisheries, being very common the juvenile *Chelonia mydas* in warm months between October and May.

On the department of Rocha it was noticed a strong meat consumption and illegal sale of carapace, as one extra way of getting money. On the other departments there was also detected the illegal sale of carapaces and heads with decorative aims. However, the turtles' meat consumption is not frequent, although it happens in Montevideo, Canelones and Maldonado.

In the period of November-December of 1999 we worked with children between 11 and 13 years old from Primary School N°40, 'República de México', as part of the test project of student Antonia Bauzá. Due to the general interest the children presented on animal studies, the topic was used as an opening for different subjects. This is an educational strategy known as 'interest centre'. The project consisted on five different stages. It started with an introducing talk, with video, poster and photographs. The children's feedback was unexpected, they showed to be extremely interested on the topic. Then there were activities related to sea turtles, in consonance with the schedule (Natural Sciences, Mathematics, Lenguaje, Geography and hand-made activities).

Although this was carried out with scarce funds and without the support from the school's director, the objective-which was to make the children aware of the need to protect the marine fauna and the responsibility they have in doing so-was fully reached. The children, for their part, helped with information. For example, a little girl, daughter of fishermen, gave information about carapaces she had at home. This project was a means to systematize the different interactions the children have with the environment preservation and marine turtles, at the same time they learn.

CONCLUSIONS

The Karumbe Project is a pioneering work in Uruguay. There had never been in our country a group of future Biologists with the aim of studying and preserving sea turtles. Unfortunately, the group has to pay for its activities. We work on changing that fact, presenting our project to every financing call. Were that possible, the group is already thinking about new activities, as the shore monitoring as well as an educational plan all over fishing

areas. It is our priority to make that Uruguay ratify the sign of the Interamerican Convención in 2000.

ACKNOWLEDGMENTS

We want to thank to Biol. Federico Achaval for share with us his time and knowledge. A special gratitude to biol. Laura Sarti and Biol. Hedelvy Guada for their 'spiritual attendance'. Thanks to Richard Tesore, director of 'S.O.S. - Rescate de Fauna Marina' Center, for the data and time offered. Thanks to Pablo Etchegaray, director of 'Museo del Mar' for the time offered and the donation of a juvenile green turtle body. Thanks to David and Lucille Packard Foundation for economic support. Thanks to Carmen Estrades for assistance in translation.

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Table 1. Data on seven green turtles (*Chelonia mydas*) that were found stranded and dead in Punta Colorada, Department of Maldonado, in May and September of 1999.

Date	Condition of turtle	Curved carapace length (cm)	Curved carapace width (cm)
May 18	Complete	40.0	35.0
May 18	Without head and flippers, carapace bit in the supracaudal scutes		37.5
May 18	Bones		
Sep 5	Complete and fresh.	39.5	35.0
Sep 5	Complete and fresh.	34.0	31.0
Sep 5	Complete	43.0	39.5
Sep 5	Carapace bitten by dogs	39.0	39.0

Community-Based Research and its Application to Sea Turtle Conservation in Bahía Magdalena, Baja California Sur, México

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INTRODUCTION

Sea turtles are an important part of the cultural history of northwestern Mexico. As in many fishing communities in the region, the uses of sea turtles by the inhabitants of

Bahía Magdalena have been an important part of their lifestyle, traditions and culture, despite evidence of decreasing turtle numbers within the bay and strict laws prohibiting their use. While over-harvest was largely responsible for their decline, it is this cultural connection to

the animals that may contribute to their recovery.

Of the five threatened or endangered sea turtle species known to inhabit the coastal waters of Pacific Mexico, two species most commonly frequent the waters within and adjacent to Bahía Magdalena: the East Pacific green turtle- or black turtle (*Chelonia mydas*) and the loggerhead turtle (*Caretta caretta*). These are also the species that are most commonly caught by the fishers of Puerto San Carlos, Puerto Magdalena, and Lopez Mateos the largest communities on the shores of Bahía Magdalena (Gardner and Nichols, This volume). The coastal waters around the Baja California peninsula serve as critical feeding and developmental habitat for these and other sea turtles, after migrating from as far as Michoacan (Nichols *et al.*, 1998) and Japan (Nichols *et al.*, 2000).

Because of the intimate relationship between the turtles and the local community and the vastness of the region the use of community-based conservation strategies are extremely important. Involving the knowledge and trust of the fishers of Bahía Magdalena has been crucial to recent research and conservation efforts. Local education and communication has led to the participation of fishers in providing valuable data such as tag returns and mortality information. Benefits of the research to the local community include increased knowledge of the local ecosystem and a higher potential for recovery of turtle populations. The goals of our research include the involvement of fishing communities in the development of conservation projects, the involvement of local students and fishers in the

collection of data, and the public sharing of research results on a regular basis. Community meetings serve as an outlet to share information on the biology of sea turtles as well as their protected status.

METHODS

Because this paper represents a variety of conservation projects, there is not one specific methodology that was used. It exists as more of a commentary about the importance of community involvement in many aspects of our sea turtle research and conservation. Research was conducted within the fishing communities of Puerto San Carlos, Puerto Magdalena, and Lopez Mateos located on the shores of Bahía Magdalena, a large mangrove estuarine complex on the Pacific coast of the Baja peninsula in Baja California Sur, Mexico. A portion of our research consisted of a socioeconomic study of sea turtle utilization within Bahía Magdalena (García and Nichols, This volume), as well as biological, and ecological studies (Nichols *et al.*, This volume; Gardner and Nichols, This volume). Research was conducted with the assistance of students from the USA who were participating in a study abroad program through the School for Field Studies' (SFS) Baja California field site: Centro para Estudios Costeros (Center for Coastal Studies) (Mider *et al.*, This volume) located in Puerto San Carlos, the largest community on the bay. A variety of data were collected, including mortality information, diet analyses, and tissue samples for genetic analysis. Local

Support of the Project to Protect and Conserve Sea Turtles in “La Encrucijada” Biosphere Reserve, Chiapas, México

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“La Encrucijada” Biosphere Reserve is located to the south of Chiapas State, Mexico, in the Coastal Plain of the Pacific (Fig. 1). Geographically, it is located between 14° 43' and 15° 40' N and 92° 26' and 93° 20' W. It encompasses 144,868 ha, of which 36,216 ha correspond to two central areas (La Encrucijada and Palmarcito) and 108,651 ha correspond to a buffer zone. The reserve includes part of the municipalities of Pijijiapan, Mapastepec, Acapetahua, Huixtla, Villa Comaltitlán and Mazatán.

The types of vegetation present in La Encrucijada include mangroves, zapotonal, popal, tular, tropical forest, dry season forest, aquatic vegetation, vegetation of coastal dunes, and palmares. On the other hand, the tidelands, coastal lagoons, flood areas and present marine environment in the area are essential in the maintenance of the characteristics physical-biotics of the area.

The area constitutes the system of wetlands of more relevance to the coast of the American Pacific due to its

extension, its structures and productivity. It is the only area that protects the ecosystems and the flora and fauna species existent in the wetlands in the coast of Chiapas. It contains mangroves of 35 m in height (considered height the highest in North America) and it is also characterized to contain the only community in México of a forest of zapotón (*Pachira acuatica*), as well as palmares of *Sabal mexicana*. It is part of the North American Waterfowl Management Plan.

The presence of sea turtle in the coast of Chiapas, mainly of the species *Lepidochelys olivacea* (olive ridley), it's registered by means of the Project of Protect and Conserve Sea Turtle in “La Encrucijada” Biosphere Reserve (REBIEN), financed by the Government of State through the REBIEN in coordination with Natural History Institute. For the realization of the protection activities, we have the camp “Barra Zacapulco” located in the town of the same name in the region of the coastal line of the South Pacific of Mexico among San Juan's outlet (N15°09.714'-

Fig. 4. Incubation treatment-pen.**Fig. 5.** Hatchling release.

Jornadas de Protección de la Tortuga Caná (*Dermochelys coriacea*): A Social Initiative for Their Conservation

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The endangered situation of *D. coriacea* in Colombia, it began to generate conservation initiatives from civil society. Since 1993, the Fundación Darién (NGO) works with students of the University of Antioquia in the Jornadas de Protección de la Tortuga Caná. Our objective is the conservation of the species through the combined work between the students and the community. Jornadas de Protección de la Tortuga Caná in Acandí y La Playona (Caribbean Coast) develop activities of environmental education, shops of painting, crafts and ecological games with children and adults. During the night we walk through the beach and we talk with the tourist or another people about rules for to observe the oviposition process. Additionally, we have information about spacial distribu-

tion in the oviposition beaches, morphometrics features of females and hatchlings, counts of eggs, incubation period, and number of hatchlings. We have practices of protection *in situ*. Until the moment we make an investigation thesis about ecological anidation process and in advance, another investigation on sexual determination in La Playona. This proposal of conservation of the marine turtle *Dermochelys coriacea* - Tortuga Caná - still doesn't have an institutional program that guarantees its continuity. This experience pretends the popularization of the conservation necessity and protection of this species and its ecosystem and the attainment of resources that allow to continue developing our work in the region.

Conservation of Sea Turtles in the Marine Environment: the Eastern Mediterranean Coast of Turkey

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The eastern Mediterranean coast of Turkey, the area between Mersin and Iskenderun, is the living and wintering environment for the endangered green turtle (*Chelonia mydas*), which mates and nests on the shores of the region. This area is also one of the most prolific fisheries of the country.

In 1995, the Society for the Protection of Nature (DHKD) and World Wide Fund for Nature (WWF) initiated the first systematic study of sea turtles by-catch in Turkey.

This study aims to both measure and publicize the problem.

The aim of the project was to determine the sea turtle population in the eastern Mediterranean coast of Turkey; to determine the mortality rate of sea turtles that are entrapped in nets during the trawling season (September 15-May 15); and to organize public awareness activities about sea turtle by-catch

The project was initially set up in pilot area Karatas near Adana. A project officer worked with the fishermen on

board of trawling boats to verify the data collected during the fishing season. Cooperation was developed with the Ministry of Agriculture, the Ministry of Forestry, the Ministry of Environment, the Coast Guard, local authorities and universities. These institutions were regularly informed on the progress. A video, highlighting the work of the project was prepared for the launch of the "International Year of the Ocean" (1998) in London. Press articles were prepared and published in several magazines and newspapers.

In the 1995-1996 fishing season, the five trawling boats taking part in the project reported that the nets in the Eastern Mediterranean entrapped 160 green turtles and 26 loggerhead turtles (*Caretta caretta*). In the 1996-1997 season, 12 trawling boats reported higher figures of entrapment-306 green turtles and 116 loggerhead turtles. DHKD has selected the green turtle as a flagship species to highlight both overfishing and related problems of by-catch in the Mediterranean.

LESSONS LEARNED

1. Captains need to receive training on the tagging system which will help identify the status, population and nesting sites of the green turtle.

2. Involving the fishermen in the project helped create a feeling of partnership. Training programs increased fishermen's awareness and changed their attitudes about the non-target species. The number of boats participating in data collection increased.

3. Cooperation with the Ministry of Agriculture, Coast Guard and local authorities had positive impacts on the project

All of DHKD's efforts will be used to declare a Marine Protected Area (MPA) in this region in the near future.

Operation Kachhapa and the Olive Ridleys of Orissa (India): Short and Long Term Management Plans

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INTRODUCTION

Large scale trawling mortalities of olive ridleys on the Orissa coast (over 50,000 turtles in five years) have necessitated the formulation of strategies to drastically reduce deaths in the immediate future. Operation Kachhapa is a collaborative effort between the state government and NGOs. Operation Kachhapa aims to protect sea turtles and their habitats by enabling strict enforcement of the non-mechanized five km fishing zone limit by the Forest and Fisheries Departments and the coast guard. It is believed that these measures would also help preserve small scale fisheries in the region. The program plans to provide logistic support for patrolling and intends to obtain public support by a media campaign. Most importantly, it plans to involve the local fishing communities in turtle conservation as any sustainable management plan must depend on the support of these communities.

MAIN THREATS TO OLIVE RIDLEYS IN ORISSA

Trawling Mortality

There are three primary mass nesting beaches of olive ridleys in Orissa – Gahirmatha (Bustard, 1974), Kar (1982) and Rushikulya (1994). Since 1993, more than 50, 000 dead turtles have been counted along the Orissa coast over

a distance of 400 km (Pandav *et al.*, 1994, Shanker *et al.*, 1999; Bivash Pandav, personal comments) and the total number dead is certain to be more than the number counted on the beaches. Shrimp trawlers and gill netters are the primary cause of mortality (Pandav *et al.*, 1998, Shanker *et al.*, 1999) and they operate in near-shore coastal waters in violation of the Orissa Marine Fisheries Regulation Act (1982) and Rules (1983), which bans all mechanized fishing within 5 km of the coast. Apart from the large scale mortality of sea turtles, the small scale traditional fisheries also seem to be collapsing due to uncontrolled and illegal mechanized fishing within the prohibited zone. None of the trawlers operating in the area use Turtle Excluder Devices.

Construction of a Port at Dhamra

A new threat is the construction of a port at Dhamra, 10 km north of Gahirmatha. The modern bulk terminal port is being built by the International Seaports Private Limited, a joint venture of between Precious Shipping Company Ltd of Thailand, Stevedoring Services of USA, and Larson & Toubro Ltd. The port area will occupy 900 acres, and will have a total berth length of 550 m. The 62.5 km rail corridor to Bhadrak will be 200 m wide occupying 3000 acres. The facility will cater to bulk cargo like coking coal and iron ore. The project has only been cleared by the Ministry of Surface Transport, owing to a loop hole in the CRZ rules.

Decline of the Nesting Beach

The current nesting sites comprise two islands (fragments of an original island which broke away from the mainland in 1989) each of which is about 2 km long and less than 100 m wide. The islands have become narrower over the past few years and inundation during spring tides may have been a primary cause for the failure of the arribada in 1997 and 1998. Most of the eggs laid at Nasi 2 during 1999 were exposed due to inundation

Other Problems

Beach lighting is a problem at Rushikulya (Jayashree Chemicals Ltd) and at Gahrimatha (Defence Research and Development Organisation). Both have been persuaded to turn lights off during the turtle season. Prawn seedling harvesting along the coast by local fishermen prevents turtles from coming ashore to nest. There is also concern over an major oil pipeline at Rushikulya nesting beach (Offshore single buoy mooring), which may affect the mass nesting beach. Another problem is habitat loss due to Casuarina plantations along the entire coast of Orissa.

THE AGENDA AND ACTIVITIES OF OPERATION KACHHAPA

Operation Kachhapa is a collaborative effort between the state government (Orissa Forest Department), and NGOs (Wildlife Protection Society of India, New Delhi and Wildlife Society of Orissa, Cuttack). It also involves consultants from sea turtle research projects at the Wildlife Institute of India, Dehradun. It involves the following activities.

Enforcement

- Providing a sea-going patrol vessel for the Forest providing Department and auxiliary support boats for their monitoring camps.
- Providing equipment for mobile camps run by the Forest Department and researchers to protect and monitor nesting beaches.
- Creating an incentive scheme for enforcement officers.
- Preparing an assessment of enforcement action and penalties incurred to date to present the results to the Orissa government's committee.
- Following all relevant court cases and pursuing private proceedings against trawlers apprehended for illegal fishing and against poachers.

Awareness

- Producing information boards in fishing port areas with traditional fishery and wildlife laws.
- Producing flyers about the need for turtle conservation and fishery and wildlife laws for the operators of fishing boats.
- Producing programs for local radio to provide information about turtle conservation.

- Establishing an e-mail update network for regional and international journalists, turtle conservationists and others.
- Providing regular media updates through nationwide TV news channels, newspapers, news-magazines, and radio.

Research and Monitoring

- Assisting research programs through tagging and monitoring of nesting turtles.
- Assessing trawler related mortality.
- Assessing breeding areas using GIS to aid patrolling and to help predict mass nesting.

Community Participation

- Involving local communities in the conservation program by enlisting their support for monitoring nesting and breeding areas.
- Involving coastal residents and industries to deal with beach lighting, and habitat encroachment.
- Enlisting the support of decisions makers like legislators and senior government officers.

Operation Kachhapa in 1999

Sixty four trawlers and gill netters were seized for illegal fishing inside the Gahirmatha Marine Sanctuary. Their trial cases were contested by lawyers engaged under Operation Kachhapa on behalf of the Forest Department in the local courts. On 10 May 1999, the fishermen of Orissa joined a nation wide strike by small scale fishermen throughout the country demanding total stoppage of illegal trawling within the coastal zone of 5 km reserved for them.

Operation Kachhapa in 1999-2000

Operation Kachhapa has been deeply involved in cyclone relief operations along the coast and particularly in primary turtle nesting areas. Relief operations have included distribution of food, blankets, and other materials. Patrolling operations were started with the Forest Department in January, 2000.

DISCUSSION*Successes and Failures*

While Operation Kachhapa has definitely served in focusing attention on olive ridleys in Orissa, the main objective of reducing mortality in the short-term has not been achieved. The program has failed to involve the Fisheries and has also not been able to get the Forest Department to patrol offshore waters adequately; consequently mortality has remained high in 1999 and 2000 (>10,000 in 1998-99 and nearly 10,000 by mid February in 1999-2000). However, the program has been able to gain the support of many local communities by providing relief in the wake of the cyclone. Due to widespread state and nationwide media coverage, olive ridleys are popular public figures, which can be used in campaigns in the future, such

as in protesting against the port at Dhamra. It is also necessary that long and short term goals are identified and programs/strategies formulated to deal with them.

Long Term Solutions

- Participation of local fishing communities in the conservation programs by monitoring nesting and breeding areas and by monitoring trawler related mortalities and reporting illegal trawling activities.
- Involvement of fisheries departments in designing and implementing sustainable harvesting strategies and promoting the use of TEDs.
- Formulation of strategies that can protect the turtle along the entire coast rather than within designated sanctuaries.

Immediate Measures

- Enforcement of the existing laws (OMFR Act, 1982, and Rules, 1983) which bans all mechanised fishing within 5 km of the coast.
- Patrolling by the Forest and Fisheries Departments and Coast Guard.
- Monitoring of mortality.
- Identification of key breeding areas and annual monitoring of breeding and nesting.

FINAL COMMENTS

Patterns of mass nesting, tag recoveries (Bivash Pandav, personal communications) and genetic data (Kartik Shanker, Unpublished data) suggest that olive ridleys in Orissa use more than a single nesting beach during a season. Further, the possibility of their nesting at new beaches seems real – there were two small arribadas at Barunei, 30 km south of Gahirmatha, in March (8000 turtles) and April (20,000 turtles), 1999 (Shanker and Mohanty, 1999). This particularly suggests that any conservation strategy must take into account the changing nature of the beaches and the changing patterns of nesting. It is important that key areas are assessed at the beginning of the season to determine turtle aggregations, so that these areas can be patrolled to protect turtles in offshore waters. Nearby nesting beaches can also then be monitored for nesting and mortality. There is a need to persist with current strategies (monitoring and

enforcement) until some of them bear fruit, while others may need to be revamped completely (e.g. management within sanctuaries). It is hoped that initiatives such as Operation Kachhapa can bring together a combination of policy makers, activists, researchers and local communities who can work together to ensure the conservation of the olive ridley in India.

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Sea Turtle Conservation in the Central Caribbean Coast Colombia

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INTRODUCTION

This research occurs on a coastal strand of approximately 50 km, jurisdiction of the National Park Sierra Nevada of Santa Marta and Tayrona. Between 1995 and 1999, 9767 eggs have been collected from the species *Caretta caretta*, *Chelonia mydas*, *Eretmochelys imbricata* and *Dermochelys coriacea*. *Caretta caretta* was the most abundant.

With the help of WIDECAS- T and the support of different regional environmental organizations, in 1999 a tagging program was initiated and blood samples were taken to study the genetic structure of the *Caretta caretta* population nesting in the area. Including local people and fisherman in developed conservation activities has been of great importance to achieving the objectives.

Under the coordination of WIDECAS- T the consolidation process of the (RETOMAR) is moving forward though participation of government and non government organizations and community groups conservation actions can be extended to other central Colombian Caribbean zones where evidence of marine turtle reproduction and foraging exists.

METHODS

The study area includes the northwest side of the Sierra Nevada of Santa Marta and covers the beaches located between the Guachaca and Palomino rivers in the Magdalena and La Guajira departments respectively. In regards to Tayrona Park, the beaches are short with cliffs, but the further east along the beach the continental platform becomes farther offshore causing the width of the beach to vary between 10 and 30 m.

The dynamic state of the waves causes permanent changes in the physical state of the coast. Driftwood and vegetation are present though out the year. The flora and fauna associated with this beach have been affected by the rapid growth of the agriculture frontier, due to the expansion of banana plantations.

Field investigations are focused on the patrolling of the beach, protection of nests and nesting females. Four monitoring centers exist in Guachaca, Buritaca, Don Diego and Palomino that have hatcheries where nest are relocated. Incubation of hatchlings occurs in the hatcheries and hatchlings are released with community participation.

Monel tags are used to tag nesting females, these tags are donated by U.S. Fish and Wildlife Service. The genetics analysis would be utilized in a PCR technique in University of Florida Laboratories (Bowen, 1999).

RESULTS

During 1995 and 1999 the most studied beaches were Buritaca and Don Diego (Tufts, 1973; Kaufmann, 1975) where the presence of the four previously mentioned species were reported. *Caretta caretta* is considered to be the most abundant. The results of the most recent studies (Pinzón and Saldaña, 1997) confirm these report.

Between 1995 and 1999, 85 nest were collected for a total of 9,627 eggs (Table 1). *Caretta caretta* was most represented with 58 nest containing 6509 eggs and representing 68% of the total nest collected. This species nests in all sectors of the monitored beach.

Eretmochelys imbricata presented the greatest percent hatching success due to the fact that the nest were not transferred from their beach of origin to another nesting beach. This transplantation occurred with *Caretta caretta* in order to guarantee protection of nest. In 1997 *Eretmochelys imbricata* nest were not recorded and nesting activity was concentrated in Cinto (Tayrona National Natural Park). In 1995, nesting occurred but the sector was not monitored.

In the five seasons, *Dermochelys coriacea* has presented biannual nesting behavior, 1995, 1997 and 1999 and always in the same sector of the beach Gauchaca and Buritaca. Low hatching success was due to adverse climatic conditions. The nesting periods of *Chelonia mydas* coincided with strong prolonged rains provoking a notably low hatching success.

ACKNOWLEDGMENTS

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Table 1. Summary of nests collected during nesting seasons 1995–1999. The species are as follows: CC = *Caretta caretta*, EI = *Eretmochelys imbricata*, DC = *Dermochelys coriacea*, CM = *Chelonia mydas*.

Species	Nests	# of eggs	Hatchlings	Species nesting (%)	Hatching success (%)
CC	58	6509	4324	66.6	66.43
EI	19	2389	1692	21.8	70.83
DC	5	348	147	5.8	42.24
CM	5	521	62	5.8	11.90
Total	87	9767	6225	100	63.74

Table 2. Nesting activity by species from 1995 to 1999.

Species	Number of nests				
	1995	1996	1997	1998	1999
<i>Caretta caretta</i>	7	9	11	22	9
<i>Chelonia mydas</i>	1			4	
<i>Dermochelys coriacea</i>	1		2		2
<i>Eretmochelys imbricata</i>		10		6	3
Total	9	19	19	32	14

The Protection Program of the “Caná” Sea Turtle (*Dermochelys coriacea*) and the Territory Management Process In Order to Create a Protected Area for Acandí And Playona Beaches, Uraba Gulf, Colombia

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Located northwest of the Urabá Gulf, Acandí and Playona beaches are considered the most important nesting sites of *Dermochelys coriacea* along the Caribbean coast of Colombia (Rueda *et al.*, 1992). The Protection Program of the leatherback sea turtle or “tortuga caná” (as named by the local population), has focused on education, research and protection activities, increasing the awareness of the local inhabitants and the local and national authorities about the plight of the leatherback.

Before the initiation of this program, other conservation efforts were made sporadically on research and protection activities by various institutions and local groups.

Aside from the need to protect the species because of high levels of egg poaching, habitat deterioration, drowning in shrimp nets, and other factors that negatively impact the population, the Darién Foundation (NGO) decided to promote an appropriation participatory process with the local communities toward the natural surrounding, specifically focusing on the “caná” sea turtle. This way, in addition of trying to change the people’s attitude toward the species, we had the opportunity to create a regional symbol of the “caná” as a sign of respect and interest for nature and the environment.

Since the beginning of the “Jornadas de Protección de la Tortuga Caná” in 1993, the local community celebrates each year the arrival of the females to their beaches with parades, a sea turtle costume contest for the small girls in town, dances, artistic expressions, songs (four songs in different musical genres that have all been written by locals), beach cleaning efforts, and other original cultural and recreational activities.

The fact that the local population has become aware of the importance of the species, its critical situation, and the particularity of having these nesting sites of *Dermochelys coriacea* on their beaches along with the few other ones in the world, have permitted the local population to achieve an important sense of value and respect for what they have. This appropriation process is facilitated through educational activities, the use of audiovisual material, reverting the information back to the community, drawings done by the children, videos where the natives can see themselves in a protagonist role, plays and tales about the caná, and newspaper articles on their efforts to take care of the sea turtles. The recognition of the community participation and the promotion of self esteem within the locals are main points in the orientation of the work. Most of these activities have been done on a voluntary basis, almost

without any financial support.

The participation of ANECB (Biology Science Students National Association of Antioquia) in the Program from the beginning, has allowed us to obtain greater knowledge of the nesting population and the sites, especially during the last years when various students have done their thesis research in Playona. The results of these studies provide good baseline data and help to establish better conservation strategies and management plans for the near future.

Interactions with the local and national authorities has fostered interest for defining these nesting sites as protected areas. During these past seven years, the following considerations regarding the protection and preservation of the species have been made by the authorities.

At the local level, the institutions in charge of the environmental issues and the Municipality of Acandí have developed:

- a. fishing restrictions during the nesting season in agreement with the fishermen
- b. limitation on sand extraction from the beaches
- c. cleanup of the sites before and during the nesting period
- d. the establishment of rules by the Municipal Planning Office with buffer zones that owners are obliged to follow in order to obtain their building licence.

At the regional and national level, considering the Darién as one of the regions of the world with the greatest biodiversity, various studies and research that have been done have all named the nesting sites of Acandí and Playona as important areas to be protected.

In the 1993 interdisciplinary study done by the "Proyecto Biopacífico", which is associated with the Ministry of the Environment and supported by PNUD-GEF, a "Preservation Strategy in the Darién región" was proposed as part of the results, and the main nesting sites of *Dermochelys coriacea* were identified as priority areas to be preserved by the creation of a Fauna Sanctuary or a Municipal Natural Reserve.

The study mentioned above also served as the basis of Resolution #1427 in December 1996, when the Ministry of Environment established the Special Management Area of the Darién (AME-Darién) along the whole border with Panamá, to be managed and protected under sustainability principles. This time, Acandí and Playona were considered as multiple function and/or absolute protection areas. This ministerial resolution mentions the importance of developing a participatory process with the communities in order to decide how to manage the territory. Various workshops on environmental territory management have been organized with the local inhabitants and landowners. Three of these workshops are planned with the people from Acandí, Playona and Caleta. One of them took place last year, and other two are planned for this year. An evaluation of the sea turtle situation was made and the people participated actively with proposals on how to proceed and

manifest their will for helping the species to be preserved.

By National Law #388 from 1997, every municipality in the country must develop a Management Plan where they take into consideration all the different factors for their future development. It is necessary to encourage the local authorities to consider the importance of the protagonist role of the local population in these discussions, so they can decide the kind of management they want for their regions and develop different sustainable production activities around the sea turtle protection program, where they can ameliorate their living standard and reduce the impact to their natural surroundings. Various meetings and workshops with the town council, municipal employees, fishermen and others have been organized.

The coordination of preservation activities by the local people, local authorities, universities students, NGO's and the Ministry of Environment through the AME-Darién, unify criteria, experiences, knowledge and resources, and give a better chance to achieve more successful results within a more global and integrated vision.

The desirable legal status for the nesting sites to be established as a protected area may not even exist within the present legal framework. We all have a special challenge at this moment to create an innovative combination where the community itself and the rest of the people and groups that are involved feel attached to the management rules and restrictions to be considered, respecting them because they have participated actively in a consensus decision making process. At the same time, they also realize the potential they have for a new and different way of local development in a more sustainable way that does not affect the species or the local ecosystems.

The continuing of this process will be crucial for the preservation of the leatherback sea turtle at these nesting sites and for the species worldwide.

The "caná" sea turtle may have a better chance of survival today thanks to its having become a regional symbol and to its ability to inspire respect for all living creatures and for the environment.

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RETOMAR (Colombian Sea Turtle Conservation Network), Searching for Alternatives for the Colombian Sea Turtle Conservation

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The main objective for the "II International Seminar-Workshop on Biology and Conservation of Sea Turtles" held in the Tayrona National Park, between the 23rd and 25th of August, 1999, was to enforce the Colombian Sea Turtle Action Plan within the frame of the WIDECAST-BP Colombian project. The goal was to define the main guidelines to design and implement the Sea Turtle Restoration Plan (STRAP), which aims to help reduce the decline of populations that inhabit the marine and coastal zones of Colombia.

This "II International Seminar - Workshop on Biology and Conservation of Sea Turtles" was the continuation of a series of events started in May of 1998 in Palomino (Guajira), which served to establish the base for the STRAP. This led to the creation of the Colombian Sea Turtle Network (RETOMAR), which includes NGOs, community grass-roots groups, and universities that are currently running up projects in both, the Caribbean and Pacific coasts of Colombia.

The workshop attendants identified diverse social, economic and ecological issues affecting the current sea turtle population. As a result of this, the participants committed themselves to the implementation of management programs in order to minimize the factors depleting sea turtle population in their nesting and feeding areas.

The lack of scientific information, weak law enforcement, and little environmental education are some other issues that contribute to the decline of sea turtles in the areas mentioned above. To face these threats, the organizations participating in the workshop developed a collaborative logical framework which included a set of written proposals that consider economic options for the local communities. This initiative had the support of the Ministry of the Environment and WIDECAST. The aim of these projects is to ensure the income of the local communities, providing the future generations with an opportunity to shift into new activities, confronting the challenge of the next millennium.

RETOMAR's members organizations include WIDECAST-Colombia, Asociacion Defensores de la Naturaleza, Asociacion Nacional de Estudiantes de Ciencias Biologicas (ANECSB), Fundacion Ave Fenix, Fundacion Darien, Fundacion Tortugas Marinas de Santa Marta, Comite de Pescadores Artesanales de Palomino, CORPAMAG, and Tayrona, Sierra Nevada and Corales del Rosario National Parks (UAESPNN). Sponsors include WIDECAST, BP Conservation Programme, Birdlife International, and Conservation International.

Results of the Sea Turtle Conservation Project in Cipara, Peninsula De Paria, Sucre State, Venezuela in 1999

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INTRODUCTION

A sea turtle camp was established by first time in Cipara in 1989 by FUDENA (Guada *et al.*, 1989), but until 1999 it could be established a camp again in 1999 on Cipara beach (Sucre State). We were following recommendations of the Sea Turtle Action Plan for the Recovery of the Sea Turtles of Venezuela with this action (Guada and Solé, in final review). In addition we have conducted annual surveys on this beach since 1988 (with the exception of 1994). In opinion of the fishermen, it is possible to find more than 30 nests per year on this beach. With these numbers, Cipara constitutes one of the most important nesting beaches for the

leatherback turtle (*Dermochelys coriacea*) in the Peninsula de Paria. The main goal of the camp was to monitor and to protect any turtle or nest on the beach. Moreover, we were strongly interested in having a place to offer field training on sea turtle research and conservation techniques in Venezuela.

STUDY AREA

Cipara is to the East of Cabo Tres Puntas in the northern Peninsula de Paria (62°42'W and 10°45' N). It is more than 1 km in length. Its sand is very white and gross along the

main part of the beach. The Cipara river may have its mouth closed during the dry season.

METHODS

Between June 14 and August 14, 1999, nightly walks were done to check the presence of sea turtles on the beach, which was divided in four sections, from west to east: Varadero, Boca del Rio, Cipara and La Remate. The turtles found were measured and tagged with metallic tags in the left rear flipper. The emergence success of the *in situ* nests (Miller, 1999) was registered too.

RESULTS AND DISCUSSION

Turtles Tagged and Nests on the Beach

Only two female leatherback turtles were tagged during the two month period, because the camp activities began near the decline of the nesting season. The data of the nests of the turtles tagged were registered (Table 1), as well the emergence success of several *in situ* nests in the beach (Table 2). The mean number of the eggs for the two tagged turtles was 72.6. The nesting activity was focused along all the beach, however the main part of the activity was focused between Cipara and Varadero. The data about nests are not abundant and the emergence success is extremely variable (23.7% to 89.2%). During the field work, we did not observed other turtle species (*Caretta caretta*, *Chelonia mydas* or *Eretmochelys imbricata*) nesting in the beach.

Surveys of Other Sea Turtle Nesting Beaches

Two beach surveys were conducted on July 27 and August 4 1999, respectively, from Cipara to Uquire. Nesting activity was identified on six beaches from east to west: Pargo, Las Hamacas, Chaguarama, El Castaño, Puerto Escondido and Los Cocos. Two of these beaches confirmed as new nesting areas were El Castaño and Chaguarama.

Additional Activities

Some preliminary evaluations of the incidental catch of sea turtles in the gill nets were done as well some observations in a nearby reef area used as a feeding ground. Several environmental education activities were conducted in Cipara and adjacent towns.

Training of Volunteers

The field work was possible thanks to a multinational team led by an uruguayan, Alejandro Fallabrino, Field's Coordinator and a venezuelan, Daniel Carrillo, Education's Coordinator, joining with six volunteers from Mexico, Colombia and Venezuela. One of the volunteers, Gilson Rivas is cooperating again with the leatherback conservation project in the Pacific coast of Mexico, since January of 2000. One of the girls, Carolina Martinez, is attending the 20th Annual Symposium to get updated information about sea turtles and is planning to go to Cipara again.

CONCLUSIONS

The number of tagged turtles was extremely low. The field work must begin before June and because of this, the camp will begin in April 2000, in order to cover the peak of the nesting season. The site offers a lot of possibilities for sea turtle research and conservation. The camp in Cipara has been planned as an activity of several years in length, but it is expected to cover at least two beaches more in the area: San Juan de las Galdonas and Querepare, to the west of Cipara, with serious problems of turtle killing in the first and of nest poachings in the second.

Table 1. Data of the tagged leatherback turtles (*Dermochelys coriacea*) and their nesting activity in Cipara beach during 1999. The length is the standard curved carapace length (cm) and the width is the curved carapace width (cm).

Beach Section	Date	Tag #	Length	Width	Nest (# of eggs)
Varadero	6/15				Yes (75)
Varadero to Boca del rio	6/17	D6652	135	108.5	No
Varadero	6/24	D6651	157.5	114	No
Boca del rio to Cipara	7/6				Yes (74)

Table 2. Data of the *in situ* nests of the leatherback turtles (*Dermochelys coriacea*) and their emergence success in Cipara beach during 1999. The data from the nest on Varadero is from the tagged leatherback D6651.

Beach section	Date	Emerged	Live in nest	Dead in nest	Undeveloped	Unhatched	Number of shells	Emergence success (%)
La Remate	6/28	48	0	5	16	6	>51	63.0
Cipara	7/7	66	0	1	6	0	>59	89.2
Cipara	7/25	69	4	7	4	1	>81	81.3
Varadero	8/14	16	17	2	26	0	>33	23.7

The IX Short Course on Sea Turtle Biology and Conservation in Venezuela in 1999: Regional Training and Cooperation in Action

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BACKGROUND

The “Courses on Sea Turtle Biology and Conservation in Venezuela” began in 1992. The first eight courses were conducted in Isla de Margarita, Maracaibo and the last two (1998 and 1999) in Puy Puy (Sucre State). A total of 169 participants have attended the courses until now. Since the III Course in 1993, we have invited foreign instructors in order to provide a regional vision about sea turtle research and conservation. Since 1996, we have had participants from countries other than Venezuela (Argentina, Uruguay, United States) and, at present this is the only course organized annually in Latin America.

DEVELOPMENT OF THE IX COURSE

The IX Course on Sea Turtle Biology and Conservation was held between June 14 and 20, 1999, in the facilities of Corpomedina in Puy Puy beach, Sucre State. The course was supported by WIDECAST, the Universidad Simón Bolívar, the Australian Embassy in Venezuela, the BP Conservation Programme, Provita, Fundación Thomas Merle and Al Frente de Paria (the last three are local NGOs). Teaching aids and educational materials were supplied by WIDECAST and National Marine Fisheries Service (NMFS, donated through Nancy Daves). We had 15 participants from Universidad Central de Venezuela (2), Universidad Centro-Occidental Lisandro Alvarado (1), Universidad del Zulia (7), Universidad de Los Andes (1) and Provita (2). In addition, we had two students of biology, one each from the Universidad de Antioquia, Colombia and the Universidad Nacional Autónoma de México.

The main instructors were Hedelvy Guada (USB/Widecast), Vicente Vera and Joca Thomé (Projeto Tamar/Pró-TAMAR, Brasil). Additional lectures were given by Wilfred Merle (Fundación Thomas Merle), Ana Trujillo (WIDECAST Associate Researcher), Alejandro Fallabrino (Grupo de Tortugas Marinas México), Henry Benavente and Marcos Yáñez (Al Frente de Paria). As in the past, the course had a strong emphasis on regional cooperative efforts to promote the sea turtle conservation. Using the example of Projeto Tamar/Fundação Pró-TAMAR, emphasis was given to the importance of involving local communities in any sea turtle research and conservation effort. No turtles were sighted during the six nights at the beach. However, a leatherback nest hatched in the hatchery

of the Puy Puy beach in on the morning of June 20 and, the participants could had the opportunity to assess its reproductive success.

The students were provided with a complete set of references mostly in Spanish but also in English; these included the “Manual of Sea Turtle Research and Conservation Techniques” (Pritchard *et al.*, 1984), the WIDECAST species identification sheets and stickers, and the “Tortuga News” bulletin. Projeto TAMAR provided numerous materials, including a list of publications, brochures, posters, T-shirts and videos. The three students with the best grades received awards: William Rainey’s “Sea Turtle Guide of Visceral Anatomy” for the first place and posters of “Sea Turtles of the World”, for the other two students.

FOLLOW-UP ACTIVITIES

Abraham Escudero (UNAM-México), one of the participants of the Ninth Course, cooperated after its conclusion with the “Sea Turtle Conservation Project in Cipara beach, Península de Paria” between June 21 and August 14, 1999. María Rondon (ULA-Venezuela), has applied to participate in camp the same project for this year (2000). Several students of the Universidad del Zulia signed letters requesting the stopping of the submission of the Cuban proposals to CITES, in November, 1999.

THE FUTURE

The next (X) Short Course on Sea Turtle Biology and Conservation will be held at the end of April, again in Puy Puy beach, under the auspices of WIDECAST, the BP Conservation Programme, Fundación Thomas Merle, Al Frente de Paria and Corpomedina. It will last eight days. We will be actively encouraging the participants in the next course to participate in the sea turtle camp in Cipara beach, on the Península de Paria. In addition, we are working to organize courses focused on specific issues, such as telemetry, incidental fisheries, strandings and necropsies, and other field-oriented topics. The plan is to invite several of the participants from past courses to attend these specialized courses, and thereby strengthen the Sea Turtle Network in Venezuela.

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Raising Public Awareness on Protection and Preservation of Sea Turtles - an Emergency in Albania

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INTRODUCTION

Publications on marine turtles in Albania are scarce (Zeko and Puzanov, 1960; Haxhiu, 1981, 1985, 1997, 1998). They talk about sporadic cases of observations and concern mainly the geographic distribution of the species in Albania. There are no special studies on the species because of lack of financial support. There are two species of sea turtles in Albania: loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*). Both endangered species are observed on the Albanian coast of the Adriatic Sea (273 km) and Ionian Sea (154 km). Sea turtles in Albania are threatened by many factors (Haxhiu, 1995) but the main one remains the low level of public awareness that explains the harmful human attitude towards them. Therefore, raising public awareness is considered as a very important tool for protection and preservation of sea turtles in Albania. In this report we talk about the educational campaigns undertaken in the recent years in Albania in order to protect the sea turtles.

METHODS

This report is based on the experience of scientific expeditions in many coastal areas of Albania in the course of 30 years (Fig. 1). Considerable data were gathered by interviews organised with fishing specialists and fishermen. Seminars and meetings were held last years and many posters were delivered, aiming the protection and preservation of the sea turtles. Visits in the Museum of Natural Sciences, in Tirana, where some interesting specimens are exposed were also an important part of the raising public awareness work. The target groups of these activities were the pupils of the coastal areas, students, local people and especially fishing specialists and fishermen.

RESULTS AND DISCUSSION

The loggerhead turtle is the most common visitor in Adriatic and Ionian Sea. Evidence of this fact is the relatively high frequency of specimens caught incidentally by fishing nets. Furthermore rare dead individuals are found along the beaches. They visit the Ionian coastal waters more often, because this part of Albanian coast is rocky, very broken and rich in calm and clean bays.

The leatherback turtle is a very rare species in Adriatic and Ionian Sea. One specimen of that species was caught 40 years ago, in the fishing zone of Shengjin, northwest of Albania (Zeko and Puzanov, 1960), and now is preserved in the Museum of Natural Sciences in Tirana.

According to Fromhold (1959) another sea turtle, the hawksbill turtle (*Eretmochelys imbricata*), is observed in Albania, but this species is very exceptionally met in the Mediterranean sea (Gasc *et al.*, 1997).

In general, by the surveys that we have done in different areas with different social categories, it results that the level of public awareness on sea turtles protection is very low. As well as other reptiles, chelonians are considered as symbol of badness in the legends and stories of Albanian people. For that reason, the human attitude towards them has always been harmful. Up to 20 years ago, sea turtles caught incidentally in fishing nets, were used as food for farm animals, mainly for pigs and hens. The majority of fishermen consider the catch of the loggerhead turtle as "bad luck". There are now some sporadic cases where the sea turtles are caught and killed by fishermen, which either use them for food or expose them as decorative object on the walls of restaurants or bars (Fig. 2). In recent years, the use of dynamite for illegal fishing has caused significant adverse impacts on sea turtle populations.

Based upon the old fishermen opinion and surveys of the last years, it seems that the number of the cases of

accidental fall of the sea turtles in the fishing nets is decreasing from year to year. This fact confirms the general idea that sea turtle population in the Ionian and Adriatic waters is today critically endangered. Therefore, raising public awareness is considered as a very important tool for protection and preservation of sea turtles in Albania. During the last years, we have worked on issues of public education, having the fishermen as our specific target group. Opened discussions, seminars, workshops and different publications such as booklets, leaflets and posters have carried out this work. A number of these posters were given to the captains of fishing boats (Fig. 3). Few individuals of sea turtles are exposed since years nearby the Museum of Natural Sciences, in Tirana. Visitors, mainly pupils and students, are informed about the importance of these precious species arguing why and how to protect and preserve them.

The first results of our work have been encouraging. Nowadays, the fishing specialists that have day to day contacts with the fishermen operating in four main harbors of Albania (Shengjin, Durres, Vlora and Saranda), advise them on how to protect loggerhead turtles, releasing carefully those individuals that may accidentally stick in fishermen nets. The majority of the interviewed fishermen have told us that their attitude and behaviour towards the sea turtles has completely changed. In August 1999, a group of fishermen from Vlora, fishing in deep seas, caught accidentally in their fishing nets an individual loggerhead turtle carrying a tag showing: E 211 Sea turtle protection P.O. Box 51154, 14510 Kifisia, Greece. The fishermen took that notice and after that did release the turtle safely back into the sea. This first result shows that the work already started may ensure a calm and safety environment for the sea turtles along the Ionian and Adriatic seas.

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Fig. 1. Map of Albania and the location of the four main harbors of the country.

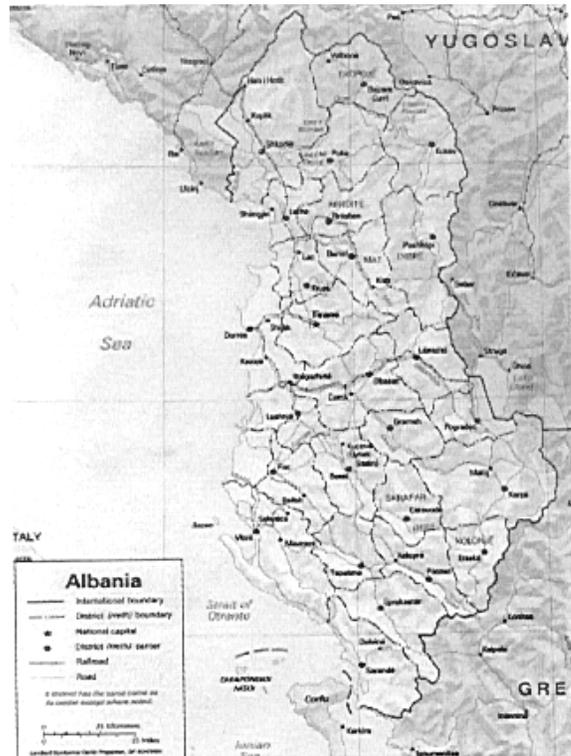


Fig. 2. An individual of *Caretta caretta* on the wall of a restaurant in Saranda.



Fig. 3. A copy of the poster “Protect Sea Turtles.”

Olive Ridley Sea Turtle (*Lepidochelys olivacea*) Conservation in Villa Del Mar, Cabo Corrientes, Jalisco, México (1996-1999)

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INTRODUCTION

To Jalisco beaches arrive four species of sea turtles: *Dermochelys coriacea*, *Chelonia agassizi*, *Eretmochelys imbricata* and *Lepidochelys olivacea*, but *L. olivacea* is the only species that arrives to this zone. Since some years ago, it's doing works of protection and conservation of this species in the coast of the state by different public institutions, like University of Guadalajara, through protection encampments.

Our job has two purposes: first the survival and recuperation of sea turtle population in Jalisco coast, in concrete, in the zone Chamela-Cabo Corrientes, that is catalogued like priority area by CONABIO (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad). Second, to make that the human population aware of the problems of indiscriminate use of the natural resources, in this case, the sea turtles.

The beach “Villa del Mar” is localized in the “Tehuamixtle” bay (105°33'W/20°06'N, 105°34'W/20°14'N) in the municipality of “Cabo Corrientes”, northwest of the “Jalisco” State, Mexico. This beach has a length of 15 km (9.5 mi).

Socio-Economic Elements

The municipality of Cabo Corrientes has an area of 60,724 ha, and it's population in 1995 was 8,744 habitants. In 1990 the 58.98% of the population that works has a maximum salary of \$170 USD per month (\$ 1,600 Mexican pesos). Most (82.39%) of the adult population hasn't basic education. We don't know any case of death by malnutrition. The villages haven't electricity and drainage,

and the medical center is 25 km away (16 mi).

Respective to the land propriety, 60% belongs to five indigenous communities, 20% belongs to “ejidos” (a form of common land), 10% is private propriety, and we don't know who the rest of the land belongs to.

In summary, these conditions reduce the alternatives of incorporation to the productive sector; increment the remainder in fishing and agriculture. Added to the little opportunities for education, the difficulties with the land propriety and the “caciquismo”, the results are underdevelopment of the communities. This provoked the irrational and indiscriminate depredation of the plants and animals that live in the area, to get economics recourses.

The University Work

The University Program of Protection Sea Turtles “QUELONIUS” has four encampments: “La Gloria” and “Majahuas” in Tomatlán, “Boca de Tomates” in Puerto Vallarta, and “Villa de Mar” in Cabo Corrientes. This program has four action lines: protection, investigation, community development, and environmental education.

The job that has been done from July to December each year has been orientated to the protection of females, the transplant of natural nests to incubation barnyards and the liberation of the breeding. In addition to this, we are doing activities of environmental education and sensitization with communities who live near to the beach.

The University Centre of Biologist and Agro Sciences (CUCBA), has like strategy to involve the young students in the different action, for in this way get more human resources in conservation, investigation and biodiversity use. In this action we have the participation of the people

who live in the area, a small collaboration of different government institution, and the participation of Mexican and foreigners voluntaries.

The financial institution is the University of Guadalajara, but the money is not enough to keep all the encampments. This is the reason we haven't worked in Villa del Mar encampment since the beginning of 1999.

RESULTS

The principle attainments of this experience were:

1. The participation of the rural communities in the different activities of protection and conservation. In this way we are generation sensitisation to his natural recourses.

2. To wake attention to an abandoned region.

3. The constant formation of professionals in protection and conservation.

In spite of the efforts that we are making in, we have a preoccupant and imminent fall down of the organisms that arrived to this beach to leave his eggs (Table 1).

There are various factors that provoke this enormous threat, the definitive extinction of the population that nests each year in this area:

1. The clandestine capture of adults organisms in the sea by nets, to the illegal sell of different products obtained of the sea turtles.

2. The eggs and animals depredation by the people who live in the region.

3. The little effort by the institution to control this actions.

4. The limited monetary, material and human resources that the protection encampments have to make his job.

There are some collateral aspects to this program like the direct relationship with the habitants of the area. We participate with him in his quotidian life. In this way we haven a better vision of his problems and permit to look for a solution in a together way.

Principle Difficulties

The monetary, materials and human resources that we have, aren't enough, inclusively, just by the fault of support, we couldn't bring about action in the last time (1999-2000).

The principle troubles are:

1. The lack of motorcycle for the sand, make us patrol

by foot. This does not permit a good vigilance on the beach because it's too long. For this reason is very difficult to compete for the nests with the habitants of proximal areas.

2. The lack of a vehicle for the transportation of equipment, materials, food, water, and any emergency.

3. Insufficient personal to patrol by foot.

4. It's very difficult to estimate the depredation that occurs in the sea. We know this fact for the death turtle by non-naturals hurts that appear in the beach next to the Tehuamixtle Bay.

CONCLUSIONS

1. The survival of the sea turtles population that arrive to Villa del Mar beach depend on the protection activities conducted by the University of Guadalajara.

2. It's indispensable that the Universitary program counts with monetary, materials and human resources to continue and improve the actions beginning in 1996 and suspended in 1999.

3. To accomplish the work, it is necessary to improve the physical area of the encampments and to buy vehicles (pick-up and motorcycle).

4. The participation of the governmental establishments who have responsibility in this ambits is indispensable.

It's necessary impulse the scientific investigation in the area. There isn't scientific information enough, in spite of was declared natural reserve in 1924 by a presidential decree.

It's demonstrated and accepted that the survival of the sea turtles in the world isn't dependent by himself capacity of reproduction. They need the activities that human doing in his favour. For this we considered essential to continue with the actions in this region though the population who nest in this beach yet exist. Without our activities, the population of the region walk to a sure extinction.

Table 1. Nests protected each year.

Year	Nests protected	Eggs protected	Breeding	% Birth rate
1996-1997	162	16,517	11,214	67.89
1997-1998	65	6264	4212	67.24
1998-1999	32	2895	2025	69.94

Life Stages of a Sea Turtle Community: From Volunteer Group to the International Community

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This poster presents the process of one small, yet successful, volunteer group on Folly Beach, South Carolina

(USA) in contributing to sea turtle conservation. Borrowing from the life stages of the sea turtle, this poster

tracks the growth of a community project from hatching to maturity, developing from individuals to groups, and reaching out across communities, countries, and continents. It presents primary 'predators' and ways of 'screening' against them, potential partners that can assist with the challenging migration, and essential technologies that support the continuing cycle. The experience shared offers other volunteer groups ways of reaching beyond their nest, beach, and community to make a lasting contribution to ensuring the return migration of sea turtles that once emerged from a community beach.

1997: EARLY PELAGIC STAGE-'THE LOST YEARS'

After a two-year absence, nest monitoring licensed by the South Carolina Department of Natural Resources returned to Folly Beach. Three enthusiastic leaders and a small troop of daily beach walkers eagerly looked forward to discovering tracks, and protecting nests and hatchlings. Competition for leadership and control, however, quickly undermined a consistent, team approach. The prescribed protocols were ignored as some individuals followed their own, 'better' plan for nest management. Their behavior placed the project as well as the hatchlings at great risk. They, fortunately, abandoned the project, leaving one lone, highly-dedicated volunteer to patrol the beach, distribute flyers to local businesses, attempt to gain the community's cooperation to reduce beachfront lighting, and monitor and document the hatching of 32 nests. Physical and emotional burnout then threatened the project's future until, on the beach, during a moment of overwhelming exhaustion and frustration, helping hands were extended by a local citizen and her daughter. The hatchling Folly Beach Turtle Watch Program emerged and began its successful crawl.

1998: JUVENILE STAGE

Energy gained from the local 'feeding ground' of mutual respect, cooperative planning, and consistent practices allowed the small team to strengthen and 'swim' further. The community's endorsement was gained through one 'turtle talk' presented at a meeting of the local civic club. The club immediately adopted the Turtle Watch Program as a funded project. Their \$500 seed-donation was used to create 'lights out' signs for placement on all public-access beach walkways and to purchase material with which to make Official Folly Beach Turtle Watch flags for sale.

Chance encounters on the beach led to the addition of three new members to the core team. Their individual skills and contacts added new possibilities for future directions as well as reinforcement for daily and nightly beach monitoring. During informal public education sessions at nest sites, the team emphasized the importance of reporting any sightings of tracks or hatchlings to the local police

department dispatchers who would then contact a 'Turtle Crew' team leader. Beach vacationers quickly became a vital and integral part of the program. The shared excitement and wonder created friends, allies, and standard-bearers for the Official Folly Turtle Watch Flag.

The potential predators of an indifferent community and uninformed visitors were eliminated by actively involving them in the program and by providing on-going communications from the program leaders in a monthly 'turtle column' in the community newsletter.

1999: SUB-ADULT STAGE

Successful growth continued through unexpected partnerships with a real estate development company, a regional newspaper, and a green grocer. Each made cash donations which were used to enhance public education through a full-color brochure and 'lights out' door hangers, and to contribute towards funding for an international sea turtle specialist from Sri Lanka. The local crew increased to ten and migration beyond the local habitat began.

Migration was aided by the development of a website named 'follyturtles.com' which maintained an on-going daily journal of nesting progress. Through the technology of the Internet, vacationers who had discovered tracks or witnessed a nest relocation could revisit 'their' nest and communicate via e-mail with the Turtle Crew even after returning to their homes in Georgia, Texas, Colorado, Pennsylvania, wherever.

Important alliances were also made through individuals within related governmental agencies: U.S. Coast Guard, U.S. Corps of Engineers, U.S. Fish and Wildlife Service, South Carolina Electric and Gas Company, Charleston County Public Schools, Charleston County Parks and Recreation Department, the Mayor and City Council of Folly Beach. Official policies and political barriers that often divide loyalties and dilute productive efforts were simply not encountered. 'Turtles bring people together' is a Crew leader's favorite quote, and it was certainly Folly's experience as diverse individuals contributed to the united purpose of protecting sea turtles and sea turtle habitat along the South Carolina coast and beyond.

Migration was further facilitated by the international sea turtle specialist who connected the Folly program with a 'sister' community project in Sri Lanka. Initial steps were taken to provide a market for the Sri Lanka project's handicrafts and, thereby, assist an industry to provide an alternative source of income to the killing of sea turtles for sustenance and sale.

Local television news stories, interviews with sea turtle volunteers, numerous newspaper articles, and regular columns in two beach community newspapers continued to both educate and engage the public in local and international sea turtle conservation efforts.

The primary predators of this stage, bureaucratic barriers and local stagnation, were avoided by connecting with individuals who were or who became sea turtle advocates, thereby extending the horizon of the local group's influence and involvement.

2000: ADULT STAGE

The dawn of the new millennium revealed determined tracks toward an enriched habitat for the local program and exciting possibilities for additional international migra

Kiawah Island, South Carolina, Turtle Program

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A presentation of the history and operation of the Kiawah Island Turtle Program from 1972 to the present, including: volunteer patrol development, nesting trends, educational presentations, environmental considerations, and scientific studies was given. The Town of Kiawah Island

received the Municipal Achievement Award in 1998 from the Municipal Association of South Carolina for a program that has been of significance and/or had a long term value to the community. The presentation included text, graphics, and photos.

Olive Ridelys Facing Ravages of Both Nature and Man in Orissa Coast, India

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INTRODUCTION

The coast of Orissa which is well known as the world's largest rookery of olive ridley sea turtles continues to remain beset with the lingering host of old problems added with the new ones inspite of the environmentalists' lobby crying hoarse over it over the years. The anxiety over continued absence of mass nesting at Gahirmatha in the seasons of 1996-97 and 1997-98 coupled with the disheartening news of more than 50,000 dead turtles washed ashore during this period was of course largely offset when the belated and serial occurrence of arribadas took place in different islands in Gahirmatha region totaling nearly 300,000 in March and April 1999. However, the news of sudden mass nesting of 1999 in its wake was seen to have brought a sense of unwarranted complacency among the officials in charge of the turtle conservation on one hand, and reversely a heightened mood of vengeance among the trawl owners who started a systematic campaign against the very rationale of turtle conservation measures taken by the Government, on the other. While this tussle was continuing in the political corridors of Orissa between the pro-turtle policy makers and their avowed antagonists, came some developments in quick succession which put the whole State in a state of turmoil, such as the change twice in the Chief Ministership of the State, the Super Cyclone of October 1999 in Orissa coast, and lastly the General Assembly Election in February and the prospect of a new Government by early March 2000. Thus the entire intervening year since the mass nesting of March-April 1999 up to the early March 2000 was just lost away without any tangible progress having been made either for the

turtles or for the fisherfolk living along Orissa coast. Of course, the migrating turtles were seen mating on the Orissa waters by the middle of November 1999, but at the same time ever increasing numbers of their dead bodies were also noticed all along the coast day by day. The fate of the turtles is thus determined by the vagaries of man and nature in the coast of Orissa, without any visible solution in foreseeable future.

WHITHER TED?

The transfer of TED technology to India was complete as far back as 11 to 14 November 1996 when a collaborative four-day Workshop-cum-Demonstration on TEDs was successfully held at Paradip, Orissa under the joint auspices of Department of Fisheries, Orissa and Project Swarajya, an NGO, attended by a four-member expert team from NMFS, USA as resource persons, and a host of national level bodies as NIO, Goa; FSI, Vizag; CMFRI, Cochin; NABARD, Bhubaneswar; Coast Guard, Orissa; Chief Wildlife Warden, Orissa; FISHFED Bhubaneswar and also the Trawlers Associations. A resolution was in fact unanimously adopted on that occasion calling for necessary research and development work on national basis for comparative testing of TED technology, and also for redesigning the TED model to suit local conditions, if and where necessary. No concrete step could however be taken for translating the resolution into action, as both the Centre and State Government slipped off into a state of complacency just following the victory of four Asian countries including India in the interim judgment of WTO Panel at Geneva in February 1997 as

against the U.S. ban on import of shrimp caught from wild without the attachment of TED. However, a powerful wave of adverse public opinion from within and outside the country that surfaced against the Government of India following the news of mass death of olive ridleys in the coast of Orissa coincidentally coupled with non-occurrence of mass nesting for two consecutive seasons in famous Gahirmatha in 96-97 and 97-98 did in fact go a long way in compelling the Centre and State Government to introduce certain eye-catching turtle friendly measures including the implementation of TED in the coast of Orissa. As a matter of fact, the Chief Wildlife Warden, Orissa announced in a meeting of trawlers, fishermen, NGOs and Government officials called by him in mid-October 1998 that he would supply at least 1000 TEDs to be fitted to the trawls of Orissa by 1 January 1999. This official assurance still remains on pen and paper except a few experimental hauls with TEDs held during January and February of the same year at Paradip and Dhamra under the joint auspices of the Department of Forest, Department of Fisheries and Project Swarajya. Keeping in view the Indian trawlers' craze for mixed catch of fish and shrimp to be caught in a single haul, Project Swarajya has advocated the need for Indianising the TED model so as to elicit the acceptability of the trawlers towards TED. In fact the State Government of Orissa who hold the same view have already devised a new nomenclature, that is, TSD (Turtle Saver Device) for such a proposed innovation. It is of course a paradox that the name came first before the holder of name was born.

SUPER CYCLONE 1999

The entire coast of Orissa was swept by an unprecedented Super Cyclone on 29 October 1999, now known as Black Friday, which blew at more than 300 km/hour with a simultaneous inroading surge of saline waves at 20 ft high, and which in its trail lasting for nearly 24 hours at a stretch killed thousands of people, innumerable cattle and wildlife, destroyed even concrete structures, uprooted old and massive trees, damaged all standing crops, and brought about a visible deformation in the landscape and its ecosystems. It had its devastating impact on the coastline too including the topography of the nesting grounds of olive ridleys. The cluster of villages called Satvaya, located in Gahirmatha region and a traditional nesting ground of sea turtles since time immemorial was further submerged into the ever encroaching sea during the cyclone. The Ekakula Forest Shed, located in the vicinity of the Gahirmatha turtle rookery and used as a monitoring camp was also badly devastated. At different points of the coast-line, new openings were created from the sea, giving rise to altogether new tidal rivers and creeks and thus changing the contours of the coast-line including the nesting grounds. Another important fall-out of the natural calamity was complete break of the economic backbone of the coastal fisherfolk,

Educational Campaign to Reduce the Impact of Artificial Light on Sea Turtle Nesting Beaches in Brazil

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INTRODUCTION

Several important stages of reproduction by sea turtles normally take place at night, under the cover of darkness on beaches. Artificial lights on or near beaches often reduce the number of female sea turtles that emerge from the ocean to nest (Witherington, 1992; Ehrhart *et al.*, 1996). When females do lay their eggs on beaches that are subject to artificial lighting, seafinding of the resultant hatchling turtles is often disrupted and they often go away from the sea (e.g. Philibosian, 1976; Peters and Verhoeven, 1994). Misoriented hatchlings face increased mortality from land predators, accidental trampling by people or vehicles, or desiccation following sunrise.

Development of coastal areas, in the form of homes, hotels, industrial complexes, and recreational areas, leads to an increase of nighttime lighting. Unchecked lighting on beaches used by sea turtles can have serious impacts on nesting populations, and as such management of lighting on or near beaches is a priority for most sea turtle conservation programs.

METHODS

On the mainland coast of Brazil, many sea turtle nesting beaches have been or are in the process of being developed for greater use residents and tourists. As such, the problem

of “photopollution” on nesting beaches is an area of concern for Projeto TAMAR-IBAMA, the national sea turtle conservation program of Brazil. Beginning in 1989, Projeto TAMAR has worked on several different levels to help mitigate the tension between rational use and development of coastal areas in Brazil with the needs of nesting sea turtles and recently born hatchlings. The approach has been multifaceted and fluid, and has evolved to meet new or unanticipated needs in particular areas. Although not all photopollution on nesting beaches has been eliminated, the programs adopted by TAMAR have been largely successful, thereby lessening the negative impacts of lights on the reproductive cycle of sea turtles.

RESULTS AND DISCUSSION

The activities of Projeto TAMAR with respect to artificial lighting on beaches can be divided into three general areas, although there is overlap and interaction among them. The first level is legislation, whereby Projeto TAMAR has lobbied to have laws (state and federal) enacted that restrict the presence of light on the main nesting beaches. The idea was not only gain legal pressure to enact changes in existing lighting schemes in coastal areas, but also to provide a means to direct and oversee future lighting installations in development projects. As early as 1990, a national decree issued by IBAMA, the Brazilian Institute of the Environment and Renewable Natural Resources, part of the Ministry of Environment of the Federal Government of Brazil, prohibited the installation of any artificial light source on the beachfront of 63 different beaches along the mainland coast of Brazil. Following practical experience, the decree was modified in 1995, and currently states that on all sea turtle nesting beaches in Brazil (as identified by Projeto TAMAR), there can be no artificial light measuring greater than zero lux that reaches the beach from the ocean up to and including 50 m above the spring high tide line (SHTL). In 1997, the state of Bahia passed a law that similarly prohibits the presence of artificial light with an intensity greater than zero lux within 50 m of the SHTL on nesting beaches in the state. This level of action provides legislative power to reinforce the other activities of TAMAR in the area of photopollution.

The second level of activity involves public education. The central idea is to inform the public, including residents and visitors who live or spend time close to the beach and hence are directly involved with artificial lights, of the negative impact lights can have on sea turtles. In general, the overall experience has been that informed residents become willing allies in changing or reducing their lights as to minimize their negative effects on nesting beaches. Indeed, by reducing lights, they become active participants in turtle conservation. Largely based on visual aides, such as posters, videos, and announcements on television, for example, the education campaign targets a wide range of people, from local fishermen in small villages to wealthy

tourists who have rented homes for the summer vacation, which coincides with the sea turtle nesting and hatching seasons. In addition, visitors at different TAMAR bases are presented with informative panels and videos highlighting negative influence of artificial lights on sea turtles. Finally, door-to-door canvassing is used to directly reach residents in their homes or businesses which are located on beachfronts. Thus public education becomes another tool to reduce the impact of artificial lights on sea turtles.

The third level of activity by Projeto TAMAR in the area of photopollution is research and technological design. There are various lines of research, including the following: the testing of newly introduced lights which have been advertised as “turtle friendly”; the development of methods to retrofit older street lights or housing lights in order to reduce or avoid the level of illumination reaching the nesting beach; the collaboration with developers to produce proactive lighting plans for future installations in coastal areas. As part of this, Projeto TAMAR has established accords with utility companies, such as COELBA (the Electric Company of Bahia), for collaborations and support during research and development. By bringing the lighting industry “onboard,” TAMAR has gained important logistic support the effort to reduce artificial lights on beaches.

All three levels feed into one another (Fig. 1). For instance, ongoing research on the impact of different light types on the behaviour of hatchlings will help to redefine the laws and decrees, if necessary, while the public education campaign helps inform, increasing the level of voluntary compliance with lighting restrictions, thereby easing the necessity of legal enforcement. It is this type of multifaceted approach towards conservation that has the best results and the greatest chance for long-term success.

Despite the success, there are still some hurdles to overcome. One of the biggest difficulties is actual enforcement of the lighting restrictions. In the case of recalcitrant developers or homeowners, it may be necessary to issue citations and fines, although education and awareness campaigns of neighboring lots or even employees may also help (Kraus *et al.*, 1998). We will also continue to test new technologies and lighting systems as they become available, to ensure they do not affect either nesting females or newly emerged hatchlings.

CONCLUSION

The campaign against photopollution in Brazil is an active process, that involves legislation, public education/awareness, and research and technical cooperation with utility companies. It is part of the larger conservation program headed by Projeto TAMAR that seeks greater harmony between coastal residents and sea turtles as a means to conserve and protect the marine coastal ecosystem.

ACKNOWLEDGMENTS

Projeto TAMAR is indebted to the coastal residents and fishermen whose tireless help has been invaluable for sea turtle conservation in Brazil. Projeto TAMAR is affiliated with IBAMA, comanaged by the Fundação Pró-TAMAR, and officially sponsored by Petrobras. The photopollution campaign has also received support from COELBA and FMNA/MMA. We thank Gustave Lopez for help in putting together the poster, and Matthew Godfrey for help with the translation.

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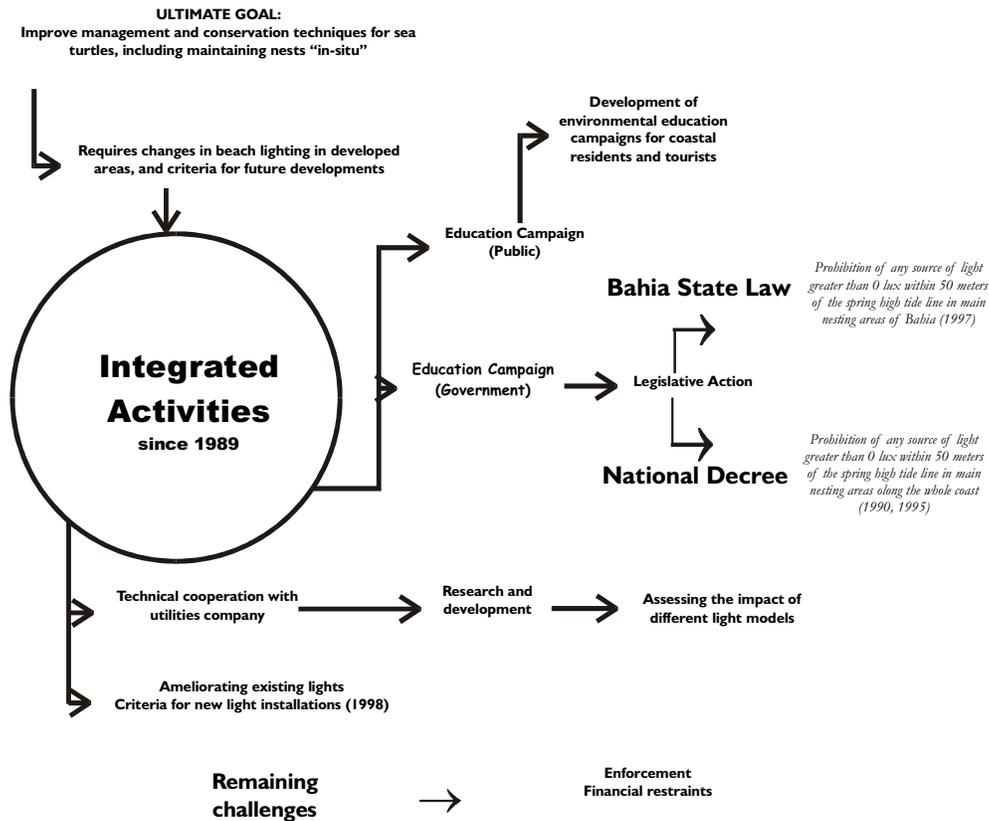
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Fig. 1. The activities of Projeto TAMAR.



Volunteer Commentaries

SHARON S. MAXWELL, BONNIE MOWERY, BAX MOWERY, AND THE SOUTH WALTON TURTLE VOLUNTEERS

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These are the collective observations of the South Walton Turtle Watch (SWTW). The presentation is a poster session summarizing facts noted while walking over 10,000 person-miles of beach, marking and protecting 236 nests, and supervising the hatching of over 19,400 eggs. The session addresses the observed nesting habits of loggerheads prior to Hurricane Opal-then storm-induced beach changes and the annual evolution of nesting patterns since Opal. It encompasses effects on nests and on egg incubation from rising ground water, storm surge over the nests, and sand compaction. Finally, it summarizes nest and egg losses during the 1996-1997 seasons-then emphasizes

by contrast the phenomenal successes achieved by selective nest relocations during 1998-1999. In addition to observations, the presentation emphasizes some of the fun aspects of saving endangered sea turtles. The SWTW volunteers are not scientists, but they are out there every day and many nights. They inspect nests daily, sometimes twice. They chase away predators, respond during the night to emergencies, rescue nests from storm surges, and dig and evaluate all nests after hatching. When changes occur and things happen, the volunteers are there; their observations are reported in this session.

Educational Strategies for Sea Turtle Conservation in the Peninsula de Paria, Sucre State, Venezuela

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In the Peninsula de Paria, serious problems threaten the sea turtles such as drowning in gill nets, the catch of turtles, and the poaching of the nests. A sea turtle monitoring program, mainly focused on the leatherback turtle (*Dermochelys coriacea*), was re-initiated again in Cipara during 1999, since its first establishment in 1989. Besides the research project, an environmental educational program is addressed to local people with special attention to children, young men and fishermen in order to involve them in sea turtles conservation through a series of illustrative talks, artistic activities and sea turtle monitoring activities.

STUDY AREA

Cipara is located in the Península de Paria, Sucre State, in northeastern Venezuela. It is a coast of more than 1 km in length limited by the Caribbean Sea and large rain forest areas. Along Cipara there are four main communities (Varadero, Cipara, la Peña y la Remate) with typical rural dwellings that lack basic water services, electricity, and suitable sanitary conditions. The dwellers practice the artisanal fisheries and agricultural activities, including participation by both men and women. Only children go to school, though the school is just to teach an elementary

educational program. Adjacent to Cipara and just to the east is Boca de Cumana, with its own school too. The last town with services before Cipara, is San Juan de Unare (located to ten minutes by boat to the west from Cipara).

METHODS

Children

The basic strategy to involve elementary school children in the educational program consisted of extra teaching activities related to sea turtles biology, ecology, and breeding behaviour, with special emphasis on leatherback conservation. Several talks took place in schools located in Cipara, Boca de Cumaná and San Juan de Unare communities. Such talks let children know and identify sea turtles species, to learn about turtle breeding behaviour (nest making, egg laying, and hatching) and the hatchling's behaviour. All of this was done using posters, pictures, puzzles, and games that made them understand what to do when they see an adult turtle or a hatchling at the beach. Additionally, puppet performances were presented to children in order to increase the child and turtle affective relation. That means that turtle puppets (female and male) adopt a name and relate a story in which they describe their external morphology, the way that the turtle moves, the way

in that they couple and the role of a female turtle at the beach. So then each time the children watch a female at the beach, they identify it with the turtle puppet. Outside school, children made a lot of turtles using paper, scissors, crayons, painting, sand and shells. Those were photographed and later placed on a house wall.

General Community and Fishermen

Local people from Varadero and Cipara got essential information through some talks about Venezuelan sea turtles species. These activities illustrated the present situation of sea turtles, general distribution, local nesting species, present protecting laws, and the way to participate in the leatherback conservation program in Cipara. That includes hatchery construction and management and the need and requirements to get the fishing permit in the future. The main goal of these activities was to show the people how leatherback conservation could make them a strong community in front of the law, and of the social, economical and cultural situation.

RESULTS

Between June 14 and August 14, 1999, young men and fishermen from different communities shared turtle monitoring activities with researchers in order to watch nesting females and, at the same time, cooperating with the morphometric process. When a nesting turtle was found first of all by a fishermen, it was immediately reported to the researchers. Similarly, children and boys reported to researchers when a hatched nest was found and helped them to release the hatchlings and even to describe the reproductive success (live hatchlings, dead hatchlings, unhatched eggs, etc.). Significantly, the fishermen invited daily to researchers in order to install fishing nets in the afternoon and take them out next morning. During the taking

of fishing nets in the morning, many data were recorded such as: type of net used, fishes species quantity, commercial price and next destiny. This activity let researchers look for trapped turtles or dolphins in the net in order to release them if they were alive or report them if they were dead. Not pouched nests were found and most of the nest in Cipara stayed *in situ*.

FUTURE GOALS

A sea turtle conservation program has been designed and submitted for funding, to be put in practice not only in Cipara, but also in Boca de Cumana, San Juan de Unare and other towns such as Puy Puy, San Juan de Las Galdonas and Guarataro. Particularly in San Juan de Las Galdonas there is an important focus of sea turtle killing. The educational program would promote local people technical training in Cipara to involve them in the sea turtle monitoring, hatchery construction, protection, description of the sea turtles feeding areas between researchers and fishermen and development of activities of artisanal work that will increase local people identification with sea turtles and will promote a source of income for them.

ACKNOWLEDGMENTS

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From the Eighteenth Symposium on Sea Turtle Biology and Conservation

Tour Operators and the Awareness of Sea Turtle Conservation at Three Eastern Mediterranean Tourist Destinations

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BACKGROUND

This survey was prompted by questions asked by delegates at the European Coastlines Conference at Swansea University, U.K. in 1994, (Poland *et al.*, 1995) after a report on an investigation into the knowledge and attitudes of English speaking tourists towards turtle/tourism issues on the Greek Island of Zakynthos.

The Mediterranean populations of green (*Chelonia mydas*) and loggerhead turtles (*Caretta caretta*) are very small but constitute unique genetic races (Bowen *et al.*, 1993). The three sites were chosen because of their importance to loggerhead turtle breeding and as tourist resorts. The tourist industry has been a major factor in reducing sea turtle populations in the Mediterranean.

The three sites show important differences. Zakynthos is the most important because it has the largest known nesting density of loggerhead in the Mediterranean (2,080 nests on a total of 3.9 km of beach in 1995; Venizelos, 1995) and the largest number of tourists for any Greek Island resort (over 350,000 per annum), the vast majority of whom are on cheap two-week package tours from the UK with a few large British companies such as Thomson and Airtours. In contrast, the neighbouring smaller island of Kefalonia has between 30 and 80 nests per annum mostly confined to one beach, and a very much lower number of British tourists. Dalyan beach in Turkey in 1989, carried 235 nests on 4 km of beach (Venizelos, 1995). Because this breeding beach is isolated by a lagoon and extensive marshes, tourist use is restricted. However, daily boat excursions from the nearby busy resort of Marmaris threaten this key nesting site. Of the three locations, Dalyan is the only one not to have a dedicated local conservation group: it has some protective legislation but a very limited awareness programme. This is in sharp contrast to the other two locations where there is active conservation.

Because the holiday season coincides with the turtle breeding season (May-September), there is conflict between tourist and turtle. The British peak holiday season is in July and August and most will travel by charter airline. On arrival, they will be met by their resident Company Representative who will brief them on local customs and

points of interest on the coach and at a 'Welcome Meeting'. Sea turtle nesting sites at all three locations are under threat from the effects of tourism (see three MEDASSET reports, Bern Convention meeting, 1997).

METHODS

The project was carried out in 1996 and involved over 22 students and 11 members of staff. The research was conducted in four phases: (Phase I) to identify the research location, references to turtles in holiday brochures and to assess the attitudes of Tour Companies to turtles as an example of an environmental issue; (Phase II) to carry out structured interviews with Tour Company Head Offices to assess their attitude towards environmental issues and how they portray this in their brochures and through their Tour Representatives at the resorts; (Phase III) to carry out interviews at research sites; and (Phase IV) to produce reports with recommendations.

RESULTS AND DISCUSSION

Phase I: The Information Provided by Tour Companies in Their Holiday Brochures

Sixteen 1998 brochures from eight tour companies were scanned for any mention of sea turtles. All but one brochure mentioned turtles somewhere although detailed information was largely restricted to the few brochures concerned with specific nesting sites. In Turkish brochures, mention is only made when it is part of a day excursion. The brochures for Zakynthos (Greece) were far more detailed. Factual points of interest were accurate although there were some slightly misleading information. Some brochures definitely used the turtle as an attraction and to give a perception of unspoilt beaches. Codes of conduct are rarely emphasised and no brochure seems to warn its customer that all the beaches are closed from dusk to dawn. Little brochure space can be spared to provide detailed information on sea turtles and their conservation. Anyone reading the brochures for resorts close to a nesting site

would be bound to know of the turtles' existence. It is a great pity that the brochures do not actively encourage more respect for the needs of sea turtles. If Tour Companies use the sea turtle to any extent to promote a resort, they have an obligation to make tourists aware of activities that can cause harm.

Phase II: The Attitude of Head Office Towards Sea Turtle Conservation

Only two major Tour companies responded; Thomson and Inspirations. Both interviews used a structured questionnaire technique although Inspirations was conducted via post whilst the Thomson interview was carried out 'face-to-face' at their Head Office in London. Both companies showed a genuine interest in sea turtle conservation but felt that the initiative should come from conservation groups, both international and local. They would be willing to cooperate and promote sea turtle conservation measures but they did not have the time or resources to initiate an awareness program. Both companies would welcome more information, as long as it was accurate, and also help to distribute leaflets at the resort and possibly on their aircraft. Including more sea turtle information in their brochures would be dependant upon cost and space.

Phase III (A): The Results of the Interviews with Local Tour Representatives

Twenty-four local Tour Representatives from 11 companies were interviewed using the structured questionnaire. The questionnaire consisted of 20 questions designed to discover the Representative's personal and professional knowledge of the turtle/tourist problem. The role of the Tour Companies is to sell holidays, the role of the Tour Representative is to ensure that his/her client has a very satisfying holiday. Although turtles provide a point of interest, they are too infrequent to be important as a selling point. There is a major role for local conservation groups in providing information to Tour Representatives and their local Offices and also to keep them informed of developments as they occur throughout the nesting season (conservationists of Kefalonia have an excellent and on-going information channel open to the Tour Companies). The Tour Representatives are very willing to do their part but are often short of time and accurate information. In some companies they need more encouragement and advice. Table 1 shows that there is a loss of information between the Tour Representative and tourist as the newly arrived tourist is often very tired and anxious and unlikely to take in a great deal at their 'Welcoming meeting', however well prepared the Tour Representative. The local Tour Company Office and the Tour Representative have a vital role.

Phase III (B): The Results of the Tourist Questionnaire

One thousand and sixty-eight questionnaires were

completed at the three sites: 43 were void. Of the valid questionnaires, 948 were for U.K. tourists and these were used exclusively in the following results. The valid questionnaires showed that importance of the Tour Representative at the 'welcome meeting' and on the coach and the holiday brochure (Table 1). Table 2 shows that the majority of companies do mention sea turtles but highlight threats and codes of conduct in little detail.

CONCLUSIONS AND CONSERVATION RECOMMENDATIONS

Tour companies are increasingly sensitive to the change in attitude of their clients to conservation issues. None of them can afford to offend local initiatives and ambitions, but they can and must influence tourist development for it to be sustainable. They must also be prepared to help safeguard any features of environmental interest. Holiday brochures should always mention codes of conduct if turtles are anywhere near the holiday resort. Information on sea turtle conservation should be sent annually to Guide Books and to Head Offices. This information should be provided by a recognised and internationally known conservation organisation (e.g., The Mediterranean Association to Save the Sea Turtles-MEDASSET). Local conservation groups should send regular statements on the turtle situation to local Tour company offices. Leaflets to be delivered and handed to passengers as they board their aircraft: a possible conservation project in itself.

A full edition of this paper will eventually be published on the Euroturtle WWW site: URL:<http://www.ex.ac.uk/MEDASSET>

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Table 1. Information source for tourists (percentage obtaining information from that source). There were 332 completed questionnaires at Dalyan, 437 at Laganas, and 179 at Kefalonia (948 total). Other sources of information scoring 6% or less were local shops (6%), other (6%), slide shows at resort (4%), local conservation groups (3%), international conservation groups (1%), on the plane (1%), information with ticket (1%), and tourist boards (local and national) (1%).

Information Source	Site			Total - all sites
	Dalyan	Laganas	Kefalonia	
Welcoming meeting	66%	58%	66%	62%
Holiday Brochure	11%	47%	27%	31%
Television and radio	31%	16%	18%	19%
Coach trip from airport	1%	22%	39%	18%
Conversation with Rep.	22%	17%	9%	18%
Guide books	20%	11%	23%	16%
Friends	14%	20%	5%	15%
Previous visit	8%	8%	24%	11%
Leaflets	1%	18%	2%	9%
Travel agent	4%	16%	12%	9%
Locals	13%	6%	1%	8%
Posters at hotel	1%	12%	8%	7%
Posters at resort	1%	12%	8%	7%

Table 2. Information provided by the tour company representatives for the top eight Tour Campaigns (figures calculated by adding all positive responses as % and dividing by the 20 possible input questions-some not included). The figures in brackets give number of questionnaires per company. There were 197 questionnaires from the minor companies. Tapestry is included as a Dalyan specialist company. The score % for information excludes private holidays.

Information provided	Major companies									Minor companies	
	Airtours (138)	Cosmos (18)	1 st Choice (89)	Inspirations (50)	Manos (60)	Sunworld (60)	Tapestry (18)	Thomson (260)	Mean (SD)	Mean	
General turtle information	Welcome meeting	67%	72%	62%	74%	72%	65%	79%	72%	69% (5.42)	68%
	On coach	20%	17%	33%	26%	30%	25%	14%	28%	26% (6.57)	5%
Turtle biological facts	Welcome meeting	9%	11%	9%	6%	17%	13%	0%	13%	11% (5.14)	5%
	On coach	1%	0%	1%	0%	0%	0%	0%	4%	3% (1.38)	0%
Threats to sea turtles	Welcome meeting	10%	22%	21%	28%	30%	33%	7%	26%	23% (9.3)	21%
	On coach	4%	0%	4%	8%	3%	2%	0%	6%	4% (2.77)	0%
How to watch sea turtles	Welcome meeting	5%	28%	11%	22%	17%	25%	0%	16%	15% (9.72)	0%
	On coach	1%	0%	1%	0%	0%	2%	0%	2%	1% (0.88)	0%
Slide shows for more information	Welcome meeting	5%	6%	7%	8%	3%	5%	0%	13%	8% (3.79)	0%
	On coach	1%	0%	1%	0%	0%	0%	0%	7%	3% (2.41)	0%
Codes of conduct to conserve	Welcome meeting	12%	22%	24%	54%	35%	45%	43%	30%	29% (13.84)	37%
	On coach	4%	0%	8%	8%	7%	3%	0	5%	5%	0%
Leaflets given out	Welcome meeting	1%	6%	2%	2%	2%	3%	0%	3%	2% (1.78)	5%
	On coach	0%	0%	0%	0%	2%	0%	0%	0%	0% (0.70)	0%
Score % for information		15%	20%	23%	25%	23%	24%	14%	26%	22% (4.5)	

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