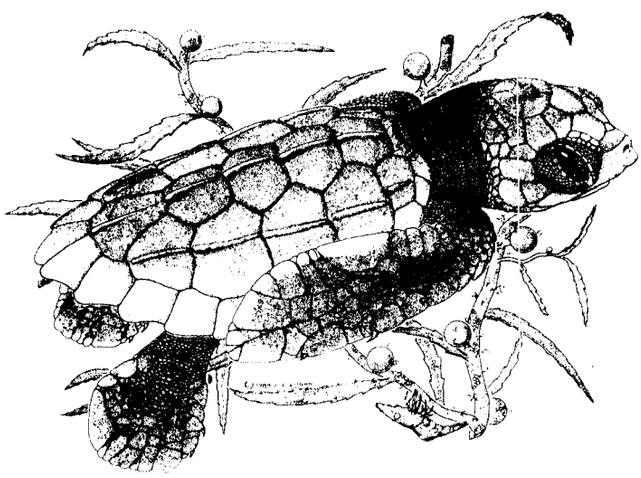
NOAA Technical Memorandum NMFS-SEFC-232

PROCEEDINGS OF THE NINTH ANNUAL WORKSHOP ON SEA TURTLE CONSERVATION AND BIOLOGY

7-11 February 1989
Jekyll Island, Georgia

Compilers:
Scott A. Eckert
Karen L. Eckert
Thelma H. Richardson

August 1989



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PREFACE

August 1989

The Ninth Annual Workshop on Sea Turtle Conservation and Biology was held 7-11 February 1989 at Jekyll Island, Georgia. The Workshop was hosted and organized by the Georgia Sea Turtle Cooperative Research and Education Program at the Institute of Ecology, University of Georgia. The Workshop brought together 380 registered participants from around the world, including representation from fifteen nations. Dr. Colin Limpus from Townsville, Australia, was this year's honored participant at the Workshop. A broad range of topics was covered in the areas of sea turtle research, conservation, and management. Seventy-six papers and 31 poster sessions were presented at the Workshop. Sixty-two papers and 22 poster sessions have been compiled in these Proceedings as extended abstracts. The extended abstract format was chosen because it provides a means of disseminating more complete information than simple abstracts, while leaving the option open for authors to submit full length papers to peer review journals. This format involves negligible editorial control. The content of these extended abstracts does not necessarily reflect the views of the compilers, the Georgia Sea Turtle Cooperative, or the National Marine Fisheries Service. Our hope is that these Proceedings will serve as a useful source of information and contribute to sea turtle conservation and recovery.

On behalf of the Workshop Planning Committee* (Rebecca Bell, Brian Bowen, Karen Eckert, Scott Eckert, Joe Ferris, Jane Fleetwood, Sandy Green, Ruth Ellen Klinger, Lloyd Logan, Charles Maley, Steve Owens, Jim Richardson, Thelma Richardson, Chris Slay, Fred Smith, and Tony Tucker), we wish to express our great appreciation to everyone who participated in the Workshop and helped to make it a success. In particular, we extend a special thanks to Chris Brown, Elaine Christens, Lynn Corliss, Judy Hicklin, Carolyn Brown, Eileen Jones, Amy Mackay, Jennifer McMurtray, Carla Melucci, Karen Payne, Carol Ruckdeschel, Mike Rugge, Bob Shoop, Charles Tambiah, and Charles Warnock who provided so much assistance during the Workshop. The evening refreshments crew is duly acknowledged. Lloyd Logan created the elegant artwork for the Workshop T-shirt and agenda cover. Dr. Joanne Whaley and Marineland of Florida generously provided a live loggerhead for the laparoscopy demonstration by Dr. Limpus. In addition, Dr. Whaley, Sally Murphy, and Lew Ehrhart provided sea turtle carcasses for necropsies. Rod Mast was auctioneer for a not-soon-to-be-forgotten fund raising experience that will almost certainly become an annual event, and thanks to everyone who donated so generously to this auction. Jim DeRevere of DeRevere Travel (Athens, Georgia) worked tirelessly in assisting with reservations and general travel needs. The Georgia Department of Natural Resources (Coastal Resources Division), University of Georgia Institute of Ecology, University of Georgia Marine Extension Service (*RV Georgia Bulldog*), University of Georgia Savannah River Ecology Laboratory, Jekyll Island Authority, and Villas by the Sea on Jekyll Island provided vital logistical support for the Workshop. Our thanks to Dr. Nancy Thompson and the Southeastern Fisheries Center, National Marine Fisheries Service, for funding, duplicating, and distributing the Proceedings.

Karen L. Eckert
Scott A. Eckert
James I. Richardson
Thelma H. Richardson

*My special thanks to this hard-working committee (JIR).

PART I: PAPER PRESENTATIONS

WHAT SCIENTIFIC INFORMATION IS CRITICAL FOR MANAGEMENT, AND WHY?

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Development of coordinated and comprehensive management plans for sea turtles, in contrast to the usual crisis management approach, requires sound science to justify policy. Given the inherent constraints of time and money, complete knowledge about the species and its requirements is not a realistic prerequisite for undertaking sound management. What is required is a rigorous examination of population structure and dynamics, and a consideration of how demographic trends might be influenced by external factors like changing environments and socioeconomics.

The critical scientific questions that must be addressed before management of sea turtles can truly be efficient are:

1) What is the size and extent of the population to be managed (i.e. what is the management unit?)

2) What is the intrinsic rate of increase in this unit in its "undisturbed" state?

3) What are the natural and anthropogenic factors interfering with this intrinsic rate?

4) Which of the above factors can be controlled through management measures and which of those measures will yield the fastest results?

These critically important questions can best be answered through advanced genetic and population biology techniques.

The first question, relating to nature of the management unit, can be answered quickly and efficiently using genetic tools for stock identification. The second question, pertaining to intrinsic rate of population growth within the management unit, should be addressed by compiling data on life history characteristics, many of which are already available from disparate sources. The third, and most important question for management, can be answered on a unit by unit basis using generic population models which have been fine-tuned for the specific circumstances affecting the management unit in question. Fourth and last, answers pertaining to the practical constraints affecting policy options must be acquired by a thorough assessment of which controls can really be imposed. Once these basic scientific issues have been addressed, policy options can be evaluated according to their potential efficacy and political tractability.

Taking such a top down approach to management provides an unusual perspective to the problem of sea turtle management and allows people working on individual pieces of the puzzle to see how their work fits in to the bigger picture. The need for comprehensive management of sea turtles is an accepted but often unacknowledged premise, and all sea turtle biologists and conservationists can benefit by being reminded of how their work contributes to the recovery of the species as a whole. Since time and money are limited, and since the environment in which sea turtles live and breed will continue to be degraded, it is imperative that we manage or conserve these species as efficiently as possible. Current government mandates and public interest will make our work easier in this decade. As we all know, extinction is forever -- and we had better not squander this opportunity, as it may be our last.

BREEDING DYNAMICS OF THE BLACK TURTLE (CHELONIA AGASSIZI) IN MICHOACAN, MEXICO

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The most important nesting and breeding grounds for the black turtle on any mainland shore are the east Pacific areas of Maruata Bay and Colola in Michoacan, Mexico. Numbers of nesting turtles, however, have been seriously reduced due to over-exploitation of both adults and eggs. Since 1982 the University of Michoacan and the [Mexican] Secretariat of Fisheries, with the assistance of U.S. Fish and Wildlife Service and World Wildlife Fund, have been carrying out a conservation/research project for the recovery of sea turtles in that area. This project was begun by Kim Cliffton in the late 1970's.

Tag recoveries have shown that black turtles nesting in Michoacan migrate from feeding areas in Central and South America and from the Gulf of California. Although a body of information exists regarding different aspects of its natural history (Cliffton et al. 1982; Cliffton 1983; Alvarado et al. 1985; Alvarado and Figueroa 1987), little is known about the breeding dynamics of this population. In this paper, information on the courtship and mating of the black turtle is presented.

Courtship

Observations of male-female interactions in the ocean were made in front of Colola, the primary black turtle rookery. Colola is an open and unprotected high-energy beach, five km long and about 120 m wide. The beach runs east-west; a rocky outcrop acts as a boundary on the west end. Since most courting and mating occurs close to shore, this rocky outcrop provides an ideal place from which to observe breeding activity. In the 1988 season, a total of 62 hours were spent observing turtle breeding activity from this rock. The 62 hours of observation were spread over a period of 12 days. Observations were made with the aid of binoculars. When ocean conditions allowed, observations were also made in the water. Thirty-six male-female interactions lasting more than one minute were recorded.

Identifications by the male of a potential mate usually occurs under water. In 78% of the male-female interactions recorded, a surfacing female was closely followed by a male; in a few cases, more than one male was in close pursuit. Surfacing females would always keep their head down looking for the pursuing male. As soon as the male appeared, the female almost always faced him. In most cases, the male dove after a few seconds. In 33% of the cases, the female dove before the male surfaced again. If the female remained on the surface and the male reappeared, the female usually maintained a position facing him, while he circled around her, getting closer each time. In some cases, a male would swim directly under a female, touching her plastron with his carapace. If the female continued facing him, after a few circlings (mean = 3.2), the male usually dove and disappeared. In a few observations (about 10%), instead of diving, the male charged the female and tried to mount while the female was facing him. In these cases, the female didn't attempt to dive or flee but positioned herself in a vertical position in the water with her plastron towards the male. This "refusal position " was described by Booth and Peters (1972) in the green turtle (Chelonia mydas) in Australia. In 52% of our observations, the male gave up and dove away after the first charge. In 48% of the cases, the male continued charging from 2 to 9 times (mean = 3.7). Occasionally while the female was facing him, the male stopped circling her and slowly approached her from the front, gently biting the skin of the neck and foreflippers. No successful matings were observed in the interactions described so far, that is, with the female facing the male as he circled her, or with the female adopting the vertical refusal position or with the male biting the skin of the female's neck and foreflippers.

In the four successful mounts recorded, the female, after surfacing, allowed the pursuing male to approach her from the side. Thus, facing the same direction and side by side, the male tried to gain a side-hold by

throwing one foreflipper over the anterior part of the female's carapace. After the male had gripped her from one side, the female titled sideways towards him, facilitating the grip of his other foreflipper. On these occasions no previous courtship was observed. Although we were not able to say when mounting resulted in intromission, we considered a mount to be successful when the male remained in position for more than 20 minutes.

In six attempted mounts recorded on the surface in which the female was approached by surprise from behind, the males were quickly dislodged by the female tilting herself headfirst into the water. In two other surprise-surface mounts, and on three occasions in which the female surfaced with a male already mounted, the males lost interest quickly and left the females within a short time (2-9 minutes). Perhaps these were unreceptive females who had their hindflippers folded together, an action to avoid copulation described by Booth and Peters (1972) in the green turtle.

Observed mating pairs were always escorted by at least one and up to six males (mean = 2.5) that took turns, one at a time, launching themselves at the mating pair, apparently trying to dislodge the male. Escorts frequently bit the tail of the copulating male and the flippers of the female. The female tried to avoid escorts by frequent dives.

On the east side of the observation rock a number of females were observed remaining on the sandy bottom right under the breakers at a depth of 1.5-2.0 m. Individual females remained there for hours, surfacing only for air. In this area females seemed to be free from the males' attentions. Booth and Peters (1972) described similar "female sanctuaries" for the green turtle.

Within the limits of the 1988 observations we can conclude that for the black turtle, unwanted copulation may be avoided either by the female assuming the vertical refusal position or by maintaining the face to face position. Once the male has mounted, the female may prevent copulation by toppling the male or by folding the hindflippers in refusal. Females may also avoid copulation by remaining within the "female sanctuary". Circling and biting the female by the male did not preclude a successful mount. Receptive females were not courted on the surface and mounting occurred from the side. Females seem to have total control over copulation in accepting the male's mounting and in allowing him to remain in place.

Mating

To obtain information on mating activity and male movements, offshore surveys were conducted during the 1985, 1986, 1987, and 1988 seasons. Transects were run with a motor boat through the core of the black turtle breeding grounds, counting, capturing and tagging both male and female turtles. Turtles were caught by hand, usually while they were mating; after being tagged and measured they were released. While intromission of the captured mating pairs was difficult to document, only pairs that remained coupled during the chase to be captured were considered as mating.

Information from the offshore surveys indicates that mating activity occurs throughout the nesting season, being more frequent during the first half of the season. The occurrence of fresh claw marks on the carapace of most nesting females throughout the season, and the presence of males in the area throughout the year, also support this probability. The occurrence of mating throughout the nesting season suggests the possibility of mating between clutches. Indeed, from nesting records of 18 female black turtles captured while mating, it was found that nine nested both before and after mating. This would indicate that sequential matings between clutches may be common. The average time between mating and nesting was 13.6 days (r = 1-38, n = 18 turtles, 27 nestings). By contrast, studies of the green turtle indicate that mating in that species occurs about a month prior to the first nesting (Owens 1980, for a review). If, in the black turtle, mating occurred a month before nesting, we would expect to find a peak of first clutch nesters about a month after a peak in mating activity. Utilizing the data from the 1986 black turtle season, we found, however, that a month after the main mating peak, first clutch nesters were low in number. Although more field data need to be gathered on the black turtle mating-nesting chronology, the evidence to date suggests the possible existence of more than one breeding scenario in sea turtles.

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THE OCCURRENCE OF HAWKSBILLS (ERETMOCHELYS IMBRICATA) ALONG THE TEXAS COAST

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The hawksbill (Eretmochelys imbricata) is the least commonly encountered of the five species of sea turtle regularly found stranded along the U.S. Eastern and Gulf coasts. In 1987, for example, only 29 out of 2,373 total animals reported to NOAA's [Nation Oceanic and Atmospheric Administration] Sea Turtle Stranding and Salvage Network (STSSN), or 1.2% of the total, were hawksbills. Of these, 13 were found on the Eastern seaboard (Florida and Georgia), 10 in Texas, and 6 in Puerto Rico and the U.S. Virgin Islands. In the Gulf of Mexico, Texas is the only state regularly reporting hawksbills. As the local STSSN observer, I found a disproportionate number of them stranded here when compared to strandings in other regions and to previous records for this species in Texas. Hawksbills in Texas waters have always been described as rare or accidental. The 77 records for Texas since 1972 reported here may represent a change in that status. During 1,300 surveys of Mustang Island Gulf beach since 1982, and with the help of local police, Park Rangers, beach-cleaning crews and the general public, I have recorded 410 stranded sea turtles including 49 hawksbills. An additional 28 hawksbill records dating back to 1972 were found in the Texas STSSN Coordinator's data base. The closest hawksbill nesting sites to the Texas coast are in Campeche and Yucatan, Mexico. Farther north, near offshore reefs fringing Veracruz State, foraging hawksbills have been reported in abundance.

The following summarize the circumstances of hawksbill strandings in Texas:

~ Recent annual strandings range from a low of two in 1985 to a high of 29 animals in 1986.

~ Seasonally, strandings occur in all months of the year, increasing almost exponentially to a peak in October and showing a sharp decline in November. Many of the October strandings occurred in 1986 when several post-hatchlings were found alive on beaches near Port Aransas.

~ Live animals are in the majority (73%) of hawksbill strandings. This is in contrast to all other species here where most animals are found dead.

~ The largest hawksbill recorded (in 1972) had a carapace length (curved?) of 67cm; this was the only adult reported. All others were far smaller than this.

~ Curved carapace length frequency has a bi-modal distribution with peaks in the hatchling/post-hatchling range (< 10 cm) and the "yearling" range (20-29.9 cm).

~ The great majority of hawksbill strandings were reported from the "Coastal Bend" near Corpus Christi. Outside of this area, two came from Lavaca Bay, four from the Galveston region, and a few from South Padre Island.

~ Strandings are concentrated in four locations: 1) Port Aransas, where the UTMSI [University of Texas Marine Science Institute] is located; 2) Mustang Island, a popular spot for beachgoers; 3) a popular county beach; and 4) near the headquarters of the Padre Island National Seashore. Most hawksbills are found among the strandlines of the barrier island Gulf beaches. Very few are found in the bays and estuaries.

~ There is a high incidence of entanglement in plastic (22% of those where such information was recorded). The most frequent form of entanglement occurs when animals get their necks and/or limbs caught in woven plastic produce sacks. Monofilament fishing line wrapped around limbs, and snagging by people fishing from the jetties have also been recorded. Yearlings are particularly susceptible to entanglement; in fact, no entanglements have been noted for post-hatchlings.

In the fall of 1986, 28 post-hatchling hawksbills came ashore, mostly in the Port Aransas region. Curved carapace lengths ranged from 5.9-10.0 cm (mean = 7.6 cm). Weights ranged from 28.5-83.5 g. One animal at 28.2 cm (curved carapace length) as also found during this time. All but two were found alive. Many were injured, having been attacked in the surf zone by fish and even shorebirds. Seven were released the following year offshore near platforms where it was assumed they might obtain food. This was thought to be preferable to releasing them by the rock jetties where many people fish. Thirteen died within weeks of their stranding.

What caused the apparent increase in the number of hawksbills found stranded in Texas? Here are some possibilities: 1) observation frequency has increased and more animals are now being found than in previous years; 2) circulation patterns have changed, bringing the pelagic juvenile turtles, along with their floating food supply, farther north; 3) they disperse northward from the nesting sites in Mexico, and yearlings find feeding grounds around the stone jetties on the Texas coast. Hatchlings move with their floating food supply and some get stranded in Texas when the debris is washed ashore; 4) there are undiscovered hawksbill nestings in northern Mexico or southern Texas.

1) Increased observation means increased discovery (i.e, they were always there but just not observed): Geographical distribution data can be seriously biased by sampling frequency, beach accessibility, and the beachgoer "population". There are few major barrier island populations and tourist centers along the Texas coastline where stranded animals are likely to be seen by lots of people: Galveston Island, Mustang Island, North Padre Island, and South Padre Island. NMFS [National Marine Fisheries Service] observers and volunteers cover the entire Texas Gulf coastline at one or two week intervals, year around. I cover Mustang Island four times per week, yet have discovered only four hawksbills (7% of the total); during the same period I found 92 (26% of the total) of the 350 other sea turtles stranded in the region. Most of the discoveries are made by the general public and city, county and state officials. I believe these data are fairly representative of the present distribution of hawksbills on the Texas coast, but that the number of observers, official or not, does present a bias.

2) Circulation patterns have changed bringing juvenile hawksbills north of their normal range: Based on 8 years (1,300 observations) of temperature and salinity data collected off Mustang Island, there is no correlation between water masses impinging on the coast and hawksbill strandings, except that most strandings occur in the fall when temperature and salinity are normally at a maximum. Yet 1983 was a year when several hawksbills stranded but fall salinity was very low, while 1985 had only one stranding and high salinity in the fall. So in general it would seem that there is little in the way of a water mass identity associated with hawksbill strandings. It is generally believed that juvenile turtles spend their pelagic period feeding among flotsam, especially the Sargassum weed. Since 1983 I have been estimating the quantity of several categories of floating debris washed ashore. I could find no association between beaching of "tropical" jetsam and hawksbill strandings.

3) Hawksbills drift north with the surface currents from their nesting sites in Mexico: The post-hatchling hawksbills that came ashore over a span of 40 days in 1986 ranged in weight from 28.5 to 83.5g. Using a formula relating weight and carapace length to age (Witzell 1980, Witzell 1983), ages of 48 to 163 days were estimated. Projecting backwards from time of stranding, possible hatching dates ranged from 15 April-19 August 1986. Hatching in April or May would appear to be too early for Mexican animals according to Witzell (1983), as the nesting season starts in April and incubation is 60 days. Two animals beached on 1 April 1984 and mid-June of 1988, giving projected hatching dates of 1 January and mid-March, respectively. This would reflect nesting in November and January. Hawksbills in the Gulf or Caribbean do not normally nest that early (or late). Because the projected nesting dates for these turtles is generally too early in the season, we must conclude that (a) hawksbill hatchlings in the wild grow faster than the captive animals; (b) somewhere in the Gulf or, more likely, the Caribbean, hawksbills nest late in the year; (c) some of these post-hatchlings come from the previous year's clutches and are growing much more slowly

than the captive animals; or (d) some of the smaller animals are from nests closer to, or even in, Texas. Is it feasible that the animals could have come from Mexico or the Caribbean? To get to Texas from the nearest known Mexican nesting sites at ages ranging from 34 to 163 days, they would have moved at speeds ranging from 34 to 7 cm/sec, assuming they moved in a straight line (Figure 1), a distance of 1,000 km. If they drifted with the current, the highest speeds are not reasonable for open ocean surface currents in this part of the Gulf. Drift cards released in the Gulf of Campeche in July have taken 60 days to reach Mustang Island, and those deployed in the Caribbean reached Texas in ten months or more. More recently deployed drifters that communicate their position via satellite show that the westward drift of Loop Current rings meander slowly and have lifetimes of many months.

4) Hawksbills nest farther north than previously reported: Both loggerhead (Caretta caretta) and Kemp's ridley (Lepidochelys kempi) post-hatchlings stranded live during the hawksbill event of 1986. These were barely larger than hatchlings and almost certainly came from south Texas or northern Mexican nests. Both these species nested on Mustang Island in 1988. It is possible that the hawksbill nests on occasion in the region, as well.

In conclusion, it is feasible that the hawksbill has nested north of its known range, based upon the size of some of the post-hatchlings stranded in Texas. Most of these juveniles, however, probably came from the Campeche or Yucatan sites. Two stranded so extraordinarily early that it is difficult to understand how they got there at that time and at that size. Young hawksbills are more common in Texas than has previously been documented. They are probably brought ashore with the floating Sargassum community when high salinity water from the central Gulf impinges on our shores. However, the evidence for any distinct oceanographic event or mass beaching of floating debris coinciding with the big hawksbill stranding of 1986 was not compelling. Yearling hawksbills may find the stone jetties a suitable feeding ground. They are susceptible to entanglement in plastic debris.

ACKNOWLEDGEMENTS

Special thanks is due to Pam Plotkin. I wish also to thank The University of Texas Marine Science Institute for providing facilities, support and patience in the turtle rehabilitation business, and the R/V LONGHORN and her crew for making several releases of rehabilitated turtles, NMFS Galveston and Panama City for providing some financial assistance for the rehabilitation work, Texas A & M Sea Grant College Program for support of some of the beach survey work, Padre Island National Seashore personnel, and all the people who help in reporting stranded turtles, without which this paper could not have been written.

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WATS II, THE WESTERN ATLANTIC TURTLE SURVEY, AND THE FUTURE

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WATS I [Western Atlantic Turtle Symposium I] was held in San José, Costa Rica, in July 1983. The Proceedings of WATS I were published nine months later -- three volumes of the most comprehensive sea turtle data ever assembled for the Western Atlantic area. WATS II was held in Mayagüez, Puerto Rico, in October 1987. The Proceedings of WATS II will be published soon (date reference 2/8/89).

These two Symposia, and their sea turtle data generation, compilation, and publication rank among the greatest happenings of international communication, coordination, and cooperation since 1941-1945. At the concluding session of WATS II, the National Representatives recommended, and the other Symposium participants supported, the plan to continue the WATS effort and to hold a third Symposium in 1993 or 1994 at a site to be selected in the Greater Caribbean Basin area.

WATS continues to work on an official governmental level to assemble data and to consider management options that will protect our six species of sea turtles. WIDECAST [Wider Caribbean Sea Turtle Recovery Team] is active a the non-governmental level in assembling Sea Turtle Recovery Plans. WATS and WIDECAST, by agreement of their directors, were working on parallel but non-overlapping courses. While that policy was useful in the formative past, we now need all the coordination we can get.

I now recommend WATS and WIDECAST commence overlapping on at least three levels:

1) administration and in planning,

2) data base acquisition, storage and use,

3) obtaining the money needed to allow us to pursue our primary purpose of sea turtle protection,

4) in coordinating quick-time response to acts of sea turtle exploitation or other harm in our area.

There are three major actions which I believe we must remember as being necessary to protect really endangered and threatened sea turtles. These are:

I. So relatively little is known of the life history and habits of sea turtles, and there are so many critical gaps in our knowledge (especially of sea turtles in the ocean) and so many poorly understood differences between species, that we do not yet have the best data to allow us to manage efficiently. We must strive to get this knowledge and fill these gaps.

II. We must keep up constant, well-planned, and long-term sea turtle protection efforts and actions. If protection efforts diminish or fade, recent experience has shown that harmful and excessive exploitation will creep in or will jump in.

III. We must get one major flaw corrected in the United States law on sea turtle endangered status: 'THE SPLIT MANDATE'. To assign protection of sea turtles on land to the Fish and Wildlife Service (Department of Interior) and sea turtles at sea to the National Marine Fisheries Service (Department of Commerce), was a guarantee by the U.S. congress that realistic protection efforts would be long delayed or have a better chance of failing. To put control of sea turtles at sea under the National Marine Fisheries Service was an automatic conflict of interest, although not too many caring people have been able to see it yet.

AERIAL SURVEYS OF MARINE TURTLE CARCASSES IN NATIONAL MARINE FISHERIES SERVICE STATISTICAL ZONES 28 AND 29; 11 AUGUST 1987 TO 31 DECEMBER 1988

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INTRODUCTION

Aerial surveys of marine turtle carcasses in National Marine Fisheries Service (NMFS) Statistical Zones 28 and 29 were conducted from 11 August 1987 to 31 December 1988. The objectives of the study were:

1. To establish a systematic weekly aerial survey of NMFS zones 28 and 29.

2. To assist the efforts of the Sea Turtle Stranding and Salvage Network (STSSN), and ensure that all marine turtle carcasses were accounted for.

3. To obtain carcasses suitable for histopathological necropsy and perform necropsies on selected individuals.

4. To observe and record the daytime shrimp trawling effort within approximately 7.0 km of the shoreline, within the boundaries of zones 28 and 29.

5. To examine the information collected from the aerial surveys together with STSSN data and investigate the possibility of any developing trends.

STUDY AREA

The study area began at the 28th parallel, approximately 5.0 km south of Melbourne Beach, Florida, and ended at the 30th parallel, approximately 15.0 km north of St. Augustine, Florida. Zones 28 and 29 contain approximately 240 km of Atlantic coastline.

METHODS

1. Every effort was made to conduct weekly surveys, weather permitting, for consistency.

2. The surveys began approximately one hour after sunrise.

3. A high winged Cessna 172 aircraft was used during all flights.

4. A fixed altitude of 200 feet, 100 meters offshore, and an airspeed of 85 knots was maintained during the surveys.

5. All sea turtle carcasses observed during the surveys were circled for positive identification, given a fixed location, and investigated by ground personnel.

6. Sea turtle carcasses suitable for histopathological necropsy were placed on ice and transported to the University of Central Florida, Orlando, Florida.

7. All daytime shrimp trawler activity (nets down and trawling only) was logged by number and location.

RESULTS AND DISCUSSION

The data collected during this study were compiled by statistical zone in order to focus on trends observed between carcass strandings and daytime shrimp trawling effort. The number of carcasses shown in Figures 1 and 2 is defined as all species reported by month to the STSSN, and shrimping effort is the number of trawlers observed working (nets down) within 7.0 km of the shoreline per month.

NMFS Statistical Zone 28 is a Turtle Excluder Device (TED) required area since 1 October 1987, except from 12 April 1988 to 1 September 1988 when Federal courts enjoined TED regulations. Zone 28 extends from near Melbourne Beach on the south and New Smyrna Beach on the north. This zone includes the Port Canaveral Shipping Channel, which has a known high population of marine turtles year around.

A comparison between daytime shrimping effort and the number of carcass strandings per zone per month, combined (Figure 1), reveals the following trends. In the period from August 1987 to February 1988, we saw a high shrimping effort and a low number of reported strandings. This is what you would expect to observe in a TED regulated area, and NMFS special agents confirm 100% compliance in Zone 28. In the months from February-August 1988, an increase in the number of strandings occurred, but daytime shrimping effort was low. Several factors may explain this. Florida state waters are open to nighttime shrimp trawling only in the months of June, July, and August, hence much of the shrimping effort is conducted at night and not observed in the daytime aerial surveys. Additionally, TED regulations went out of effect on 12 April 1988, and did not go back into effect until 1 September 1988. From September-December, an increase in shrimping effort was observed, similar to the effort seen in the fall of 1987, and carcass strandings remained low. We believe this shows the effectiveness of TED use in zone 28.

NMFS Statistical Zone 29, a non-TED regulated area, lies to the north of zone 28 and includes the area from New Smyrna Beach north to St. Augustine. The total number of marine turtle carcass strandings reported from August 1987 to December 1988 in zone 29 was 258. This is significantly higher than the 110 in zone 28 for the same period. It also should be noted that there was three times as much shrimping effort observed in zone 29 than zone 28.

When we compare shrimping effort to carcass strandings in zone 29 (Figure 2), definite trends begin to appear. The period from August through November 1987 exhibited an increased level of shrimping activity. In the same period it was clear that the number of strandings increased with the increase in shrimp trawling, decreased somewhat in October but rapidly increased to more than 25 strandings in the month of November. In the months from November 1987 to March 1988, a gradual but still significant shrimping effort was seen. Stranding totals declined during these months, with a low of four carcasses reported in February 1988.

From March through the end of May 1988, shrimping effort remained low. This is probably a response to the closing of the Florida east coast shrimp beds from 1 April to 30 May. Carcass strandings increased rapidly again in March but declined through May. It is possible that these strandings were the result of shrimping being conducted outside Florida waters during the closed season. Beginning in June (the opening of shrimping season in zones 28 and 29) shrimping effort increased slightly and remained stable with less than five trawlers per month through August. Note that June through August are the only legal months for nighttime trawling, and much of the activity was not recorded in the daytime surveys. Carcass stranding totals indicate that, beginning in June, the number of carcasses increased rapidly (from six in June to more than 15 in August).

In October shrimping effort was at the highest point of the year with over 150 sightings. Marine turtle stranding totals also reached their highest point in October. Trawling effort declined slightly in November 1988 and carcass strandings appeared to follow the decline. Shrimping effort increased again in December to 100 sightings and carcass strandings again climbed to slightly less than 30.

In summary, the trends observed in this study add to the circumstantial evidence for a correlation between marine turtle carcass strandings and shrimping effort in zones 28 and 29.

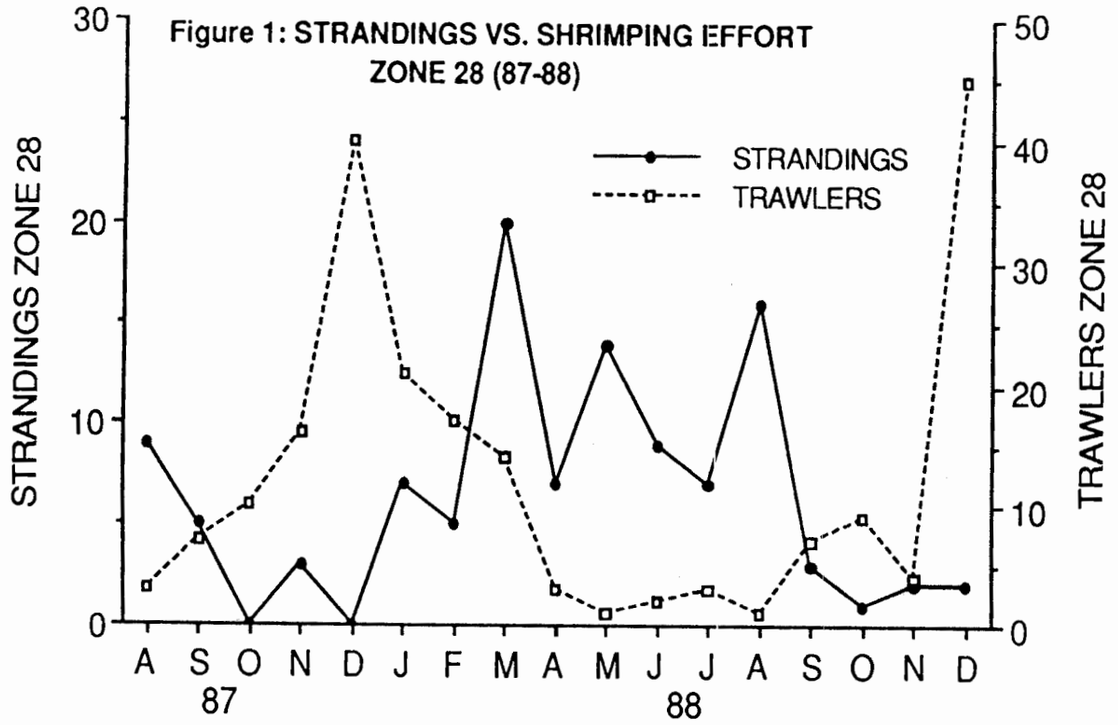
Figure 1: STRANDINGS VS. SHRIMPING EFFORT
ZONE 28 (87-88)
STRANDINGS
TRAWLERS
STRANDINGS ZONE 28
TRAWLERS ZONE 28
30
20
10
0
50
40
30
20
10
0
A S O N D J F M A M J J A S O N D
87
88

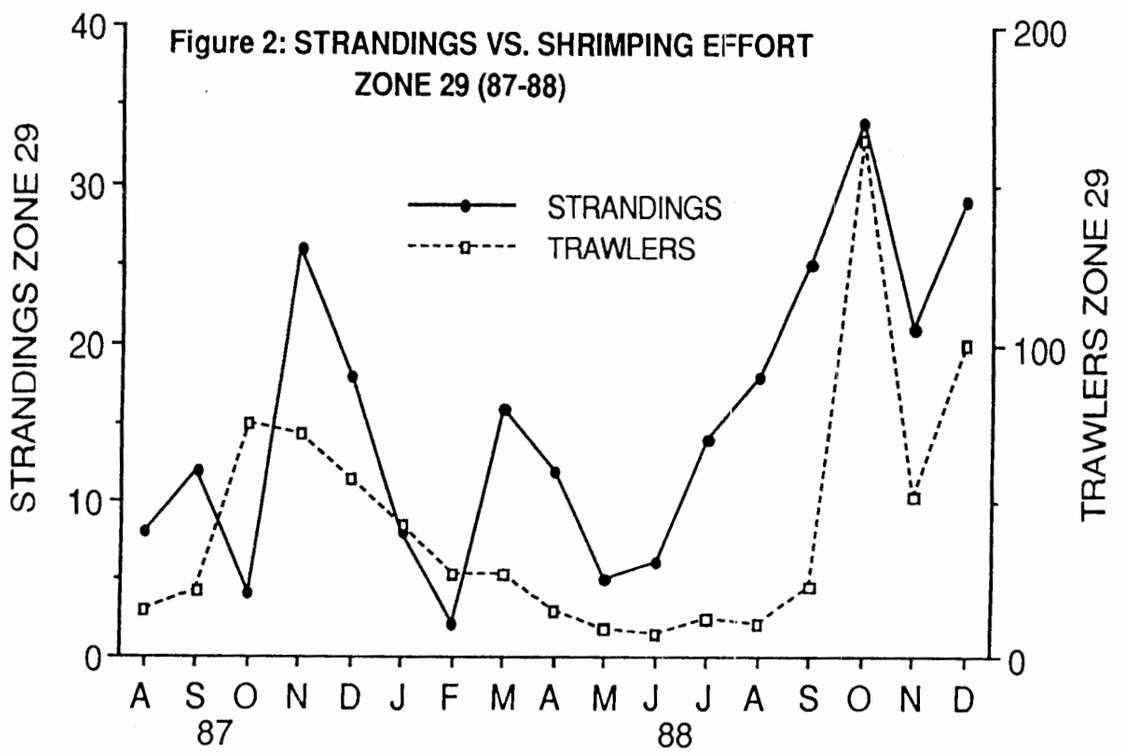
Figure 2: STRANDINGS VS. SHRIMPING EFFORT
ZONE 29 (87-88)
STRANDINGS
TRAWLERS
STRANDINGS ZONE 29
TRAWLERS ZONE 29
40
30
20
10
0
200
100
0
A S O N D J F M A M J J A S O N D
87
88

POPULATION STRUCTURE AND EVOLUTIONARY HISTORY OF THE GREEN SEA TURTLE, CHELONIA MYDAS

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Tagging data indicate that female green sea turtles return to the same location to nest in successive nesting seasons. This site fidelity has lead researchers to suggest that nesting turtles return to their natal beach. One consequence of natal homing would be a restriction of gene flow between rookeries. To test this hypothesis, four Atlantic, three Pacific and one Indian Ocean rookery were surveyed with mitochondrial DNA (mtDNA) restriction analysis. Results indicate that the Chelonia mydas complex consists of at least two major phylogenetic units, corresponding to Atlantic and Indo-Pacific populations. In the Atlantic, significant mtDNA genotype frequency shifts indicate a contemporary restriction on gene flow between nesting colonies. Results are consistent with a natal homing hypothesis. However, the overall similarity of mtDNA genotypes within the Atlantic indicates that isolation between rookeries is recent, or that genetic exchange occurs at a low level. Disjunct Atlantic colonies are isolated over ecological time but not over evolutionary time.

ENVIRONMENTAL FACTORS AND SEASONAL OCCURRENCE OF SEA TURTLES IN LONG ISLAND, NEW YORK

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The occurrence of Kemp's ridleys in the western North Atlantic has been established for several years (Pritchard and Marquez 1973, Carr 1980, Lazell 1980, Meylan and Sadove 1986), but the survivability and reproductive value of these individuals has only recently become the subject of scientific research. Previous descriptions of the Atlantic as a Kemp's ridley habitat vary. Hendrickson (1980) characterized the area as a "highly disadvantageous environment," while Carr (1980) considered it unlikely that all of the Atlantic population was lost and Lazell (1980) found that Kemp's ridleys in Massachusetts were generally healthy.

Our research has concentrated on Kemp's ridleys occurring in the waters surrounding Long Island, New York, a population which is strictly juvenile (SCL ranges from 22 cm to 38 cm). Kemp's ridleys are first seen in the area in August, when water temperatures range from 20°-25°C (Figure 1). During this period an abundance of prey items are available. During November water temperatures begin to fall rapidly and by early December conditions in the area are lethal (below 7° C) to Kemp's ridleys. Water temperatures fall to as low as 0° C and remain in the lethal range for the next four months. Since we do not consider it likely that sea turtles hibernate or brumate in Long Island, survivability of this population would depend on migration to a warmer (i.e., southern) habitat.

From mark-recapture studies and collection of stranded animals during the years 1985 to 1988 we examined 107 juvenile Kemp's ridleys. Seventy-five percent of the animals were dead due to prolonged exposure to water temperatures below critical thermal minimum (cold-stunning). For the years 1987 and 1988 we tagged 18 Kemp's ridleys during the summer and collected 29 cold-stunned individuals during the winter. Only one of the cold-stunned individuals was a recapture (Figure 2). While these data indicate a large population of juvenile Kemp's ridleys utilizes New York waters, they do not indicate what proportion of the population becomes cold-stunned. We have found that several factors, such as wind direction, frequency of beach patrols, and public awareness, influence the number of cold-stunned individuals encountered. We have minimized the effect of the latter two by creating a 130 member volunteer beach patrol, obtaining frequent media exposure and mounting posters on all beaches. Our research indicates, however, that regardless of beach coverage, wind direction is a major influence in determining the number of cold-stun related strandings. This is due to the passive movement of floating cold-stunned turtles.

Whether the threat of exposure to lethal temperatures is off set by beneficial factors in the Long Island area, such as an abundance of prey items, may be determined by the percentage of the population that migrates successfully. If it can be shown that juvenile Kemp's ridleys do migrate southward, from Long Island to warmer waters, it would also suggest an ability to migrate to the Gulf of Mexico, providing evidence of the reproductive value of the Atlantic population.

ACKNOWLEDGEMENTS

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MEAN WATER TEMPERATURES FOR LONG ISLAND SOUND, NY (1985–1988)

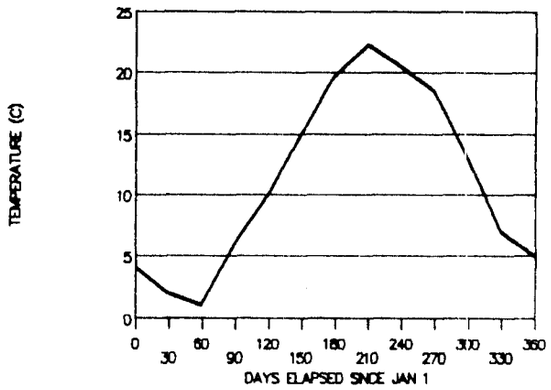

FIGURE 1. Combined means of surface and bottom water temperatures. Water temperatures become lethal to Kemp's ridleys by early December and remain lethal until April.

TAGGED, COLD–STUNNED, AND RECAPTURED L. KEMPI (1987 – 1988)

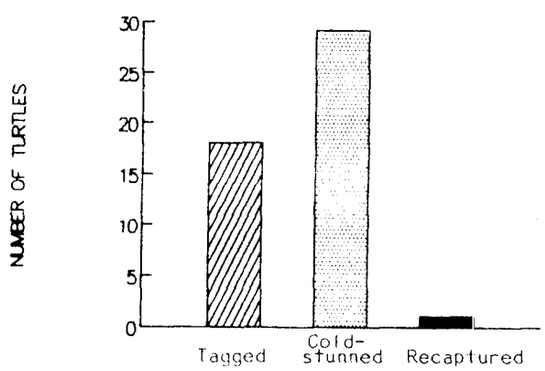

FIGURE 2. Tagging was conducted during the summer and early fall, while cold-stunned turtles were recovered in the late fall and early winter. Recaptures represent cold-stunned turtles with tags.

SATELLITE TELEMETRY OF KEMP'S RIDLEY SEA TURTLE, LEPIDOCHELYS KEMPI, IN THE GULF OF MEXICO

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INTRODUCTION

The goal of this study was to develop techniques to examine movement and behavior of Kemp's ridley sea turtles (Lepidochelys kempi) at sea. The first phase of the study concentrated on: 1) reducing the size of the transmitter and housings for use with Kemp's ridley (the smallest of sea turtles), and 2) incorporating a saltwater switch and software so that diving behavior could be analyzed in addition to monitoring movements.

MATERIAL AND METHODS

The study area was the range of adult Kemp's ridleys, generally confined to the Gulf of Mexico. Ridleys were captured and tagged as they completed a nest deposition at Rancho Nuevo, Tamaulipas, Mexico. The study used the TIROS-ARGOS, polar-orbiting satellite system for data collection and locations. Transmitters were constructed by Telonics, Inc. (Mesa, Arizona) and consisted of two types: a trailing "float" and a carapace mounted "backpack." Data collection was the same for either style.

Data transmitted to the satellites were temperature, duration of the previous dive, the mean submergence duration summed over the previous 12 hour period, and number of dives per 12 hour period. Position fixes were calculated by the Doppler shift in transmitter frequency.

RESULTS AND DISCUSSION

Nine backpacks and nine floats were attached to ridleys in May 1987, April and June 1988. Data transmissions were received from telemetered turtles from zero to 127 days. Fourteen tracks of turtles were obtained that revealed nearshore (< 50 m depth) movements north (4 turtles) and south (7 turtles) from the nesting beach; three turtles ceased transmitting before moving away from Rancho Nuevo. Two of the north moving ridleys ceased transmitting in the vicinity of Corpus Christi, Texas, and one showed indications of being taken aboard a boat. Of the seven southerly moving tracks, two ceased transmissions in the vicinity of Cabo Rojo, Veracruz, and one of these showed signs of nesting again; two were tracked to Campeche Banks and three tracks turned north up the western Yucatan Peninsula, two of which ended at Cabo Catoche, the most northeastern part of the Peninsula. The nearshore tracks of the turtles suggests that post-nesting Kemp's ridleys essentially occupy the littoral zone as corroborated by prey preference (portunid crabs) shown in the literature.

Submergence data were summed over a 12 hour period before being transmitted to the satellite from individual turtles. The mean dive duration in a 12 hour period was generally less than 30 minutes and the mean was 18.1 minutes (sd=16.1). Occasionally, turtles dove for > 60 minutes per 12 hour period. Individual dives of up to approximately 100 minutes were recorded, but rarely and with no specific regularity, such as might be expected if the turtles were engaged in sleep periods.

The number of dives per 12 hour period ranged from zero to over 300, but the predominate pattern was < 80 dives per 12 hours. The mean number of dives per 12 hours was 69.8 (sd=55.6). Mean total submergence per 12 hour period was always > 600 min and was clustered tightly about the mean of 693.8 minutes (sd=16.6). This corresponds to a total surface time per 12 hour period of 27.2 minutes. The variation in the submergence time was much less than the variation in the mean dive duration or number of dives. This indicates that, as an index of a turtle's respiratory restraints, the submergence time is a more precise number.

Individual turtles show a high degree of variability in the number and average duration of dives but match higher numbers of dives with shorter durations and vice versa, yielding similar submergence times. The mean percentage of time ridleys spent below the surface was 96%. Although no information on depth of dive is available, it is likely that most of the time submerged is spent on the bottom of the littoral areas these turtles frequented.

ANOVA was used to test for significant differences in behavior among turtles. There were significant differences among turtles in mean dive duration per 12 hours ($F=3.515$) and the number of dives per 12 hours ($F=5.939$). The product of the two variables, total submergence in 12 hours, also differed significantly among turtles ($F=5.394$). There was no significant difference between day and night behavior.

SUMMARY AND CONCLUSIONS

The satellite system has proven successful, and data have been collected that could not have been otherwise obtained without a much greater investment in time and money. Several technical problems still remain that have not yet been solved satisfactorily. Some (if not all) of the transmitters that were never heard from upon entering the sea may have leaked. Several housings during testing experienced this failure and one transmitter that was returned by a Mexican fisherman was full of sea water, which made it negatively buoyant so that it never reached the surface to transmit. Further testing of housings in hyperbaric conditions is necessary.

The methods of attaching the transmitters to the turtles was also an area of concern, especially on Kemp's ridleys. We attached both versions of the transmitters to the turtles with the turtles' welfare in mind. The backpack style could not be harnessed as firmly as we desired because we had to ensure that the transmitters would detach from the turtles within the year. Some of the early terminations of transmissions from the backpacks may have been due to premature shedding of the transmitter.

Although the suppositions presented above may have contributed to the termination of the study earlier than had been hoped, a great deal of information was obtained that is important to the management of the species. Female Kemp's ridleys appear to be nearshore dwellers, using the shallow littoral zone along the coast of the Gulf of Mexico. The data produced here, although not a complete picture of the zones the turtles occupy, indicate that in-water protection should concentrate on nearshore activities, such as fishing operations, oil industry actions, etc. If female ridleys still occupy areas such as off the mouth of the Mississippi River, it is necessary that investigations to determine over-wintering sites continue. These areas will also need to be afforded protection and very well may occur in deeper waters which remain warmer than nearshore areas during winter.

ACKNOWLEDGEMENTS

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INTERNATIONAL TRADE IN SEA TURTLE PRODUCTS

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The major sea turtle products traded internationally are raw tortoiseshell (principally from the hawksbill, although small quantities of green turtle shell occasionally enter trade), raw skin and processed leather (mostly from olive ridleys, but also from green sea turtles), manufactured articles of hawksbill shell, stuffed hawksbills and green turtles, oil for use in cosmetics, cartilage for turtle soup and, finally, green turtle meat.

Unlike most wild animal products, sea turtle products are often classified under exclusive categories in the Customs' statistics of many countries. The most comprehensive statistics are for "tortoiseshell", the name most commonly used for hawksbill shell. Customs statistics for the other sea turtle products are less readily available.

However, there are problems even with the tortoiseshell figures. Only Japan clearly differentiates between species, listing a category purely for hawksbill shell called "bekko". All other countries categorize this shell as "tortoiseshell", which I have used as meaning shell from hawksbills only.

A further problem is that Customs data for tortoiseshell in many Asian countries sometimes includes shell from freshwater turtles, which is widely used in Chinese medicine. To avoid inaccuracies arising from this problem, I calculated the average value of hawksbill shell per kilo from the major exporting countries. Where large quantities of tortoiseshell have a very low value, I assumed that they do include shell from freshwater species and made allowances for this.

TRADE IN TORTOISESHELL

Since the mid-1970's, the major importers providing the stimulus behind the international trade in tortoiseshell have been Japan, Hong Kong, China, Singapore and Taiwan, and in Europe for a number of years only, the Federal Republic of Germany, Italy, France and the Netherlands. The most important country involved in this trade is Japan. The broad pattern of Japan's imports shows approximately half its shell coming from the Wider Caribbean, and the other half from Asia, Africa and the Pacific islands.

Since 1976, according to Customs figures, 49 countries have been involved in the export of tortoiseshell, 20 in the Wider Caribbean. Twenty-eight of these countries are Parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), all but seven trading at some time in contravention of CITES. The major exporters from Asia have been Indonesia, the Philippines, Thailand, and the Maldives; from Africa, Kenya and Tanzania; from the Pacific, the Solomon Islands and Fiji; from the Caribbean, Cuba, Haiti, the Cayman Islands, Panama, Honduras and Jamaica.

TRAFFIC (Japan) has estimated, based on dealers' data, that the average weight of shell from hawksbills in the Caribbean is 1.34 kg; 0.75 kg, and 0.88 kg from hawksbills in Asia and Oceania, respectively. Using an average of 1.06 kg of tortoiseshell per hawksbill, as derived from the dealers data, it is possible to estimate from Customs statistics that since 1976, tortoiseshell from approximately 736,000 adult hawksbills has entered international trade.

In the 1980's the pattern of trade began to change. The Appendix I listing of sea turtles under CITES (which prohibits trade) at last began to have some effect. When Japan signed the Convention in 1980, it adopted reservations on the Appendix I listing of the hawksbill, olive ridley and green sea turtle. The immediate effect was a reduction in the average annual imports of tortoiseshell from 40 tonnes to 30 tonnes, the latter representing 28,000 turtles. This was not based on any scientific assessment of the level of exploitation hawksbill populations could withstand, and remains an arbitrary limit. (In October 1987, Japan

dropped its reservation on the green sea turtle). Many other CITES Parties' illegal exports appear to have ceased.

However, it is clear that this change is, to some extent, merely cosmetic. Some countries, such as Panama, simply ceased reporting their exports of tortoiseshell in their Customs and CITES statistics, giving the appearance of compliance with the Convention. In this case it is known that exports continue with the aid of military personnel, making it difficult to stop. Indonesia began re-routing an increasing amount of its tortoiseshell trade with Japan through Singapore, though this diversion now appears to have ended.

Japan's response to mounting pressure to stop importing shell from CITES Parties (who were not signing the requisite export documents authorizing such trade) was more complex. Japanese Customs statistics for 1987 indicate a dramatic rise in the proportion of shell coming from non-CITES-Parties; in 1988, virtually no shell imported into Japan came from CITES members. Although their Customs data are generally believed to be accurate, it is clear that this absence of CITES Parties is unlikely to fully reflect the truth.

It is more probable that some shell is being laundered through non-parties to indicate compliance with CITES. The main exporters of tortoiseshell to Japan in 1988 were the Maldives, Jamaica, Cuba, Haiti, the Comoros Islands (off Moçambique), Fiji and the Solomons. It seems fairly likely that the shell from Fiji, the Solomons and the Maldives is genuinely from those waters. However, the level of exports from the Comoros Islands, Jamaica and Haiti has increased substantially since 1986, and it is very likely that this involves shell coming from elsewhere.

It seems too coincidental, for example, that in 1986 Honduran exports of tortoiseshell to Japan dropped from over 2 tonnes to zero, and those of Jamaica increased by a similar amount. In 1987, exports from Belize dropped a further 2 tonnes, and Jamaican exports increased by this amount yet again. Cruz, Espinal and Erazo (1987), in their presentation to WATS II [Western Atlantic Turtle Symposium II], estimated that 9,000-18,000 hawksbills were being killed annually by the Honduran lobster fishermen for the shell. As Japan has not recorded any imports of tortoiseshell from Honduras since 1985, this shell is likely to be transshipped through either Jamaica or Panama.

The value of shell from the Caribbean has been on average two to three times greater than from elsewhere. This reflects the greater thickness and hence higher value of shell from this region as compared to Asian tortoiseshell. The demand of the Japanese dealers for the thicker Caribbean shell ensures that it will be very difficult to alleviate the pressure on these depleted populations of hawksbills.

In a paper submitted in 1987 to WATS II, Dr. Anne Meylan stated that the most optimistic assessment of nesting female hawksbills in the Wider Caribbean (excluding Cuba) is 4,975. In 1988 alone, Japan imported tortoiseshell of almost 12,000 adult hawksbills from this region. Thus it is clear that the Caribbean populations cannot withstand this high level of exploitation for much longer.

WORKED TORTOISESHELL

Japanese import figures under the category of worked "bekko" relate only to stuffed hawksbills. While it is impossible to estimate how many sea turtles this trade represents on a global scale, TRAFFIC (Japan) estimates that Japan alone imported more than 577,000 stuffed hawksbills from 1970 to 1986.

GREEN TURTLE SHELL

There is very little raw green turtle shell traded internationally as the shell is very thin and does not have the physical properties of tortoiseshell, making it unsuitable for manufacturing purposes. However, the Japanese have been recording imports of worked green turtle shell. This trade has been documented as being composed of stuffed green turtles. TRAFFIC (Japan) estimates that for the years 1970 to 1986, 380,000 to 400,000 stuffed green sea turtles were imported into Japan.

SEA TURTLE SKIN AND LEATHER

The major importers of sea turtle skin since the early 1970's were Japan, Italy and France, until France and Italy dropped their reservations under CITES. Japan is probably still the largest user of turtle skin, and from 1976 to 1986 imported the skins of approximately 165,500 olive ridleys and 38,000 green turtles. Today the majority of skins come from Ecuador.

Japan also imports processed turtle skins, almost solely from Mexico. Between the years 1976 and 1986, Japan imported leather of 327,000 olive ridleys from that country.

TURTLE OIL

It is not known to what extent sea turtle oil is traded internationally. In 1984 and 1986, in contravention of CITES, Italy imported over 1 tonne of sea turtle oil from the Cayman Turtle Farm. It is likely that the Farm is the largest source of any oil entering international trade. Very little sea turtle meat enters international trade today.

CONCLUSION

To conclude, sea turtles, as we all know, face many threats. A few can be softened by our actions (e.g., by promoting the use of Turtle Excluder Devices in shrimp trawls). However the drain on sea turtle populations all over the world from direct exploitation is far more difficult to resolve. In many instances it necessitates dramatic improvements in the socio-economic conditions of local peoples. Where we can make an impact is at the market end of the chain, principally in Japan. The drain on the world's hawksbills and olive ridleys perpetuated by Japan will be a major focus of our [Greenpeace] campaign in the coming years.

GROWTH AND REPRODUCTION IN THE BLANDING'S TURTLE: A LIFE HISTORY MODEL FOR SEA TURTLES

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Turtles have been identified as being the epitome of long-lived organisms and paragons of delayed sexual maturity and iteroparity. A central issue in the evolution of life histories in general can be derived from the following question paraphrased from George Williams's insights into the evolution of senescence: Why is it that after the seemingly miraculous feat of morphogenesis, a complex metazoan is unable to perform the apparently much simpler task of merely maintaining that which is already formed? The range of longevities observed among organisms bears out the conclusion that turtles as a group are doing a much better job of maintaining their soma through time than are many other organisms. Both short- and long-lived organisms live in a variety of abiotic and biotic environments in which events important to their success vary in stability and predictability. Within these environments all organisms attempt to solve the same general problems of obtaining resources and avoiding death. Within this framework, it does not seem reasonable to expect life history theories that attempt to use single environmental factors to predict suites of life history traits will be successful. Instead, two lines of approach seem to offer promise in increasing our understanding of life history evolution: 1) development of theories that attempt to predict the direction of change in a single life history trait, rather than a whole suite of life history traits, in response to environmental change, and 2) exploration of the issues of extrinsic and intrinsic causes of death for clues to the possible origins of the evolution of longevity.

Age and body size are implicated as an important variables in life history theories, and many age effects are assumed to be mediated directly through increases in either survival or reproductive output associated with increased body size. For example, models relating body size and age at first reproduction are based on the assumption that females maintain growth rates characteristic of juveniles during the period that they postpone sexual maturity, and as a result become larger and produce either more or higher quality offspring. Whereas intuitive assumptions about the relationships of body size and age may be correct in many cases, accumulating data indicate that frequent exceptions may occur among the amphibians and reptiles.

Among vertebrate ectotherms increased reproductive output is generally found to be associated with increased body size. For example, almost all variation in total clutch mass found among some species of turtles can be accounted for by a linear model of the relationship between total clutch mass and body size of females. The most general pattern is that the increase in clutch mass associated with body size results from an increase in egg number; however, in some species both clutch size and egg size have been shown to vary as a function of the body size of females. Therefore, the amount of variation in body size among adult females within a population of turtles may be an important determinant of variation in the number, size and possibly the quality of offspring produced. In order to place the association of body size with variation in reproductive characteristics in the context of life history evolution, it is necessary to understand not only the extent that body size effects reproductive output within and among individuals, but also how body size variation arises within a population. Changes in body size within an individual are primarily the result of three factors: 1) size at birth, 2) age, and 3) growth rate. In contrast, variation in body size among adult females can result from differences in: 1) size at birth, 2) growth rates as juveniles, 3) age at sexual maturity, 4) growth rates as adults, and 5) age. Turtles in general delay sexual maturity for an extended period compared to many other reptiles. Therefore, cumulative effects of differences in growth rates of turtles, over an extended juvenile period when growth rates are highest, can potentially cause a substantial portion variation in size among adults

Growth and reproduction in the Blanding's turtle (Emydoidea blandingi) were studied in southeastern Michigan from 1975 through 1988. Sex ratio of adults in the population was 1 male:3.8 females. Mean body sizes of adult males and females were not significantly different; however, the largest individuals in the

population were females. The average size of a group of females with mean minimum ages of 47 years was not significantly different from a younger group with a mean age 21 years. Body size of adults reached a plateau at approximately 200 mm carapace length and 1,200 g in body mass. Not all adults in the population grew after reaching sexual maturity. Observations of nesting, palpation and X-radiographs of females indicated that the youngest female matured an age of 14 years. Approximately 59% of the reproductive females in the population were smaller than the second youngest reproductive female that was 15 years old. The smallest reproductive female in the population (157 mm and 163 mm plastron and carapace length, respectively) was 20 years of age and was smaller than the mature 14 year old. Over 11 years clutch size ranged from 3-19 (mean=10.2) eggs. Clutch wet mass ranged from 60.4-183.4 g (mean=111.7, n=17) and relative clutch mass of nine females averaged 0.12. Clutch size, and to a lesser degree egg size, showed a significant positive relationship with body size, but not with age of females. Reproductive frequency was significantly associated with age but not with body size of adult females. Hatchlings averaged 31.0 mm plastron length, 35.3 mm carapace length, and 9.2 g in body wet mass.

The data on Blanding's turtles indicate that body size is an important determinant of many life history traits. A large portion of the body size variation among adults was apparently due to variation in both growth rates of juveniles and age at sexual maturity. A similar situation has been demonstrated for other freshwater and marine turtles. Of the reproductive traits examined, only reproductive frequency was shown to be independent of body size but influenced by age. The demographic data available to date on Blandings' turtles and on most marine turtles indicate that the traits of high juvenile mortality, delayed sexual maturity, iteroparity, and extended longevity combine to make population stability in the face of sustained increased mortality through harvesting of adults extremely unlikely.

THE HAWKSBILLS OF JUMBY BAY, ANTIGUA, WEST INDIES

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The hawksbill (Eretmochelys imbricata) is not generally a colonial nesting animal. It tends to nest singly or in low numbers on small, remote beaches with dense shrubbery and little open sand. Given the substantial dollar value of hawksbill shell on the international market, the continuing presence of this endangered species in Caribbean waters may be the serendipitous result of its reclusive reproductive behavior. Consequently, demographic studies of the hawksbill are rare to nonexistent. However, an exception to the general rule concerning hawksbill nesting behavior has been found off the north coast of Antigua in the West Indies. A remote yet accessible gathering of hawksbills nests each year along Pasture Bay beach (500 m) on Long Island, a small resort island (300 acres) known by its commercial name - Jumby Bay. The beach and nearshore waters are protected from tortoiseshell hunters and turtle egg gatherers, and there are no natural nest predators on the island. This report summarizes the first three years of an intensive investigation of the Jumby Bay hawksbills.

HISTORY AND PHILOSOPHY OF THE PROJECT

The presence of hawksbill nesting at Pasture Bay has been known locally for many years. In 1984 John Fuller identified the location to James Richardson with the hope that a study of the Jumby Bay hawksbills might be initiated. Richardson, Corliss, and Bell began a preliminary survey in 1986, using that season to test the effectiveness of an intensive research design that would not cause undue disturbance to the nesting females. Tagging was begun in 1987 and continued in 1988. In addition, environmental education and resource management have been important elements of the program.

METHODS

Saturation tagging means that no nesting event is allowed to occur within the study area without the adult female being identified. Studies of this kind on leatherbacks and loggerheads have provided new understanding of nesting effort (fecundity) by individual turtles and new estimates of population numbers derived from crawl counts (see Tucker in these Proceedings). The Pasture Bay beach is patrolled nightly at hourly intervals from 2000-0500 hrs from middle June to late November. Nesting females are measured and marked redundantly in three different ways: monel flipper tags; a diagnostic pattern of drill holes in the trailing edge of the postcentral scutes; a photographic record of the barnacle pattern on the carapace. Nests are marked, and the contents are examined for hatching success after natural emergence has occurred.

RESULTS

Two seasons (1987 and 1988) of tagging data are presented in Table 1. Although scattered nesting occurs in every month of the year, the major nesting season runs from mid-June until mid-November. Since five is the modal number of nests per turtle, a nesting season for an average female hawksbill would be 56 days. The extended ($\pm$150 day) nesting season for the Jumby Bay population indicates that the initial arrival of hawksbills at the Pasture Bay nesting beach is distributed widely (mid-June to late September), similar to the asynchronous arrival of leatherbacks at St. Croix, U.S. Virgin Islands (Eckert, personal communication), but quite different from the synchronous arrival of loggerheads (late May to mid-June) at Little Cumberland Island on the temperate Georgia coast. It may be assumed that the remigration interval for Jumby Bay hawksbills is two or more years, because no turtle present in 1987 was seen in 1988.

DISCUSSION

Jumby Bay hawksbills exhibit higher seasonal fecundity than previously recorded. If we estimate that an average individual female will lay ±700 eggs/season and produce ±560 hatchlings/season (80% hatch rate), then we can predict that 61 females collectively produced roughly 34,000 hatchlings during the last two nesting seasons. Thus, it can be seen that Pasture Bay beach is a major source of neonate hawksbills from the Leeward Islands of the West Indies.

It should also be noted how tenuous the continuing survival of the Jumby Bay turtles would be without proper protection. A single gatherer of tortoiseshell could have easily poached all 61 females in the last two seasons, if Pasture Bay beach had not been protected. More than half of these animals were on the beach after 30 September, the opening day for the legal take of nesting females under Antigua's Turtle Ordinance of 1927. Evidently, the offshore location of Pasture Bay beach was an important factor in protecting the nesting females before Long Island was designated as a private nesting sanctuary.

The Jumby Bay hawksbills exhibit extreme site fidelity to Pasture Bay beach, perhaps to a greater extent than has been documented for any other species of sea turtle. The majority of females are seen nesting on five occasions during the season. Only rarely does a female not show up for an expected nesting visit. Pasture Bay beach is a natural beach with an east-northeasterly exposure. An adjacent, artificial beach (Jumby beach) with a northerly exposure seemingly provides adequate nesting habitat but has no crawl activity. Additional natural beaches on the adjacent mainland are less than a mile away with hawksbill nesting activity, yet the Jumby Bay hawksbills appear not to use these beaches, either.

The future of the Jumby Bay nesting colony appears guarded but good. The resort is excited about the nesting turtles and supportive of a research/management/education program. They realize that nesting hawksbills are good for business. Resort guests find pleasure in observing the nesting turtles, and the turtles appear not to be affected by the presence of the guests under controlled conditions. Interpreting the nesting turtles to inquisitive guests is a high priority of the program. Construction along Pasture Bay beach is being modified to protect the turtles and their nesting habitat. Houses are set back behind critical nesting habitat, and house lights are screened to prevent disorientation of hatchlings on the beach.

Environmental education is another part of our program that is growing in importance. In order to encourage more local involvement, we intend to invite a local Antiguan teacher to participate as a research intern during the 1989 season. Furthermore, Corliss has introduced sea turtle education programs into a number of the local schools with great success. It is hoped that our achievements at Jumby Bay will spread to other beaches of Antigua and Barbuda, and the sea turtle conservation efforts of this important West Indian nation will grow.

Table 1: Results of a two year hawksbill study at Jumbi Bay, Antigua, West Indies.

Season value	1988	1987
1. Number of females	39	22
2. Patrol season	2 July- 29 Nov.	20 June- 20 Nov.
3. Patrol length (days)	151	154
4. Internesting interval (days)	14.8	14.1
5. Total nests	156	99
6. Total crawls	227	164
7. Mean nests/night	1.03	.64
8. Mean crawls/night	1.50	1.06
9. Max. nests/night	5	5
10. Observed mean nests/turtle	3.9	4.2
11. Calculated nests/turtle	4.4	4.8
12. Max. observed nests/turtle	6	6
13. Mean seasonal crawls/turtle	5.8	7.5
14. Mean crawls/nest	1.46	1.66
15. Mean nests/crawl	.68	.60
16. Mean hatching success	85%	79%
17. Incubation to emergence (days)	68	61
18. Mean clutch size	147	157
19. Range of clutch sizes	70-203	65-215

SEXING THE SEA TURTLE

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A number of methods have been tried in attempts to develop systems to ascertain gender in sea turtles. These include endocrinologic and cytotoxicity assays, tests for sex-specific cell-surface antigens, and tests for sex-specific DNA. Sex chromosomes have not been identified in sea turtles, but some success has been reported in hormone assays and in tests for H-Y ("male") antigen, and we have now obtained evidence of sex-specific DNA in the green sea turtle (Chelonia mydas) and in Kemp's ridley sea turtle (Lepidochelys kempi).

SEX-SPECIFIC ANTIGENS

H-Y is a male-specific cell-surface molecule defined by antibody from male-sensitized female mice. The molecule is phylogenetically conservative and has been found in every vertebrate species so far studied, generally in association with the heterogametic (XY) sex. In mammals, for example, H-Y is found in males, and in birds, it is found in females.

Recently, Wellins (1987) used monoclonal H-Y antibody with cells from males and females of the green sea turtle and the loggerhead sea turtle (Caretta caretta). In both species, higher levels of H-Y antigen were observed in male cells, but the method was found to be labor-intensive and it was noted that the range of values for male and female could overlap.

SEX-SPECIFIC DNA

By digesting flow-sorted Y-chromosomes of the human, Page et al. (1987) obtained a series of Y-chromosome-specific DNA sequences that could be used as probes for corresponding sequences in DNA from males but not females. One of the sequences was present in the Y-chromosome of all eutherian mammals tested. When that DNA was hybridized to DNA from reptiles, including species with temperature sex determination (TSD) and those with genotypic sex determination (GSD), a corresponding segment was identified in male and female; no sex-specific hybridization was observed (Bull et al. 1988).

CONSERVATIVE REPETITIVE DNA

Satellite DNA originating in the W-chromosome of the banded krait (Bungarus fasciatus) is found in quantitative excess in females of most ophidian species. The satellite DNA, called 'Bkm' (for 'banded krait minor'), consists of highly-repetitive GATA sequences found throughout the genome in diverse taxa including reptiles, birds and mammals. Although Bkm may not be involved directly in sex determination, Bkm sequences are concentrated in the male-determining region of the mouse Y-chromosome, in association with the testis determining genes.

We used the Bkm2(8) probe to screen DNA from the sea turtles, C. mydas and L. kempi, both of which are TSD species. DNA from 5 male and 5 female C. mydas, and 15 male and 15 female L. kempi, was extracted with phenol and chloroform and digested with restriction enzymes. Electrophoresis was carried out in agarose gels and the resulting DNA fragments were transferred to nitrocellulose and hybridized with a biotin-labelled Bkm probe. Positive hybridization, indicating presence of Bkm-like sequences in the DNA being tested, is manifested in this system as a visible band.

Under those conditions the Bkm probe revealed a "fingerprint" pattern consisting of about 20-25 fragments in each digest. Seven of the enzymes generated male-specific fragments (Figure 1). Two of the enzymes generated male and female fragments.

Appearance of sex-specific Bkm-related fragments in TSD species such as the green turtle and Kemp's ridley was unexpected, but could be explained if there were an underlying genetic mode of sex determination in these animals, or if TSD involves structural modifications in DNA adjacent to, or directly involved with, the sex determining genes (Singh et al. 1981). The question of structural modification could be tested in embryos prior to the critical sex-determining period; the sex-specific bands should appear in all embryos or, alternatively, in none. Presence of the bands in some embryos would argue for GSD.

As for the question whether Bkm could be used to distinguish between male and female in the young of these species, the techniques are straight-forward and readily accomplished by trained personnel. But the complex banding patterns generated by the Bkm probe are difficult to interpret, and it remains to be ascertained, by use of a broader sample of animals, that the method is routinely accurate. One way to increase the efficiency of the method would be to clone one of the fragments and use that as a probe, under conditions that would preclude generation of multiple bands. If this were done, and if sex-specific fragments occur uniformly among the sea turtles, gender could be identified routinely, given the proper facility and a few drops of blood.

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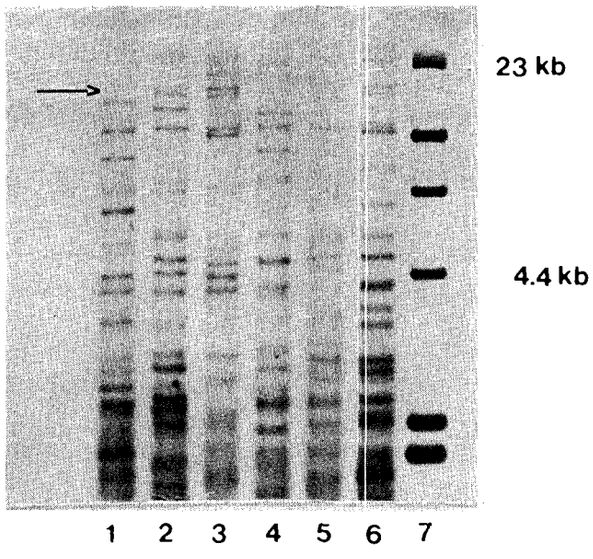
FIGURE 1



***Male-specific bands in BstNI digest of DNA from* L. kempi**

DNA from females was placed in lanes 1, 4, 5 ; DNA from males was placed in lanes 2, 3, 6 ; molecular weight markers were placed in lane 7. Arrow marks 16.6 kilobase male-specific fragment. This pattern was observed in 15 males and 15 females. A similar pattern was identified in C. mydas.

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RECENT RESULTS ON HATCHLING ORIENTATION RESPONSES TO LIGHT WAVELENGTHS AND INTENSITIES

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This three-year study investigated the effects of wavelength, light intensity, and selected lights on the sea-finding orientation and disorientation behavior of hatchling sea turtles. A total of 9,075 loggerhead hatchlings (Caretta caretta), 325 green turtle hatchlings (Chelonia mydas), 40 leatherback hatchlings (Dermochelys coriacea), and four pen-reared loggerhead yearlings were used in tests during the 1986-1988 nesting seasons. Hatchlings were taken from both hatchery and in situ nests in Florida located at Delray Beach and Boca Raton, Palm Beach County, and City of Jupiter Island, Martin County. Each test was conducted by releasing 15 hatchlings 10 feet in front of an experimental light source, shown either from the dune, water, northward, or southward direction on the beach. A series of longpass filters, which have low transmission of light in the shorter wavelengths and high transmission in the long wavelength end of the spectrum, were used to determine hatchling responses to light wavelengths. A low pressure sodium (55 watt) light, which is a commercially available monochromatic long wavelength light source, was also used to test hatchling responses.

For this study, those hatchlings orienting directly toward the light source as well as sideways (perpendicular to the light) were considered to be disoriented. Hatchling loggerheads were positively phototaxic/disoriented with lights containing the shorter (blue) wavelengths and negatively phototaxic with long (yellow, red) wavelength lights which exclude wavelengths shorter than 530 nm (Figure 1a). Hatchlings also oriented away from the light when a long wavelength light source was shown from any direction other than the dune (Table 1). Loggerhead hatchlings were attracted to lights containing 375 nm wavelengths at intensities as low as 0.12×10^{14} quanta/sec/cm^2. The mean number of hatchlings orienting sideways dramatically increased in the 400-530 nm wavelength range (Figure 1b). Preliminary tests on hatchling leatherback and green turtles showed similar responses; however, tests with the yearlings showed mixed reactions in response to long wavelength light. If properly positioned, long wavelength lights, such as low pressure sodium vapor lights, might be used in beach areas without disorienting hatchlings. However, before widespread use of long wavelength lights occurs, additional research is needed on the effects on hatchling leatherback and green turtles and the adults of all species.

Table 1. Mean loggerhead hatchling responses to a long wavelength light source shown from directions other than from the dune. (Light source either a low pressure sodium (55 watt) or a longpass filtered 610 nm light).

(LONGPASS 610 - 4.4 x 10^{14} quanta/sec/cm^2)

LIGHT SOURCE DIRECTION (N = 5 EACH DIRECTION)	ORIENTATION DIRECTION			
	AWAY FROM LIGHT	TOWARD LIGHT	LEFT* OF LIGHT	RIGHT* OF LIGHT
NORTH	11.6	0.4	0.0	3.0 (W)
SOUTH	12.2	0.8	2.0 (W)	0.0
WATER	9.6	1.4 (W)	2.0	2.0
DARK (LIGHT IN WATER)	0.0	15.0 (W)	0.0	0.0

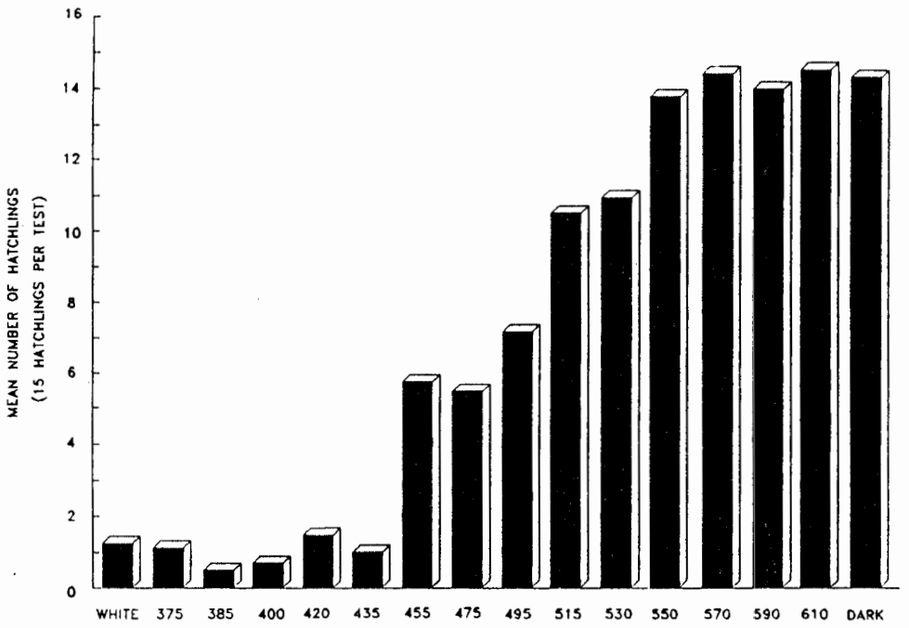
(LOW PRESSURE SODIUM - 7.2 x 10^{14} quanta/sec/cm1^2)

LIGHT SOURCE DIRECTION (N = 5 EACH DIRECTION)	ORIENTATION DIRECTION 1			
	AWAY FROM LIGHT	TOWARD LIGHT	LEFT* OF LIGHT	RIGHT* OF LIGHT
NORTH	9.6	0.4	0.0	3.0 (W)
SOUTH	9.0	0.8	1.5 (W)	3.7
WATER	8.8	0.7	2.5	3.0
DARK (LIGHT IN WATER)	0.0	14.7 (W)	0.0	

(W) = WATER

* ALL HATCHLINGS INITIALLY WENT AWAY FROM THE LIGHT BEFORE ARCHING SIDEWAYS

(a)



(b)

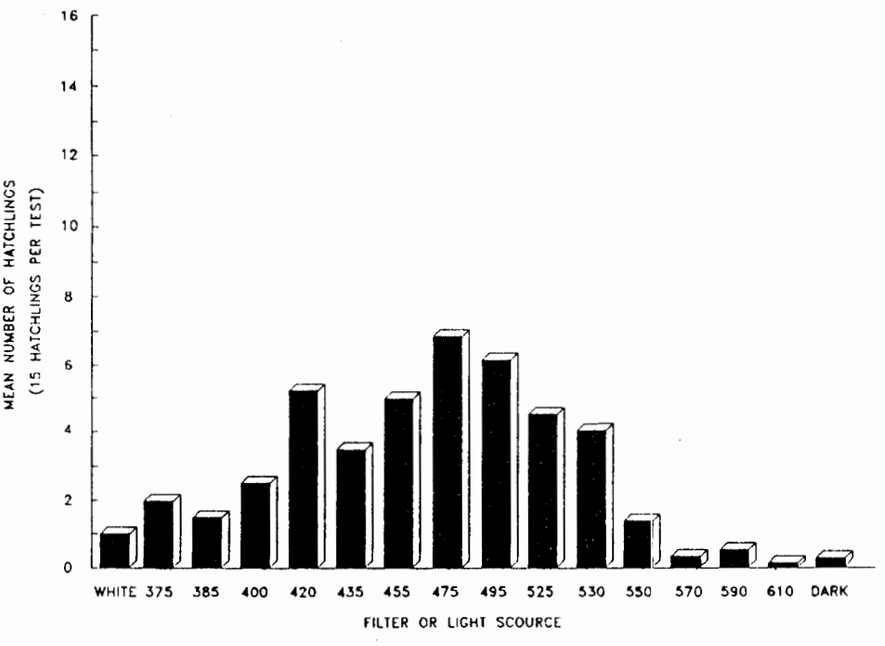


Figure 1. Hatchling responses to each longpass filtered light source, white light, and no light. Light source shining from the dune direction. (a) Mean number of hatchlings going to the water for each light source. (b) Mean number of hatchlings orienting sideways for each light source.

INTERNATIONAL TRADE IN HAWKSBILL SEA TURTLE SHELL IN THE WIDER CARIBBEAN

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Historically, sea turtles have been an important resource for Caribbean people, and they have been heavily exploited for local consumption (Bacon et al. 1983) and international trade (Mack et al. 1981, Carr et al. 1982, Roet 1983, Meylan 1984, Canin and Luxmoore 1985, Milliken and Tokunaga 1987). Populations of all species are declining in the region (Bacon et al. 1983). Because sea turtles are migratory and the waters of many nations are easily accessible to their neighbors, solutions to exploitation must be devised and agreed upon regionally.

Japan is the world's largest trader in sea turtle products and has contributed significantly to the depletion of the hawksbill in the Wider Caribbean and around the world. While in the past other nations such as the Netherlands and France have been major markets for Caribbean shell and French trade continues to deplete hawksbills in the Lesser Antilles, Japan's toll on the hawksbills of the Wider Caribbean is unequalled by any other nation.

My primary source of information is a report entitled Japanese Sea Turtle Trade 1970-1986 by Tom Milliken and Hideomi Tokunaga of TRAFFIC (JAPAN), the wildlife trade monitoring arm of the World Wildlife Fund. The report was commissioned and published by the Center for Marine Conservation in 1987 to determine how many turtles were utilized and where exploitation was occurring. Data were obtained from Japanese Customs Statistics and from interviews with Japanese dealers of hawksbill shell.

Each year Japan imports approximately 30,000 kg of raw hawksbill shell or bekko from around the world for its shell industry. Japanese artisans produce the world's finest quality shell through a laborious process of heat, pressure, carving and polishing. Beautiful and ornate combs, hair ornaments, jewelry, and eyeglass frames are expensive and highly prized items. Today Japan's trade in sea turtle shell is fashionable and highly lucrative.

In many areas of the world international trade in sea turtle products has been restricted by CITES [Convention on Trade in Endangered Species of Wild Fauna and Flora], the major international wildlife treaty regulating the trade in endangered species of animals and plants and their products. Under CITES all species of sea turtles are listed on Appendix I which means that trade is prohibited. CITES allows for reservations or exceptions to Appendix I listings, however. When Japan acceded to CITES in 1980, it took reservations on olive ridley, green, and hawksbill sea turtles (the reservation on green turtles was dropped in late 1987). At that time the Japanese government set a maximum import quota of 30,000 kg of raw hawksbill shell.

Japan is therefore allowed to continue to trade sea turtle products but only under certain conditions. It cannot trade with 1) other CITES countries without a legal export document (which in most cases should not be given) or 2) with a non-CITES country that prohibits trade in that endangered species. Since acceding to CITES, Japan has frequently violated these restrictions.

The results of the Japanese sea turtle trade survey are staggering. Between 1970-1986 Japan imported the equivalent of 251,660 Caribbean hawksbills. These imports represent 51.1% of Japan's worldwide hawksbill shell imports. During this 16 year period, trade from the region was widely distributed, with 26 countries providing shell. Over time trading patterns appear to have changed, in large part as a result of CITES restrictions. In some areas there has been an increase in trade, in others a decrease.

Four major exporters, Panama, Cuba, the Cayman Islands and Haiti, have provided 3/4 of Japan's imports from the region. The majority of the region's hawksbills are found in the western Caribbean, and patterns of trade from these four exporters are very interesting. Panama supplied 15% of Japan's total imports for the 16 year period, the equivalent of 75,906 hawksbill turtles. While many of these turtles were of Panamanian origin, Panama also served as a collecting point for shell harvested in the region. Panama acceded to CITES in November 1978, but shell imports into Japan continued until 1986. Today there are numerous reports of lucrative sea turtle shell smuggling by the Panamanian military.

The Cayman Islands, a dependent territory of the United Kingdom, was also a regional collecting point. With few resident hawksbills, the territory is ranked as a major supplier of shell to Japan, providing the equivalent of 27,590 hawksbills from 1970-1986. CITES came into force in May 1979, but it was not until 1984 that all trade to Japan ceased.

From 1970-1986 Cuba supplied 15% of Japan's total shell imports, and today Cuba is the world's major exporter of shell to Japan. Cuba is not a member of CITES, but until recently its exports have not increased as CITES restrictions have curtailed exports from other nations in the region. Sea turtles are legally captured only by state controlled fishery cooperatives (Groombridge and Luxmoore, 1987). Cuban biologists admit, however, that populations are in decline (Weber, pers. comm.). The quality of shell from Cuba is among the worlds best; the light color makes it particularly popular for the manufacture of eyeglasses. Annual exports to Japan through 1987 represented about 3500 turtles per year. In 1988 exports represented a harvest of 5200 animals.

Haiti is a non-CITES country which has steadily increased its exports to Japan since 1981. As hawksbills are no longer abundant in Haitian waters, it is feared that Haiti is serving as an entrepot for shell coming from other areas. In 1988 Haiti exported the equivalent of 3000 hawksbills, nearly doubling its exports of recent years.

International restrictions on sea turtle trade have affected Japan's importing patterns in recent years because Japan has agreed to reduce or eliminate its trade with CITES nations. Whether this is a genuine effort or a documentary ruse is subject to debate. It is suspected that shipments of hawksbill shell obtained elsewhere are simply being rerouted on paper or in actuality through non-CITES countries. There are numerous reports of Japanese dealers illegally buying shell in CITES countries in the Wider Caribbean, including Panama, Honduras and Colombia. As few Caribbean island nations are members of CITES, they are showing up on Japanese import documents as sources of shell.

The weight and quality of Caribbean hawksbill shell make it particularly valuable to Japanese buyers. Today, Japan continues to trade in large volumes of hawksbill shell from the Caribbean. In 1986 and 1987 about 14,500 kg of bekko, the equivalent of more than 10,000 hawksbills, were imported into Japan from the region. Alarmingly, imports jumped to 15,922 kg, the equivalent of 11,000 turtles, in 1988. How the species can sustain this heavy level of exploitation when fewer than 5000 hawksbills nest in the region each year (Meylan, 1987) is questionable.

In addition, the effect of French trade in the Caribbean should not be underestimated. For years French fishermen and buyers have heavily exploited sea turtles in Martinique, Guadeloupe, and the Lesser Antilles (Carr et al. 1982, Meylan 1983, 1984, Pritchard 1984). There is a critical need for conservation in the French Antilles as a result of local consumption and the tourist trade in jewelry, shell and other souvenirs (Carr et al. 1982). Because the extensive reefs of Guadeloupe and Martinique provide excellent developmental and foraging habitat (Carr et al. 1982), this exploitation has also resulted in the depletion of regional populations. Furthermore, French fisherman and buyers have not limited their activities to the waters of the French Antilles. The French islands have been most intensely exploited, but no island in the Lesser Antilles has escaped their attention (Meylan, 1984). France maintains that exports from the French Antilles to metropolitan France are permitted as domestic shipments and are not prohibited by its compliance with CITES regulations. No attempts are made, however, to prevent the sale of sea turtle products to tourists from other nations. France and its overseas departments further violate CITES

restrictions by reexporting sea turtle products from Taiwan and the Philippines to meet the demands of the tourist trade (Pritchard 1984).

International trade in hawksbill shell from the Caribbean is a problem of very substantial proportions, and nations in the Wider Caribbean are going to have to act aggressively to protect their turtles. The solutions include adoption and strict enforcement of regional fisheries legislation and accession to CITES by all Wider Caribbean nations. A moratorium on the taking of hawksbills should also be considered.

There is no doubt that international trade is draining the region of a valuable resource. It is also jeopardizing the continued existence of one of the region's special species. This trade must be curtail, and it must be curtailed now.

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SEA TURTLES AND THE KIWAI, PAPUA NEW GUINEA

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Cultural and economic systems establish geographic patterns of resource use. Changes in these systems create changes in the exploitation of resources. The Kiwai are marine hunters, fisherfolk and foragers of the Papua New Guinea portion of the Torres Straits. Dugong (Dugong dugon) and green turtle (Chelonia mydas) have been hunted on a selective yet sustainable basis for food, ceremonial occasions, and trade. These animals have been harpooned from a variety of indigenous canoes and were shared among all the residents of the Kiwai villages.

As a result of missionaries, colonialism, and independence, the reciprocal economy of the Kiwai has been gradually replaced by a monetary economy. A great demand for money has been imposed upon the Kiwai for medical care, purchasing outboard motors and petrol (gasoline), paying for school fees and taxes, and particularly for supporting church activities. Few opportunities exist for employment along the Kiwai Coast and the main source of money has been the sale of culturally and nutritionally important marine resources, particularly green turtle and dugong. Increased monetary demands and recent legislation in Papua New Guinea prohibiting the sale of dugong meat due to the dugong's endangered status have resulted in an increased harvest of endangered green turtles.

Customarily, sea turtles were viewed as a resource for all and the sharing of turtle meat established reciprocal obligations. With the monetization of the Kiwai economy, turtles began to be viewed as individual property that can be disposed of without consideration of cultural obligations. Today, most of the green turtles caught by the Kiwai are sold in Daru, the Provincial capital (Table 1) with the money being used to pay group and individual expenses (Table 2). Turtle hunting has evolved into a joint effort to obtain money but this money does not enter the customary reciprocal obligation system. The sharing of turtle meat within the village, other than for feasts, is considered a special event. Most turtles harvested for feasts are sold (Table 3).

Turtles are usually brought into Daru alive, butchered, and the meat sold for about $US 0.50 to $US 1.50 per kilogram. Some turtles are sold alive, yielding about $US 45.00. Prices vary inversely to the number of turtles in the market at one time. The turtle hunters prefer female turtles because of their perceived better taste and higher fat content, and female turtles may yield 'iopu' (unshelled eggs) which are favored for their taste and medicinal value. The annual green turtle harvest by the Kiwai ranges from 3,000 to 5,000 animals.

Green turtles provide the only easy source of money for men who are too old or unable to dive for crayfish (reef lobster), who cannot afford barramundi or prawn nets, or who cannot find other employment. A Kiwai turtler can easily exceed the biweekly wages of private and public employees and still work less hours. Conservation strategies for green turtles along the Kiwai Coast must include consideration of alternative opportunities for money for the Kiwai.

Table 1. The disposition of 226 green turtles caught by Tureture village hunters, February-December, 1986.

Use	Number	Percent
Sold in Daru	129	57
Sold in village	19	8
Sold to other villages	11	5
Traded to other villages	7	3
Gifts to other villages	2	1
Distributed according to custom within Tureture	6	3
Eaten at feasts	52	23
TOTAL	226	100

Table 2. Purposes of turtle hunting trips by Kiwai men from Tureture village, Western Province, Papua New Guinea, February-December, 1986.

Purpose of Trips	Number of Trips	Percent
Church monies, including Christmas feast	26	59
Bail and fines	5	11
Repair of outboard engines	3	7
Bride price	4	9
School fees	2	5
Independence Day feast	2	5
Meat for sharing within village	1	2
Beer	1	2
TOTAL	44	100

Table 3. Animals collected for the Tureture Church Anniversary, May 24, 1986.

Species	Amount	Disposition
Green Turtle	36	Sold in Daru
Green Turtle	2	Traded for vegetables & fruits
Green Turtle	1	Sold to Kunini School
Green Turtle	16	Eaten for feast
Dugong	2	Eaten for feast
Deer	1	Eaten for feast
Reef Fish	388 kg[1]	Sold in Daru
Reef Fish	42 kg[1]	Eaten for feast
Crayfish	263 kg[2]	Sold in Daru

[1] Weight of uncleaned fish
[2] Weight of tails only

DESCRIPTION OF SEA TURTLES DISTRIBUTION RESEARCH IN NORTH CAROLINA

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We began an evaluation of methodologies to determine the distribution and species composition of the sea turtle fauna and the importance of the extensive estuarine waters of North Carolina to the turtles. The Pamlico-Albemarle Estuarine Complex of North Carolina (6,630 km^2) is the second largest estuarine system in the United States and the largest estuarine system in the southeast. Until stocks became depleted around the turn of the century (Pope 1939), the loggerhead, green and Kemp's ridley sea turtles supported a fishery which was primarily prosecuted in Pamlico, Core and Bogue Sounds and the Newport River (Figure 1) (True 1887, Coker 1906, 1951). Little else is known about sea turtles in the inshore waters of North Carolina. The field study period was from July through December, 1988 and was supported by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, Office of Protected Resources.

The first method evaluated voluntary public involvement. Using a poster, we asked the public to report any sightings of sea turtles. Attached to the poster was a gummed pad of prepaid, addressed postcards that asked for the date, location, and species sighted and whether the turtle was dead or alive. About 450 posters have been placed along the coast at a variety of locations including marinas, piers, bait and tackle shops, commercial fish houses, dive shops, public aquaria, airports, etc. Private ferries, tour boats, and research vessels carried sighting logs and also contributed sighting locations. Overall, this program reported 211 turtles of which 32% were dead. Most returns were from the ocean side of the barrier islands, particularly in the Cape Lookout area. We had coast-wide distribution of the posters by late fall and released an article to the newspapers promoting public participation. We hope to reap the benefits of these efforts in 1989.

The second method evaluated the use of public ferry boats as survey platforms. We placed sighting logs on all of the North Carolina Department of Transportation ferries. The ferries cross the mouth of the Cape Fear River, Pamlico Sound, the lower Neuse and Pamlico Rivers, Hatteras Inlet and Currituck Sound. The ferry boat captains recorded the number of passages made daily and location of any turtle sighted, alive or dead. The number of live turtles sighted ($n=13$) was small (Table 1). Most live turtles were sighted at Hatteras Inlet during the warmer early fall months. None were seen in November and December, although other sources revealed turtles in the eastern portions of Pamlico and Core sounds during these months. Twelve turtles were reported dead and most reports were from the ferries crossing the inlets of Pamlico Sound in September and October.

The third method evaluated was aerial surveys over Pamlico and Core Sounds. We divided the Sounds into 3 areas: Core Sound (34°41' to 35° N), southern Pamlico Sound (35° to 35°20' N) and northern Pamlico Sound (35°20' to 35°48' N). Transects in Core Sound were spaced to survey 30% of the Sound; the design for southern and northern Pamlico Sounds was to survey approximately 8% of those areas. We were able to fly only the first two areas before the end of the year.

Core Sound, surveyed on November 1, yielded sightings of 14 turtles (Figure 2). All the turtles appeared to be small loggerheads, probably juveniles, except one which was small but did not appear to be a loggerhead. With the exception of two turtles seen together, turtles were solitary. Turtles were sighted either on the shoals of the eastern shore (where there are large meadows of seagrasses) or on the eastern edge of the channels. The survey of southern Pamlico Sound was conducted on November 15 and produced eight sea turtle sightings (Figure 3). Except for one turtle, all were seen in the eastern basin, particularly near Hatteras Inlet, or on Bluff Shoal which divides Pamlico Sound into east-west basins. Like Core Sound, much of the shoal area of Pamlico Sound behind the Outer Banks contains submerged vegetation.

To gather data on the species and size composition of the turtles in the inshore waters, we located fishermen who volunteered to tag and keep records of sea turtles incidentally captured in their nets (mainly pound nets). We obtained Endangered Species Permits for these fishermen, demonstrated tagging procedures and asked them to double-tag, measure, and photograph the turtles encountered in their fishing operations. Five cooperating fisherman tagged a total of 47 turtles (Table 2) and another 77 turtles were caught and released, including three Kemp's ridley turtles. Most tagged and released turtles were loggerheads (55-93 cm CCL), but green turtles (25-50 cm CCL) and Kemp's ridleys (23-43 cm CCL) were also tagged and released. During the 1988 study period 10 tagged turtles were recaptured. One was a 1986 headstarted turtle released near Naples, Florida; the others were recaptures of our own releases in 1988 which gave information about short-term movements.

All the green and Kemp's ridley sea turtles were captured and tagged in the fall; summer and early fall catches were exclusively loggerheads. The Pamlico and Core Sound fishermen related an annual pattern of multispecies catches early in the year (May and early June), loggerhead catches throughout the summer and early fall, and multispecies catches again in the fall with a high proportion of small turtles. This pattern may indicate immigration in the spring, sorting by habitat throughout the summer, and emigration in the fall.

In summary, we have demonstrated that immature green and Kemp's ridley sea turtles and loggerheads of all sizes utilize the inshore waters of Pamlico and Core Sounds, North Carolina. Continuation of the distribution work is needed to determine which areas of the Sounds are critical habitats. We shall continue to monitor the species and size composition with a long-term objective of estimating how many turtles utilize the Sounds.

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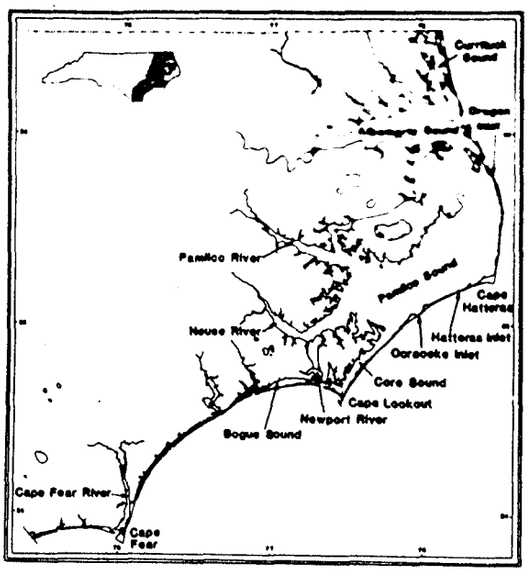


Figure 1 Coastal North Carolina

Table 1 Live turtles sighted on ferry passages made by the N.C. D.O.T.

	MONTH					
	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
Ft. Fisher – Southport	1	3	0	0	0	4
Cedar Is – Ocracoke	0	0	1	0	0	1
Swan Quarter – Ocracoke	0	0	0	0	0	0
Ocracoke – Hatteras	5	1	1	0	0	7
Cherry Branch – Minnesott	0	1	0	0	0	1
Aurora – Bayview	0	0	0	0	0	0
Currituck – Knots Is	0	0	0	0	0	0
Total	6	5	2	0	0	

Total Sightings = 13

Table 2 Sea turtle tagging summary 1988

	Species		
Month	*Caretta caretta*	*Chelonia mydas*	*Lepidochelys kempi*
June	5		
July	6		
August	7		
September	3		
October		6	2
November	9	7	2
December			1
Total	30	12	5

Figure 2 Aerial Survey of Core Sound, 1 November 1988

(Waters deeper than 6 ft. are shown stippled)

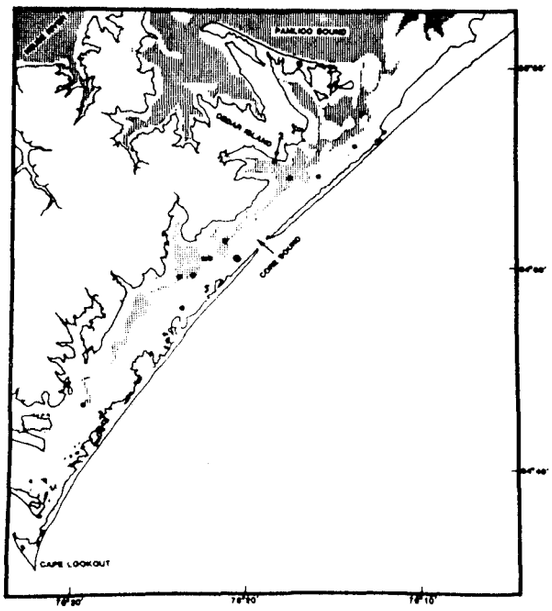
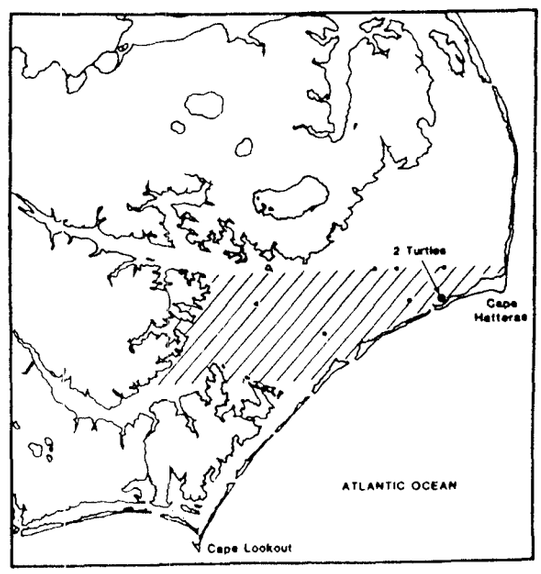


Figure 3 Aerial Survey of Southern Pamlico Sound, 15 Nov. 1988



POPULATION DYNAMICS OF SEA TURTLES UTILIZING SHALLOW COASTAL WATERS OFF HUTCHINSON ISLAND, FLORIDA

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Condenser cooling water for Florida Power and Light Company's St. Lucie Power Plant on Hutchinson Island in southeast Florida is drawn through three large diameter pipes located in the Atlantic Ocean 365 m from shore in about 7 m of water. The structures housing the pipes apparently attract sea turtles. Turtles entering the pipes are rapidly transported by currents into a 1,500 m-long intake canal where they are systematically captured, examined, tagged and returned to the ocean.

Between March 1976, when the first unit began operating, and November 1988, 1,918 sea turtle captures occurred at the plant. All five sea turtle species inhabiting continental waters of the United States were represented in the catches, with loggerheads accounting for 84.6% of all captures. Green turtles were also well represented (13.9%), while leatherbacks (n=8), hawksbills (n=6), and Kemp's ridleys (n=15) were only occasionally entrapped.

The size frequency distribution for loggerheads captured at the St. Lucie Plant (mean=65.8 cm minimum straight-line carapace length, MSCL, ±12.9 cm) is similar to that reported for other sample populations along the southeast coast of the United States (Figure 1); there were no individuals less than 40 cm in length, the sample population was predominated by juveniles (≤70.0 cm MSCL), there was a general paucity of large juveniles and sub-adults, and a secondary accumulation of adults gave the curve a weakly bimodal appearance. Green turtle captures were similarly predominated by juveniles (mean=35.6 cm MSCL ±14.2 cm), with over 80% of all captures involving individuals less than 40 cm in length. A comparison of size-class data from the St. Lucie Plant and the Mosquito Lagoon on the central east coast of Florida (Mendonça and Ehrhart 1982) suggests that nearshore coastal waters constitute an intermediate habitat for green turtles leaving the pelagic environment prior to entering their traditional feeding pastures in lagoons and estuaries.

Adult loggerheads (≥85.0 cm MSCL) captured at the St. Lucie Plant (n=187) were composed primarily of females (83%), with the majority of female captures occurring during the nesting season (May-September). Captures of adult males were low but relatively constant throughout the year. Juvenile loggerheads were captured most frequently in January and February and least often in November and December (Figure 2). Seasonal capture data supported by both tag returns and recaptures indicated that a portion of the juvenile loggerhead population moved into higher latitudes during the summer, while others remained in the study area all year long. Seasonal trends were quite pronounced for green turtles, with over 50% of all captures occurring in January and February. Winter may be the principal time for recruitment of pelagic-stage green turtles into coastal habitats. Alternatively, winter pulses may represent either southerly latitudinal migrations or increased local movements associated with declining water temperatures (Mendonça 1983).

Blood samples collected from 233 juvenile loggerheads between 1983 and 1986 and analyzed for serum testosterone indicated that females outnumbered males by a ratio of 2.4:1.0. This bias toward females, which is significantly different from a 1:1 ratio ($p \leq 0.05$), persisted throughout the year. Similar findings have been reported for other sample populations in the southeastern United States (Wibbels et al. 1987). Collectively, these findings provide compelling reason to reassess the explicit assumption of a 1:1 sex ratio in contemporary loggerhead population models.

Over the 13 year monitoring period reported here, captures of loggerheads exhibited no persistent long-term increase or decrease. Captures of green turtles were significantly greater ($p \leq 0.05$) during 1983-1988 than during the preceding six-year period. However, installation of the third and largest intake pipe during 1982-83 presently confounds interpretation of observed patterns. An accumulating database will hopefully permit a more accurate assessment of long-term trends. The St. Lucie Plant canal capture program may provide one of the best gauges available for monitoring population dynamics of loggerhead and green turtles in the southeastern United States.

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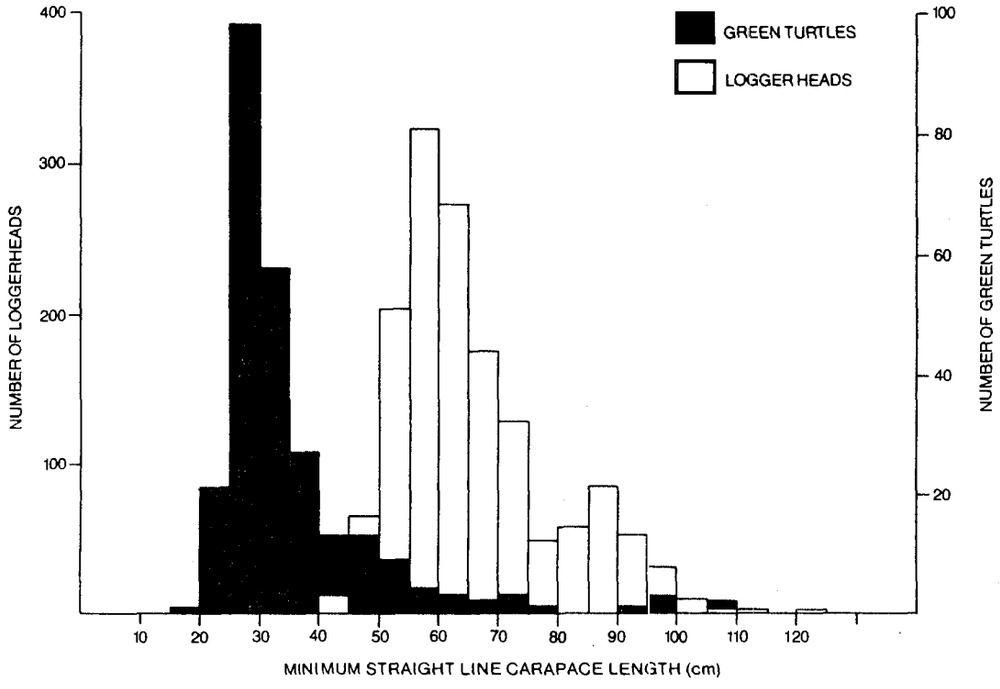

Figure 1. Size-class distribution of loggerhead (N=1,473) and green turtles (N=259) captured at St. Lucie Plant, March 1976 - November 1988.

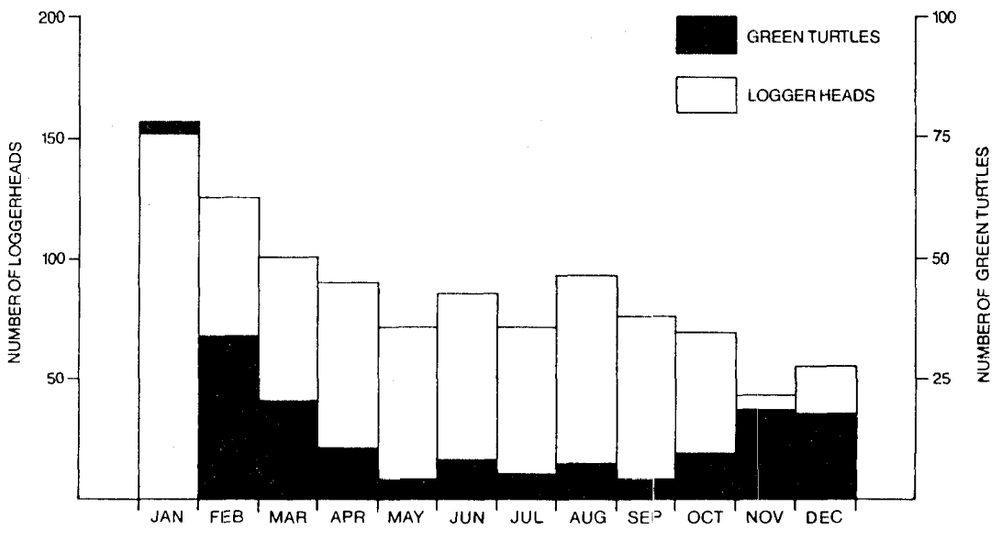

Figure 2. Number of juvenile (MSCL≤70.0cm) loggerhead (N=1,032) and green turtles (N=214) captured each month at St. Lucie Plant, 1977-1987.

NESTING CYCLES IN SEA TURTLES: TYPICAL, BUT NOT CYCLES

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My message is a simple one: I seek to convince you that the "nesting cycle", one of the most commonly recorded characteristics of sea turtle reproduction, is illusory and of little value as typically reported. Specifically, I hope to show that: a) non-annual reproduction is typical for many turtle species, not just for sea turtles; b) the phenomenon of "nesting cycles" in sea turtle populations is not an example of truly cyclic behavior, and; c) as usually reported, the characteristic "nesting cycle" of a particular sea turtle population is a meaningless descriptor. The first two points will be made quickly, after which I will concentrate the remainder of my time on demonstrating the third.

First, most of us are familiar with the idea that individual adult females of most sea turtle species rarely reproduce in consecutive years. A cursory glance at the freshwater and terrestrial turtle literature shows this is true for other turtle species (Table 1). Sea turtle biologists usually see only those females that are reproductively active in a given year. Thus, they become impressed by individual patterns as a turtle appears on the beach in some years, but not in others. By recording the numbers of years between visits, we are able to identify 2-yr, 3-yr, and even longer intervals for some individuals. For some beaches (or species) a 2-yr interval seems to predominate, while for other beaches (or species), a 3-yr interval seems more prevalent. Those who study freshwater turtles can capture adult females whether or not they are reproductively active. Thus, freshwater biologists may record non-annual reproductive behavior as the proportion of adult females that are reproductively active (Table 2). This is simply another way of recording the same phenomenon seen in sea turtles.

Secondly, we have known for some time that the "nesting cycle" of sea turtles is not an example of cyclic behavior. Carr and Carr (1970) referred to "irregular reproductive periodicity" in Chelonia, noting that individuals sometimes switched from 3-yr to 2-yr cycles and vice versa. Hughes (1974) and Richardson et al. (1978) noted that female Caretta also switched intervals. Unfortunately, most of us continue to refer to the intervals as "cycles".

Wood and Wood (1980) reported that adult female green turtles taken from wild stocks with predominantly 2-yr or 3-yr nesting intervals exhibited a predominance of 1-yr intervals when well fed in captivity at the Cayman Turtle Farm. Thus, reproductive intervals probably are determined, at least in part, by nutrient or energy acquisition (Wood and Wood 1980), just as has been suggested for freshwater species.

Finally, I maintain that observed reproductive intervals are of little utility in and of themselves. To demonstrate the point, let's imagine a population in which 5% of the adult females gain sufficient energy or nutrients to reproduce in 1 year, 15% require 2 years to do so, 30% require 3 years, and 50% require 4 years (Table 3: "Real Interval"). Note, however, that turtles are more likely to survive for 1 year than for 2, 3, or 4 years. Thus, the reproductive intervals of turtles observed on the beach will not be the same as the real, underlying intervals. We can illustrate the point by simulating beach observations for two theoretical populations that have the same underlying real return intervals, but different annual survival rates (Table 3).

Population A (Table 3) has an annual adult survival rate of 40%. Thus, although the 4-yr interval actually predominates in the population (i.e., 50% in the "Real Interval" column), we would observe a predominant 2-yr interval (32% in Population A) among turtles seen on the beach, because few would have survived to return after 3-yr or 4-yr absences (i.e., even though 30% and 50% of them, respectively, started out to do so, the observed rates are 25% and 17%, due to low annual survival).

Population B (Table 3) has an annual adult survival rate of 55%. Thus, although the 4-yr interval actually predominates in the population, we would observe a predominant 3-yr interval (30% in population B),

because few of the turtles would survive to return after 4-yr absences (i.e., even though 50% of them started out to do so, only 27% of those that show up on the beach have both survived and returned after 4-yr absences).

The reasons for these disparate results are quite simple. The observations we make on a nesting beach are only of the survivors, which are not a realistic representative sampling of the underlying proportions of females that require 1, 2, 3 or 4 years to amass sufficient nutrients or energy to reproduce. Those returning after 4 years have had to survive for 4 years, while those returning after only 1 year have had to survive only 1 year! Clearly, the chances of surviving 4 years are smaller than the chances of surviving 1 year, so 4-yr intervals will be under-represented in the sample observed on the beach. The lower the annual survival rate, the greater the degree of under-representation of 4-yr intervals (Table 3).

Let us take the example of a population with an annual adult survival rate of 40%. Let O_i be the proportion of turtles observed on a beach returning after an interval of i years (i=1,2,3, or 4). Let R_i be the actual percentages of turtles that can amass sufficient energy to return after i years, and use the figures for "Real Interval" in Table 3 for this purpose. Furthermore, let S_i be the chance of surviving for i years.

Now, if annual survival rates are 40%, then $S_1 = 0.40$. But the chances of surviving for 2 yrs is given by $S_2 = (0.40) \times (0.40) = 0.16$. Similarly, $S_3 = (0.40) \times (0.40) \times (0.40) = 0.064$. And by similar reasoning, $S_4 = (0.40) \times (0.40) \times (0.40) \times (0.40) = 0.00256$.

If all we see are the survivors, the percentage of observed 1, 2, 3, and 4-yr returns we observe on the beach is given by:

$$O_i = R_iS_i \div \sum_{i=1}^{4}[R_iS_i]$$

For example, for 4-yr returns, $O_4 = (R_4S_4) \div [R_1S_1+R_2S_2+R_3S_3+R_4S_4] = (0.50 \times 0.00256) \div [(0.05 \times 0.4)+(0.15 \times 0.16)+(0.30 \times 0.064)+(0.50 \times 0.00256)] = 0.17$ or 17%. But what is the significance of these patterns?

If we observe two sea turtle populations with observed return intervals shown for Population A and Population B (Table 3), how are we to interpret the data? It could be that the two populations differ in terms of their ability to gather nutrients or energy necessary to initiate reproduction. On the other hand, it might be that one population has farther to migrate than the other, and hence must spend more time (on average) amassing nutrients or energy. It could be, however, simply that annual survival rates differ in the two populations, perhaps due to natural mortality, or because one population is more heavily exploited than the other.

Of course, the factors mentioned above probably interact to determine the observed distribution of return intervals for each population. My point is this: In the absence of data on survival rates, we cannot use recorded data on return intervals to make meaningful comparisons between populations or species. As usually recorded, such data are not informative.

In closing, I reiterate that non-annual reproduction probably is the rule among turtle species and certainly is not in any way unique to sea turtles, that "nesting cycles" of sea turtles are almost certainly not examples of cyclic phenomena, and that data on return intervals should be interpreted with great caution. One further caveat must be made concerning the use of return intervals. If such data are used to adjust estimates survivorship or tag loss, care must be used lest we incorporate survivorship into our calculations twiceover. If we incorporate survivorship into an equation explicitly, we must be aware that using observed return intervals in the same equation will once again incorporate survivorship implicitly, because survivorship is an implicit part of our observed return intervals (see equation for O_i, above.)

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Table 1. Selected turtle species in which some adult females may not reproduce in a given year.

Pseudemys (=Trachemys) scripta	Cagle 1944
Trachemys scripta	Frazer et al. 1989
Terrepene ornata	Legler 1960
Macroclemys temmincki	Dobie 1971
Deirochelys reticularia	Gibbons and Greene 1978
Chrysemys picta	Tinkle et al. 1981
C. picta	Christens and Bider 1986
C. picta	Schwartzkopf & Brooks 1986
Emydoidea blandingii	Congdon et al. 1983
Kinosternon subrubrum	Gibbons 1983
Geochelone gigantea	Swingland and Coe 1978
Gopherus polyphemus	Landers et al. 1980

Table 2. Estimated percentages of reproductively active adult females in selected turtle species.

Trachemys scripta	27-47%	Frazer et al. in press
Chrysemys picta	50-70%	Tinkle et al. 1981
C. picta	40-80%	Christens & Bider 1986
C. picta	43-73%	Schwartzkopf & Brooks 1986
Emydoidea blandingii	23-48%	Congdon et al. 1983
Chelydra serpentina	60%	Congdon et al. 1987
Kinosternon subrubrum	34-71%	Frazer et al. unpubl. data
Caretta caretta	44%	Richardson & Richardson 1982

Table 3. Actual and observed percentages of sea turtles able to renest in 1, 2, 3, or 4 years. Real Intervals: true percentage of females able to return at intervals indicated if all survived. Population A: percentages observed on the beach assuming a 40% annual survival rate. Population B: percentages observed on the beach assuming a 55% annual survival rate.

	Real Interval	Population A	Population B
1 Year	5%	26%	16%
2 Year	15%	32%	27%
3 Year	30%	25%	30%
4 Year	50%	17%	27%
	100%*	100%**	100%***

* of adult females in the population
** of those surviving to return to the beach
*** of those surviving to return to the beach

ALPHAXALONE/ALPHADOLONE AND KETAMINE HCL AS ANESTHETIC AGENTS IN THE LOGGERHEAD SEA TURTLE (CARETTA CARETTA)

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Three loggerhead (Caretta caretta) sea turtles were given intravenous (IV) injections of sodium thiopental (8 mg/kg), ketamine hydrochloride (18mg/kg), or ketamine hydrochloride/acepromazine maleate (17/0.19 mg/kg). Ten additional sea turtles were given alphaxalone/alphadolone injections. Dosages of 4 to 6 mg/kg were administered either intravenously (IV) or intramuscularly (IM). All turtles were monitored until completely recovered. The turtle receiving sodium thiopental became anesthetized in five minutes, remained in that state for 50 minutes and recovered in 25 hours. Turtles receiving ketamine hydrochloride alone or in combination with acepromazine maleate showed maximum effects 10 minutes after injection. Ketamine alone caused only mild sedation, while, when given in combination with acepromazine it provided 15 to 24 minutes of anesthesia and recovery times as long as three hours. Turtles receiving alphaxalone/alphadolone at 4 mg/kg IM did not attain anesthesia, while those animals receiving the drug at 6 mg/kg IM achieved anesthesia in 7 to 38 minutes. When administered IV at a dosage of 4 mg/kg, anesthesia was reached in 2 to 6 minutes, lasted 10 to 20 minutes, and the animals recovered fully in 26 to 55 minutes.

SEA TURTLES AND THE EXPLOSIVE REMOVAL OF OFFSHORE OIL AND GAS STRUCTURES

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Concern was raised over the impacts of explosives on sea turtles when 51 dead turtles were found stranded on upper Texas beaches during mid-March to mid-April of 1986, the same time that a series of 22 underwater explosions occurred in support of oil structure removals. In July 1986, 11 sightings of at least three turtles (two loggerheads, Caretta caretta, and one green turtle, Chelonia mydas) were made during the removal of a platform approximately 30 miles south of Sabine Pass, Texas. What appeared to be a dead or injured turtle drifting with the current 10 feet below the surface of the water was reported 1.5 hours after detonation of explosives. Later that year the National Marine Fisheries Service (NMFS) and Minerals Management Service (MMS) consulted under Section 7 of the Endangered Species Act of 1973. The result was that oil and gas companies wishing to use underwater explosives were required to submit a permit application to MMS. Included in the permit issued by MMS is an Incidental Take Statement prepared by NMFS describing requirements which must be met to protect sea turtles in the area. Among these requirements is the use of qualified observers to monitor for sea turtles.

The observer program described in the Incidental Take Statements began in March 1987. From that date through the end of 1988 a total of 69 platforms and 39 caissons or other single pile structures were removed in state and federal waters of Louisiana and Texas. Thirty-six turtle sightings were made at 14 structure removal locations; 12 in Louisiana and 2 in Texas. Twenty-one loggerhead, 1 green turtle, and 14 unidentified sightings were reported during 1987-1988. Of these, 27 were made during the day and 9 at night. Thirteen sightings were made from helicopters and 24 from vessels. The frequency of turtle sightings at various distances from the structure being removed were 13 within 30 yards, 15 within 30-500 yards, and 8 within 500-2,600 yards. If sightings made during 1986-1988 are included, turtles were present at removal sights during all months except January and May. In excess of 30 additional turtle sightings were made at offshore platforms during 1987-1988, but these have not been included here because the structures were not being removed.

One platform removal was of special interest. At a platform located approximately 5 miles off of Corpus Christi, Texas a loggerhead turtle was observed 5 times at the surface before being captured 27 hours later by a diver while it was sleeping on the sea floor under the platform. The turtle was brought aboard a vessel and released at another platform about 3.5 miles away. Observers subsequently returned to the area to relocate the animal. Although 6 hours of surface monitoring resulted in no sightings, divers surveying the bottom located a loggerhead turtle sleeping underneath the platform. Six days later a loggerhead was observed at the surface. One and one-half hours after this sighting the turtle was seen on the bottom during a diver survey. Two days later a loggerhead was observed 23 times at the surface (between 1530 and 0700 hours) at another platform approximately 0.5 miles away. Despite 3 diver surveys during this period, no underwater sightings were made. It is thought that all sightings might be of the same individual because observers reported the same approximate length of 2-2.5 feet.

One 152-pound loggerhead turtle was captured by divers at another removal site about 100 miles off the Texas-Louisiana border. This turtle was flown by helicopter to Galveston and held at the NMFS Galveston Laboratory for use in a turtle tracking study.

SUMMARY

The data show that sea turtles associate with offshore platforms. There is also evidence of resident turtles at platforms. However, the degree of association and the extent of residency are not yet known. Surface observations are not always effective in detecting the presence of turtles. During 1987-1988, no turtles

were known to be killed or injured by explosions, but this is difficult to assess because the carcass of an impacted turtle probably sinks and is not visible from the surface for several days until it bloats from decomposition and subsequently refloats. The observer program described here has saved one turtle off Corpus Christi from certain death or serious injury and probably another turtle 100 miles off the Texas-Louisiana border. In addition, the program is a valuable source of information pertaining to turtle distribution, seasonality, and behavior at offshore artificial reef habitats.

INTRASEASONAL VARIATION OF DERMOCHELYS CORIACEA REPRODUCTIVE CHARACTERISTICS AT CULEBRA, PUERTO RICO

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The study area was located at Culebra Island and consisted of two adjacent beaches with a combined length of 2.25 km, where over 90% of all leatherback sea turtle (Dermochelys coriacea) nesting occurred. Soon after the nesting seasons started in 1984 and 1985, the beaches were patrolled hourly (seven nights per week) with the help of EARTHWATCH volunteers in an effort to observe and tag each nesting turtle. Forty-two turtles are known to have nested during the two year study; 90% of the 266 nestings were witnessed. With so few turtles each year, unwitnessed nestings (tracks found later in the study area or on another beach) could often be accurately fitted into a particular turtles' nesting sequence at a point where the turtle showed an internesting interval of approximately twice the normal length of time. Most pre-patrol nests were also attributed to known turtles by counting back average internesting intervals for the earliest nesters in the season. Approximately one unwitnessed nest was added to each turtle's observed clutch frequency, giving an estimated clutch frequency. Then each turtle's clutches were labeled as her first, second, third, etc. Reproductive data from assumed nestings were not included in the results.

Egg size, number yolked and yolkless eggs, internesting interval, percent hatch, and fertility were analyzed for seasonal variation by two commonly used methods described in Fraser and Richardson (1985). The first method is to examine the reproductive characteristic in relation to the date for the entire nesting season, and the second is to follow the changes that occur for individuals over time. For the first method, I used both linear and second order polynomial regressions of the reproductive variable against Julian date. The second order polynomial curve fit the data better in all cases, and was used to detect patterns of variability other than monotonic changes.

When examining individuals, they can be grouped as 3-time nesters, 4-time nesters, etc. Since Culebra had only 33 turtles that nested three times to an assumed 11 times, I decided to group all the turtles together as in Figure 1. The first and last clutches were differentiated from the middle clutches, which were then grouped in a way that would form fairly even sample sizes. Reproductive variables were then plugged into the figure to derive grouped means. With this classification, I could test for differences between first and last laid nests and those laid in between by analysis of variance (ANOVA). For those ANOVA which showed a difference in means, a Tukey-Kramer test for unplanned comparisons was used to test which means were different.

The general results are summarized in Table 1. The low r^2 values for all regressions indicate that other factors in addition to date (such as heredity, body size, nutrition) may also be important in determining reproductive values. The shape of the regression curves were more informative and were compared with the ANOVA results.

A seasonal increase then decrease was seen for egg size, yolked egg number, and yolkless egg number in both the regression curve and the individual grouped means. The Tukey-Kramer test showed that first-third and mid-third clutches were significantly different from the last clutch for egg size, and the mid-third clutch was significantly different from the last clutch for yolked egg number. The Tukey-Kramer did not reach significance for yolkless egg number, however, the greatest difference was between the first clutch and the mid-third. The regression of internesting interval by date showed a decrease in time as the season progressed; however, neither this pattern nor any other was seen for the individual grouped means. Neither percent hatch nor percent fertility significantly changed over the season by either method.

Seasonal variation in egg size had previously been unreported for sea turtles (Frazer and Richardson 1985), however clutch size variation had been reported for loggerhead, green and Kemp's ridley sea turtles. So little is known about yolkless eggs, that finding this non-random pattern of variability may give us a clue to

their biology. Finding no variation in percent fertility or percent hatch again may enable us to make inferences regarding the biology of the population. For example, mating may have been adequate and sperm storage ample enough to last the season, since no decrease was found in fertility.

An attempt should be made to distinguish between ultimate causes of variation, such as selective factors which have evolved over time, and proximate causes, or environmental factors which have a more immediate effect on variability. For example, clutch size may always increase then decrease, regardless of environmental factors, because it is the optimum configuration for embryonic survival rates in Culebra. However, in all likelihood, proximate causes are more important in determining clutch size, as has been found in other species of turtles and reptiles. When analyzing the possible effects of environment, it is important to remember that all the follicles for that season may have begun to mature before the nesting migration.

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Figure 1. Consolidation of 3-time nesters to 11-time nesters into one classification which differentiates between the first clutch, the first-third, mid-third, and last-third of middle clutches, and the last clutch for 33 Culebra leatherbacks in 1984 and 1985.

1												2												3
1				2															3					4
1				2								3							4					5
1				2							3		4						5					6
1			2		3							4						5		6				7
1			2		3						4		5					6		7				8
1			2		3					4		5		6				7		8				9
1		2		3		4					5		6				7		8		9			10
1		2		3		4				5		6		7			8		9		10			11
first clutch				first-third								mid-third							last-third					last clutch

Table 1. Results of two tests for seasonal variation of reproductive characteristics for leatherback turtles at Culebra. First reproductive variables were regressed against Julian date using the second order polynomial, then differences in means for individual clutch divisions (Fig. 1) were tested by ANOVA (DF between groups = 4).

	2° Polynomial Regression			Model I ANOVA		
Variables	r^2	P	DF	F	P	DF
Mean Egg Diameter (mm)	0.068	≤ 0.01	138	3.797	≤ 0.01	131
Number Yolked Eggs	0.101	≤ 0.0001	265	4.620	≤ 0.005	197
Number Yolkless Eggs	0.036	≤ 0.05	204	2.423	≤ 0.05	198
Internesting Interval (days)	0.047	≤ 0.025	172	2.494	≤ 0.05	171
Percent Hatch	0.025	NS	201	0.974	NS	190
Percent Fertility (arcsin)	0.008	NS	199	1.925	NS	189

EGG SURVIVORSHIP OF TORTUGUERO GREEN TURTLES DURING THE 1986 AND 1988 SEASONS

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Tortuguero beach extends 22 miles on the northern Caribbean coast of Costa Rica and is the major nesting site in the western Atlantic for green sea turtles (Chelonia mydas). The purpose of this study is to determine the egg survivorship for natural nests of Tortuguero green turtles, and important reproductive parameter for demographic studies and conservation programs.

My study area included the central two miles of the beach. Approximately 17% of nests laid on the beach are deposited in this two mile section (Carr et al. 1978). The beach was divided into two zones, the vegetation/border zone (which includes the vegetation and two meters from the vegetation border) and the open sand zone (below the vegetation/border zone).

I conducted a nesting census within the study area every 2-7 days from July through November in 1986 and from the middle of June through November in 1988. The number and position of all nests were recorded.

To investigate egg survivorship, a representative sample of nests within the study area was marked and followed throughout incubation. Clutch size was counted during nesting, and emergence success was determined by counting egg shells following incubation.

Seasonal nesting distribution indicates that the most concentrated nesting activity occurred from August to September. Peak nesting occurred during the later half of August in 1986 and the first half of September in 1988. Approximately 11,700 nests in 1986 and the first half of September in 1988. Approximately 11,799 nests in 1986 and 10,500 nests in 1988 were deposited in the two mile study area section of the beach.

The proportion of nests deposited in the vegetation/border zone and in the open sand zone was, respectively, 51.4% and 48.6% in 1986 (n=3,413), and 58.4% and 41.6% in 1988 (n=3,516). The proportion of nests in the two zones were significantly different in 1988 (chi-square test, $P < 0.001$), but not in 1986.

Emergence success was 46.3% (SD=39.2, n=32) in 1986 and 42.5% (SD=39.6, n=51) in 1988 in the vegetation/border zone and 57.3% (SD=37.5, n=42) in 1986 and 57.8% (SD=37.8, n=37) in 1988 in the open sand zone. Differences between two zones were not significantly different in either year (Mann-Whitney test, alpha = 0.05).

The major causes of clutch mortality were erosion and inundation from waves, and freshwater flooding from sporadic heavy rains. Due to these two causes in 1986, 22.3% and 23.8% of sample nests in the vegetation/border and open sand zones failed to produce hatchlings, respectively. In 1988, these proportions were 25.5% and 18.9% for the vegetation/border and open sand zones, respectively. Predation, mainly by coatis (Nasua naria) and ghost crabs (Ocypode quadrata), and excavation by nesting female turtles also reduced the egg survivorship.

Two rainfall events in 1986 (4 August, 141 mm/day; 5 December, 178 mm/day) and one rainfall event in 1988 (5 October, 221 mm/day) caused freshwater flooding on the beach and damaged the nests. Similar rain-induced mortality of loggerhead turtle clutches has been reported for the Georgia (USA) coast (Kraemer and Bell 1980). At Tortuguero, flooding results from an interaction of the degree of water saturation on the beach and the height of ocean waves.

Rainfall greater than 140 mm/day caused substantial egg mortality. Such days of heavy rain occur during the normal green turtle incubation season at Tortuguero. Since 1978, nine years had at least one of these heavy rains during the major incubation period from July to November. The timing of heavy rainfall is crucial with respect to the overall egg survivorship in a season. At Tortuguero, abiotic factors (such as heavy rainfall and high waves) probably play an important role in determining egg survivorship.

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SATELLITE TELEMETRY OF LOGGERHEAD TURTLES IN THE WESTERN NORTH ATLANTIC

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Mortality studies, aerial surveys, and radio/sonic telemetry has shown Chesapeake Bay is an important summer foraging area for juvenile loggerhead turtles, Caretta caretta (Bellmund et al. 1987, Byles 1988, Keinath et al. 1987, Lutcavage 1981, Lutcavage and Musick 1985). Those data, along with tag returns, suggest turtles travel north close to shore from south of Cape Hatteras in spring and south past Cape Hatteras in fall.

Although conventional telemetry is well suited to limited tracking, long term tracking of migrating turtles is not a minor task. It is labor intensive and costly; personnel must be on station 24 hours a day and tracking vessels suitable for extended periods at sea costing upwards of $,2000 per day are required (two days are equivalent to the price of one satellite transmitter).

We used the French Argos system which is mounted on polar orbiting U.S. NOAA [National Oceanic and Atmospheric Administration] satellites. The satellite determines transmitter position by doppler shift, and also receives digital data from on-board sensors. The data is then available through a computer information service. All our transmitters had temperature sensors, and one had sensors to determine: 1) number of dives in previous 12 hour session, 2) mean dive duration in previous 12 hour session, 3) duration of last dive, 4) a failsafe signal. The four parameters were determined by an on-board seawater switch which turned on when the sensor was in air and the animal was at the surface.

Stainless steel hardware was used to attach transmitters through holes drilled in the rear of the carapace. Xylocaine was used to relieve discomfort from drilling. Recaptured turtles previously telemetered show no signs of injury from the attachments. A 0.5 m lanyard linked the turtle and the transmitter to prevent damage to the transmitter from turtle bites. Compressible rubber was placed between the carapace and attachment plates to allow for growth and reduce abrasion. Transmitters were 10 cm x 45 cm cylinders painted with antifouling paint to reduce fouling and associated drag.

A male loggerhead fitted with a transmitter which contained the four sensors described above was released in Chesapeake Bay in September 1987. Unfortunately no positions were recorded, but nine dive parameters were received over 27 days. Mean duration of last dive (28 minutes) was near mean dive duration over 12 hours (22 minutes), and both were similar to dive durations reported for summer resident loggerheads in Chesapeake Bay (Byles 1988). The animal averaged 6 dives per hour.

Two loggerheads released near the mouth of Chesapeake Bay (fall of 1985 and 1986) confirmed our overflight data and traveled south close to shore. One turtle (1985; Byles 1988) entered Pamlico sound through Oregon Inlet during a severe northeast storm and the transmitter subsequently detached from the turtle. The other turtle traveled south past Cape Hatteras and again the transmitter detached from the turtle. In both cases we feel the turtles were caught by trawlers and the transmitters detached by fishermen who tossed them overboard.

One transmitter deployed on a loggerhead in October 1986 was not heard from until eight months later when it started transmitting from downtown Newport News. A person found the transmitter on a Hampton beach and gave it to his dog to play with. Part of the carapace was still attached to the transmitter, and we latter learned the turtle was drowned in a pound net leader in the Potomac River and cut loose by fishermen. The turtle probably sank and disintegrated during the winter, subsequently releasing the transmitter. The transmitter was refurbished and deployed on a loggerhead 1987.

Another loggerhead was released off Oregon Inlet in November 1985 (Byles 1988). As expected, the turtle traveled south past Cape Hatteras to Cape Lookout near shore. The turtle then went into the Gulf Stream and traveled north to off the Virginia-Maryland state line by early January. Then the turtle entered the west wall of the Gulf Stream and traveled south. The transmitter stopped transmitting in mid-January. We felt this animals' movements were anomalous until our last track when we released a loggerhead off Cape Hatteras in December 1987. In the 180-day track the animal traveled to north of Bermuda, south to the Gulf Stream off Georgia, and north in the Gulf Stream off Virginia when the transmitter stopped transmitting. Total distance covered was some 4,000 km; the turtle averaged 1 km/hour (not taking currents into account). The turtle had been captured in Chesapeake Bay twice before but failed to return in 1988.

The oceanic travel of the last two turtles raises questions:

1) Is oceanic movement typical? Most loggerheads inhabiting Chesapeake Bay are sub-adults (see Barnard et al., this volume), but the turtles we tracked were close to sexual maturity. Is there a switch from immature coastal habitats to offshore habitats at maturity?

2) Why did the tracked loggerheads become oceanic? Is the movement related to mating?

3) What were the loggerheads eating? Chesapeake Bay loggerheads forage exclusively benthically (Keinath et al. 1987, Lutcavage 1981, Lutcavage and Musick 1985), but our transmitters could not withstand dives deeper than 100 m so the animals must have been foraging at or near the surface. Did they forage on jelly animals or Sargassum and its related infauna/epifauna?

Satellite telemetry is useful in the study of wild sea turtle movement and behavior, but raises new questions. With the development of smaller packages and different sensors, we will be able to study smaller individuals, smaller species, and more biological parameters.

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FISHING CHARACTERISTICS OF THE MORRISON SOFT TED

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Several shrimp trawl net designs are currently used in the southeast commercial shrimp fishery. Essentially, the principle for each net is identical. A net consists of a bag of webbing attached to wings, which are spread open by a pair of otter boards. These nets are towed along the ocean bottom where they catch shrimp.

A TED ('Trawling Efficiency Device', or 'Turtle Excluder Device') is a piece of gear which is inserted into a shrimp trawl to exclude unwanted sea turtles. Currently, seven different TED designs are available for commercial use in the southeast. One of these devices is the Morrison Soft TED.

Incidental capture and drowning of sea turtles has been determined to be a source of mortality. The U.S. National Marine Fisheries Service estimates that approximately 11,000 sea turtles drown in shrimp trawl nets on an annual average (Federal Register 1987). Schroeder (1986) reports 8,300 sea turtle strandings between January 1980 through December 1986 in coastal areas from North Carolina to Texas. Most of these turtles were loggerheads, Caretta caretta, but nearly 600 Kemps Ridleys, Lepidochelys kempi, were also present. It is difficult to determine the precise cause of death.

The Endangered Species Act (ESA) of 1973 was enacted to prevent or retard species extinction due to man made causes. The ESA is a tough law and is solely concerned with the preservation of a particular species. Economic considerations are not provided for, and it is rare that exceptions are made (Conner 1987).

Sea turtle drownings attributable to shrimping prompted three options under the ESA (Conner 1987):

1) Limit or shut down the shrimp fishery.
2) Establish a quota system for sea turtle mortality.
3) Do nothing other than require fishermen to release captured turtles.

These options have been the driving force behind current gear development work. This project has consisted of two phases; turtle exclusion at Cape Canaveral, and shrimp retention off St. Simons Island, Georgia. Only those TEDS which successfully exclude sea turtles are subjected to further study.

All research was conducted aboard the R\V Georgia Bulldog. This vessel is a 72 foot wood hull shrimp trawler, which has been modified into a multi-purpose fishing boat.

The Morrison Soft TED is a deflector panel of eight-inch stretched mesh webbing installed on the inside of a shrimp trawl (Christian et al. 1988). In theory, shrimp should pass through the mesh of the panel and into the bag, while larger organisms such as sea turtles are deflected up and out of the net.

Two 60 foot flat trawls were used. The port net was equipped with the TED gear and the starboard net was the control. Tow times ranged from 0.8-3.6 hours (average=2.3 hrs, sd=0.7 hrs).

Shrimp catch data were obtained from 48 trawl samples. A total shrimp catch rate of approximately 10 pounds/hour in the control net was the desired criteria for accepting a sample in the results. This occurred 27 times (56.3%) and all statistical analysis was performed on these data.

Overall, the Morrison TED exhibited an 8.5% reduction in total shrimp catch, approximately 1.7 pounds per tow. However, this difference is not statistically significant and fluctuated greatly. Shrimp size caught were not affected by the TED.

Resolution of the sea turtle problem has become a highly political and emotional issue. In general, coastal development is incompatible with the life cycle of turtles. The most successful solution to this problem will be one which deals solely with facts.

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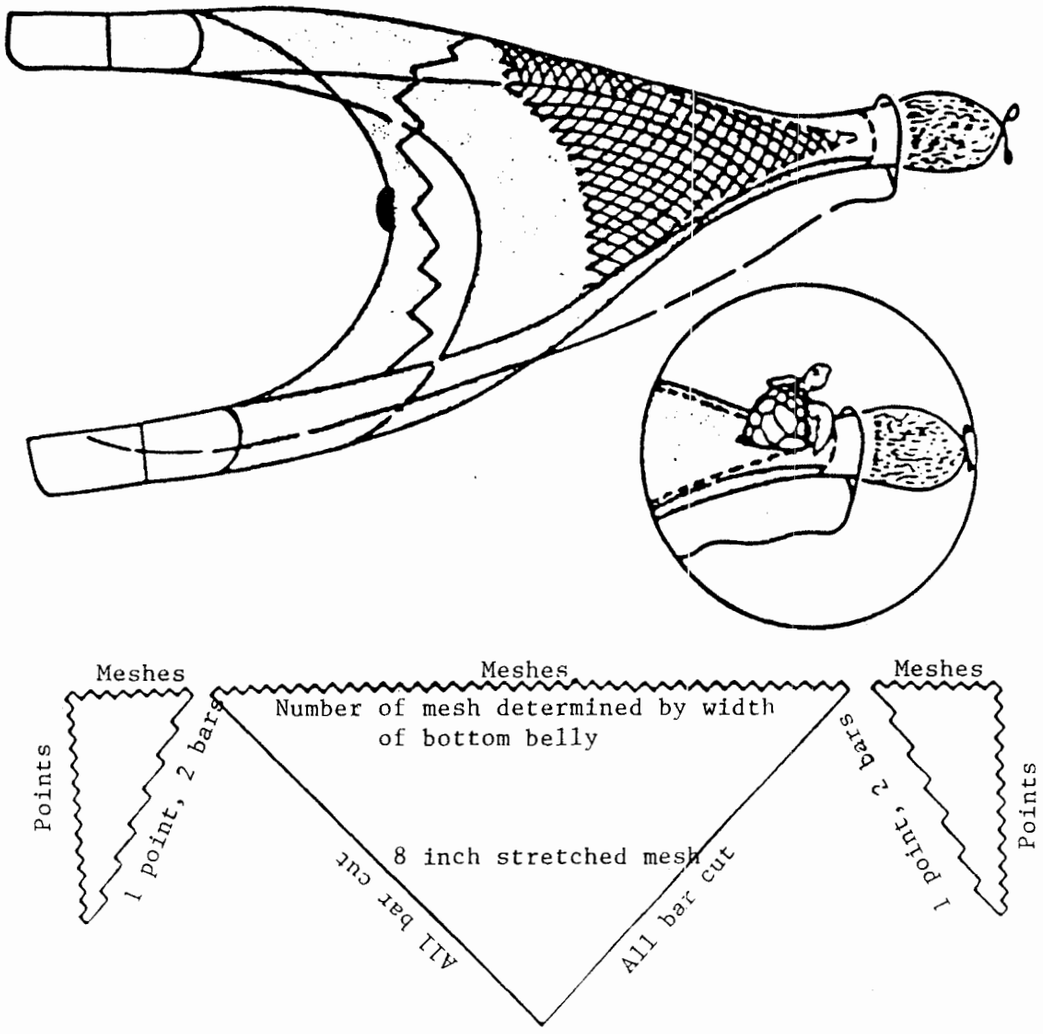

SCHEMATIC EXAMPLE OF MORRISON TED'S MAIN PANEL AND JIBS.

EVALUATION OF COMMERCIAL USE OF TEDs

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The U.S. National Marine Fisheries Service, in cooperation with the shrimp industry, initiated a TED Evaluation Program in the spring of 1988. The overall objective of the program is to determine the effects of commercial utilization of certified TEDs on commercial shrimp trawlers in the South Atlantic and Gulf of Mexico. The program is aimed at determining catch rates of shrimp for TED-equipped trawls and trawls without TEDs in selected shrimp fishing areas of the southeast region.

The U.S. Federal Government implemented mandatory use of TEDs in the Gulf of Mexico and South Atlantic in 1988. However, the state of Louisiana sued the Federal Government and the courts upheld the regulation. The U.S. Congress revised the date of implementation to 1 May 1989 for all except the Cape Canaveral, Florida, area.

Trained observers have been placed on shrimp vessels operating off of the states of Texas, Louisiana, Alabama, Mississippi, Florida, Georgia and South Carolina. Through 1988, trained observers have collected information on 39 trips from commercial vessels fishing for 2750 hours. The difference of catch rates of shrimp between TED and standard nets have varied by area and season ranging from a loss of 37% to a gain of up to 38%. Three turtles have been caught in the Gulf of Mexico and 17 in the South Atlantic, all in the non-TED nets.

A NOTE ON THE DISTRIBUTION OF LEATHERBACK TURTLES (DERMOCHELYS CORIACEA) ALONG THE FLORIDA COAST IN FEBRUARY 1988

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During the past five consecutive winters (1984-1988), the New England Aquarium has been conducting aerial surveys along the coasts of Florida and Georgia in an effort to locate and photograph North Atlantic right whales on their calving grounds (Figure 1). These surveys were conducted along the coasts of Florida and Georgia out to twenty miles, using primarily high wing, single engine aircraft. The duration of the surveys has ranged between ten days and two months. Although effort in the offshore areas has varied from year to year, surveys have been consistently conducted along the Florida coast within two miles of the beach from Amelia Island to Fort Pierce, due to the coastal habits of right whale cows with calves. In the course of these surveys, sightings of other marine mammals, sea turtles, sharks, rays, and any unusual phenomena were also noted.

In February of 1988, surveys along the Florida coast revealed an unusually high number of leatherback turtle sightings. During New England Aquarium surveys in previous years, few leatherback turtles had been sighted. Between 14 February and 27 February 1988, 168 leatherbacks were sighted along the northeast coast of Florida. On 22 February 1988, during a coastal survey from Amelia Island to Fort Pierce along tracklines 1/4 mile and 1 1/2 miles parallel to the coast, 68 leatherback turtles were sighted between St. Augustine and Sebastian Inlet. The highest concentration occurred between Daytona Beach and Cape Canaveral, a 50 mile stretch of coastline (Figure 2). Sixty one of the sightings were along the inshore trackline, while only seven were seen along the offshore trackline. Surveys of this area before 14 February revealed no leatherback sightings and a survey on 16 March, after a two week interlude, also revealed no leatherback sightings. These data indicate that this occurrence of leatherbacks near the beach was a short term event extending from mid February until at least the end of February.

These sightings are significant considering the lack of leatherback sightings in previous years surveys. Other researchers' data indicate that leatherback sightings in this area tend to be infrequent during the winter and more common during the summer.

Our 1989 surveys are still in progress. Leatherback turtles are again being sighted, but appear to range over a larger area with no evidence of a concentration as in 1988.

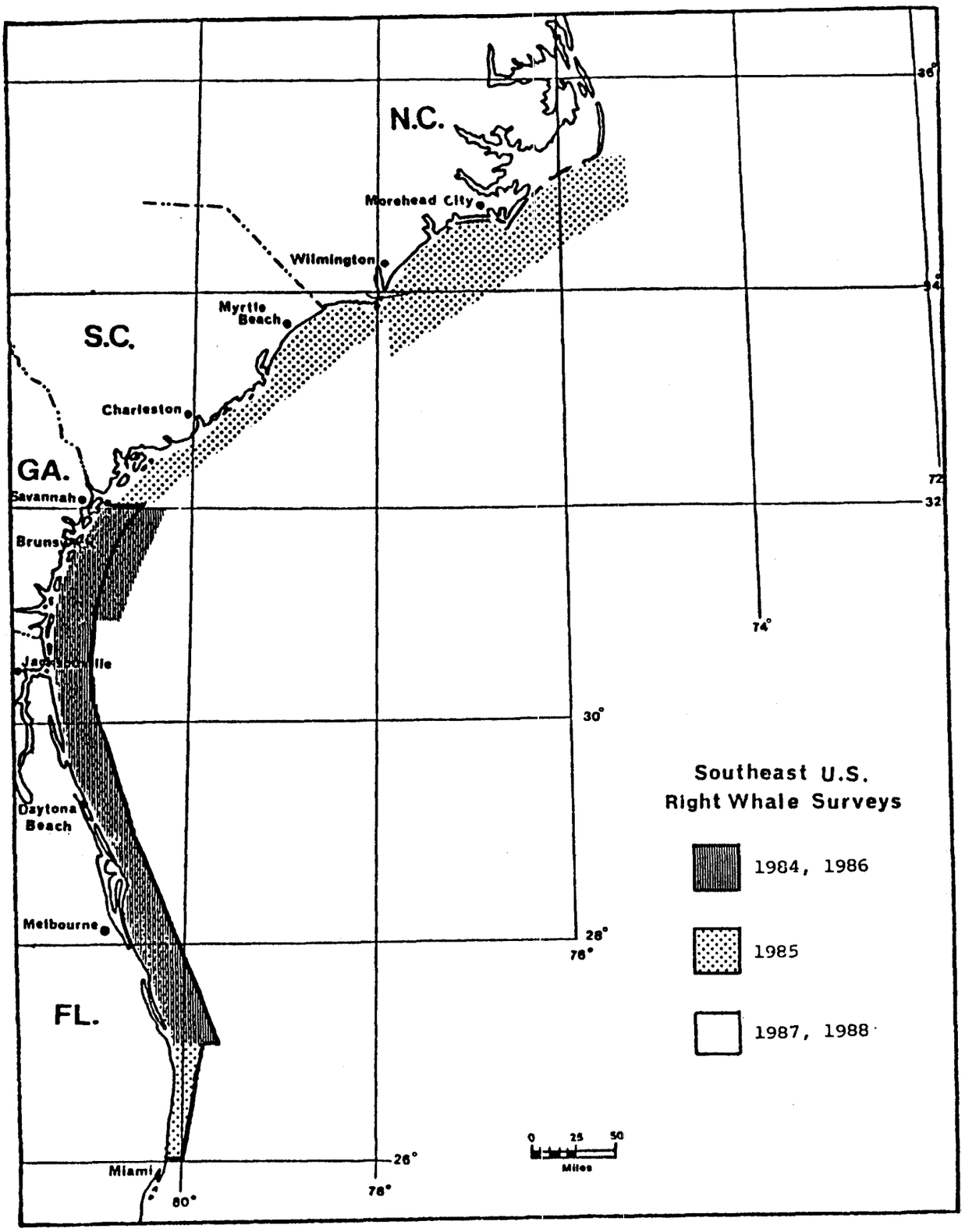

Figure 1. Right whale survey areas: 1984 - 1988.

THE EFFECTS OF AN IODOPHOR COMPOUND ON SKIN LESION DISEASE IN SEA TURTLES

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The culture of sea turtles provides a means for reestablishing depleted natural populations through restocking, and at the same time alleviates pressures of over-exploitation on existing populations. A major problem in the rearing of sea turtles is disease control, particularly skin disease. Necrotic skin lesions develop within the initial months of raising hatchlings and usually result in death if not treated. Unfortunately, most treatments for controlling skin diseases in sea turtles have proven to be ineffective and labor intensive (Haines and Kleese 1977, Frye 1973, Witham 1973a).

The primary objective of this study was to determine the effectiveness of an iodophor compound (Vanodine^R) for treating already established skin lesion disease observed in sea turtle aquaculture. Samples of skin lesions encountered in the culture of sea turtles were described and identified. Bacteria associated with these skin lesions were isolated and identified.

METHODS

Four month old loggerhead sea turtles (Caretta caretta) were selected randomly and separated into two groups of 35 turtles each. One group remained untreated and the other group was treated with Vanodine, administered directly into the holding tank water, at a final concentration of 1:10,000 (100 ppm). Exposure to Vanodine treatment was 8-10 hours during the daylight active period. This procedure continued for seven weeks, at which time the untreated group was treated with Vanodine and the treatment in the initially Vanodine-treated group was terminated. This cross-over experiment was identical in procedure and duration to the initial treatment study.

Lesion scrapings were performed weekly on a representative number of afflicted turtles. The scrapings were immediately placed in thioglycollate media (BBL) and after 12-18 hours incubation at 23°, streaked on Blood agar, PEA (phenyl-ethylene-alanine), and MacConkey's agar. Identification of bacteria was made by api 20E (Analylab Products 1985).

The Mann-Whitney U-Test was used in this study because of the non-normal distribution of the data. Trends in lesion development were analyzed by Spearman rank correlation.

RESULTS

Microorganisms isolated and identified from the skin and scute lesions of sea turtles are presented in Table 1. These organisms were mostly gram negative rods of the family Enterobacteriacaea. Two species of Vibrio and a fungus (Candida sp.) were also isolated. Collectively, these bacteria are normal flora of the vertebrate enteric tract and usually not detrimental to healthy turtles, but frequently add to the morbidity and mortality of turtles already weakened by other diseases (Taylor 1969). The pathogen Salmonella was the only organism isolated from scute lesions.

Scatter diagrams of the weekly distribution in skin lesion numbers which developed in the Vanodine and untreated groups, before and after cross-over, are shown in Figure 1. Skin lesions were established in both groups at the beginning of the study. Spearman rank coefficient (rho) in the Vanodine treated group before cross-over indicated a significant ($P < 0.0005$) decreasing trend in skin lesion number, while the untreated group had a significant ($P < 0.0005$) positive trend. After cross-over, rank correlation revealed highly significant ($P < 0.0005$) negative and positive trends when turtles were treated and removed from treatment, respectively.

The z-statistics from the weekly comparisons of skin lesion numbers between Vanodine and untreated groups are presented in Figure 2. After one week of treatment, skin lesion numbers were significantly lower in the Vanodine treated group ($P < 0.0005$). After cross-over, there was an initial reduction in the degree of statistical separation in the groups followed by a significantly lower number of lesions in the Vanodine group by week eleven, with increasing levels of significance thereafter.

DISCUSSION

Vanodine very effectively reduce skin lesion number compared to the untreated group after one week of treatment on turtles which had already developed skin lesions and this difference generally increased with time. After cross-over, the significant increasing and declining trends in the untreated and Vanodine groups, respectively.

Vanodine seems to have two important roles in controlling skin lesion disease in sea turtle culture. First, the germicidal properties of the iodophor cause a possible reduction in the microbial load infiltrating the lesions. Second, Vanodine treatment of the water in the holding facility permits sufficient time for lesion healing by inhibiting the invasion of "opportunistic" pathogens.

The procedure developed in this study for treating an entire group of sea turtles by administering the iodophor directly into the water of the holding facility is very efficient when compared to the labor intensive practice, utilized by many previous methods, in which turtles were treated individually. Raising sea turtles under captive conditions will remain useful until world-wide conservation practices are established and enforced.

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FIGURE 1

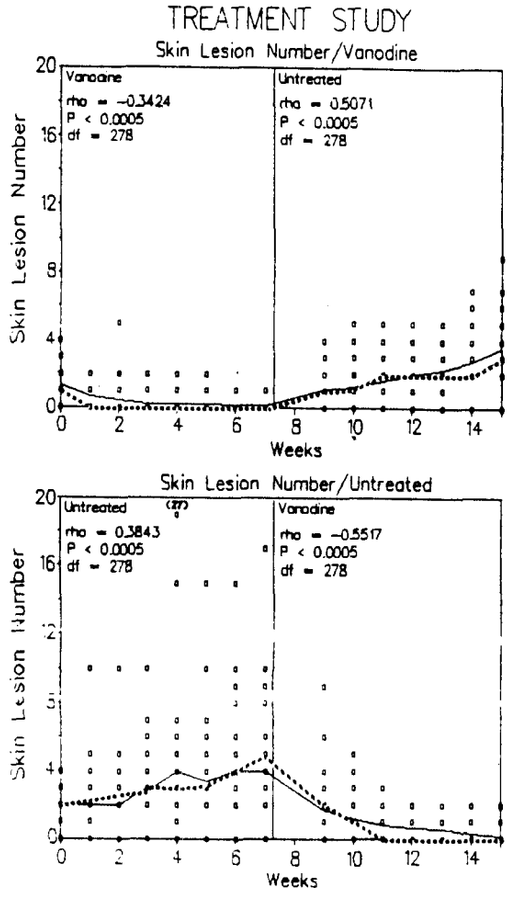

Figure 1. Scatter diagrams showing the weekly distribution of skin lesion numbers in each group, before and after cross-over, in the study. (Top) Vanodine treated group switched to no **treatment. (Bottom) Untreated group switched to Vanodine treatment. Solid line, weekly mean of skin lesions per turble;** Broken line, weekly median; "rho", the Spearman rank coefficient **as an indication of the trends before and after cross-over; P, significance level of rho.**

FIGURE 2

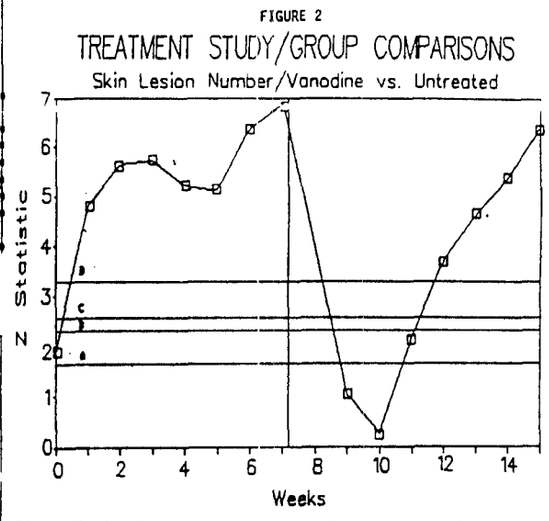

Figure 2. The time course and significance levels of z statistics derived from weekly Mann-Whitney U-Test comparisons of skin lesion numbers between Vanodine and Untreated groups in the cross-over experiment. A through D shows the respective 0.95, 0.99, 0.995 and 0.9995 confidence levels at which the null hypothesis may be rejected.

TABLE 1
ISOLATION OF MICROORGANISMS ASSOCIATED WITH SKIN LESIONS IN SEA TURTLES

Species	Morphology	Anatomical Position	Diseases	Number of Isolations
Vibrio fluvialis	bacteria: gram negative rod	flippers, tail	gastroenteritis	14
Salmonella sp.	bacteria: gram negative cocci	shell, scutes (carapace, plastron)	septicemia gastroenteritis	14
Aeromonas hydrophilia	bacteria: gram negative rod	flippers, tail, shell	gastroenteritis	12
Vibrio parahemolyticus	bacteria: gram negative rod	flippers, tail, shell	gastroenteritis	10
Enterococcus sp.	bacteria: gram positive cocci	eyes, tail	septicemia urinary infections	10
Candida sp.	fungus	flippers	infections of mouth, skin, claws, cloaca; variety of systemic diseases	4
Enterobacter cloacae	bacteria: gram negative rod	tail	bacteremia, pneumonia, urinary tract infections	4

ECONOMIC ANALYSIS OF SEA TURTLE EGGS IN A COASTAL COMMUNITY ON THE PACIFIC COAST OF HONDURAS

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The economic importance of olive ridley (Lepidochelys olivacea) sea turtle eggs to local inhabitants, the impact of exploitation on the resource, and the ability of the resource to sustain current levels of exploitation is discussed.

Field work was conducted from July to December 1987. Surveys of potential nesting beaches were conducted by boat every two weeks throughout the Gulf of Fonseca, Honduras. Nocturnal beach patrols were conducted at Punta Ratón throughout the nesting season. At the time of egg collection, egg collectors were interviewed. Case studies were used to calculate the cost of living at Punta Ratón. Five households were selected to participate and each household was interviewed every 10 days.

Nearly 100% of the olive ridley eggs laid in the Gulf of Fonseca were collected and sold during the 1987 nesting season. A total of 742 egg clutches were recorded at Punta Ratón from May to December. Of this total, 651 egg clutches were collected and sold to intermediaries. The average number of eggs per clutch was 98 for a total of 63,798 eggs.

Egg prices almost quadrupled throughout the study with a low of $0.08 per egg in the middle of September to a high of $0.31 per egg at the beginning and end of the nesting season. Egg collectors earned approximately $10,000 through the sale of sea turtle eggs from the beach at Punta Ratón. There were at least 224 different egg collectors at Punta Ratón; of these, 15.2% were not residents of the community. These non-residents earned $2,320 of the total income earned through the sale of sea turtle eggs from Punta Ratón.

The community of Punta Ratón is comprised of 93 households, of which 88.2% have at least one member participating in the collection of turtle eggs. Total income earned through the sale of turtle eggs by the residents of Punta Ratón was $7,680 or 76.8%. The income earned per household by residents ranged from $3.75 to $684.56 per household. In 1987, the majority of the households (80%) earned $160 or less through the sale of sea turtle eggs.

Almost 100% of the olive ridley eggs laid in the Gulf of Fonseca over the last 40 years have been collected and sold. Although the majority of households receive some income through the sale of turtle eggs, only a few earn a substantial quantity. Unless a considerable number of egg clutches are protected, nesting activity will diminish and the reproductive effort of the olive ridley will be divided amongst an ever increasing human coastal population.

For more information, please refer: Lagueux, C.J. Economic analysis of sea turtle eggs in a coastal community on the Pacific coast of Honduras. In: Neotropical Wildlife Use and Conservation, J.G. Robinson and K.H. Redford (eds.). University of Chicago Press, Chicago (in press.)

ENVIRONMENTAL REGULATION OF GREEN TURTLE BREEDING IN EASTERN AUSTRALIA

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The number of female green turtles, Chelonia mydas, nesting annually at Heron Island in the southern Great Barrier Reef has fluctuated through three orders of magnitude from year to year (Figure 1) since monitoring of the Heron Island population became a Queensland Turtle Research Project in 1974. The numbers of green turtles nesting annually on the other major eastern Australian rookeries fluctuate approximately in parallel with those at Heron Island (Limpus unpubl. data). No corresponding relationship has been identified for the other sea turtle species. Large fluctuations in numbers of nesting green turtles in successive breeding seasons are not just a recent event. "Great Numbers" of green turtles (=courting and migrating turtles) were available for capture by aboriginal turtle hunters in southern Torres Strait in the spring of 1846, but the 1847 and 1848 seasons were both "very bad seasons", and the 1849 season had "not been a very good season" (Moore 1979, p.210). Moorehouse (1933) describes reduced numbers nesting at Heron Island in the 1928-1929 season and approximately average nesting numbers in 1929-1930 (when compared to recently recorded nightly nesting numbers). In 1949-1950 there were very low numbers of green turtles nesting at Heron Island and Northwest Island, but average to above average numbers nesting at Northwest Island the following season (Limpus unpubl. data).

Using Darwin atmospheric pressure as an index of the ENSO (El Niño Southern Oscillation) weather phenomenon, Limpus and Nicholls (1988) demonstrated a positive correlation between the numbers of green turtles nesting at each of Heron Island and Raine Island and the ENSO effect. These rookeries lie towards the opposite ends of the Great Barrier Reef. The strongest correlation was found with the Darwin atmospheric pressure averaged over the November-January period 2 years before the nesting season ($r=0.78$ for Heron Island where total annual nesting populations were recorded; $r=0.74$ for Raine Island where the nightly average number of nesting females ashore on the island in early December was used as a measure of annual nesting density; see Figure 2.)

In recent decades there has been no indication of significant annual fluctuations in the numbers of green turtles resident in feeding grounds that supply females to these rookeries. Since 1983, studies have been in progress in eastern and northern Australia to assess the annual breeding status of adult female green turtles in their feeding grounds. Adult female green turtles that live year round on Heron and Wistari Reefs adjacent to Heron Island and which nest at the southern Great Barrier Reef rookeries (including Heron Island) were examined by laparoscopy (Limpus and Reed 1985a). Adult female green turtles from the coastal area of the southwest Gulf of Carpentaria include females which migrate to nest at Raine Island, and some of these turtles were dissected to determine their breeding status after their death following a cyclonic stranding (Limpus and Reed 1985b). The proportion of adult female green turtles present in each of these widely separated feeding grounds that was recorded in vitellogenesis, or recorded as having bred in any one year, varied widely from year to year (Figure 3). These data indicate that changes in annual breeding rates of adult female green turtles as recorded in their feeding grounds (range: 50-60% in 1984, <10% in 1983) are large enough to account for the annual fluctuations in nesting numbers recorded at the nesting beaches.

The individual female green turtle does not breed annually. For each there is a sequence of preparation spanning more than a year that precedes the first nesting for a breeding season: a fat deposition phase begins more than a year before the first nesting; vitellogenesis begins approximately 10 months before; migration to courtship occurs some weeks before; courtship occurs approximately four weeks before; ovulation occurs approximately two weeks before. The ENSO effect apparently regulates annual green turtle breeding numbers at the rookeries by influencing the proportion of adults in the feeding ground that commences preparation for breeding in any one year. The two year time delay between the measured climatic event (November-January Darwin atmospheric pressure) and mid-nesting season results mostly from the extended time needed by the female to prepare for a breeding season. The mechanism by which

the ENSO effect operates on the environment and/or green turtles to initiate preparation for breeding has yet to be determined.

Because climatic effects can influence annual breeding numbers, there is a need for caution when using only a few years of observations of annual breeding numbers as the basis for judging whether or not a nesting population of green turtles is changing in numbers. Using that parameter by itself, it is probably necessary to maintain decades of monitoring of annual breeding numbers before the stability of a population can be determined reliably. By linking the number of breeding females at the rookeries with the proportion of adults in the feeding grounds that were breeding for that season, it should be possible to estimate the total number of adult females in the entire feeding range. Through this approach to estimating population size, it may be possible to identify population trends in a shorter period of time.

In the short term, identification of a correlation between an index of the ENSO effect and green turtle nesting density at individual rookeries two years later has the potential for improved planning for turtle management, especially in the Australasian region where eggs, courting turtles, and/or nesting females are harvested. For example, it could allow better anticipation of the logistical support needed in egg protection/hatchery projects or could allow for the setting of a harvest quota tuned to the particular nesting season.

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Figure 1. Fluctuations in annual nesting populations of sea turtles at Heron Island. Closed circles represent data collected within the Queensland Turtle Research Project since 1974. Open circles represent approximate values obtained from various publications by Dr. H.R. Bustard.

Figure 2. Scatter diagram showing correlation between mean November-January Darwin atmospheric pressure and green turtle nesting numbers 2 years later. After Limpus and Nicholls (1988).

Figure 3. Data illustrating the correlation between the proportion of adult female green turtles that bred in any one season year from each of 2 unrelated feeding grounds and the number of green turtles that nested on Heron Island in the same season. Squares denote Heron and Wistari Reef feeding ground samples. Triangles denote cyclone Kathy stranded turtles from southwestern Gulf of Carpentaria.

Figure 1.

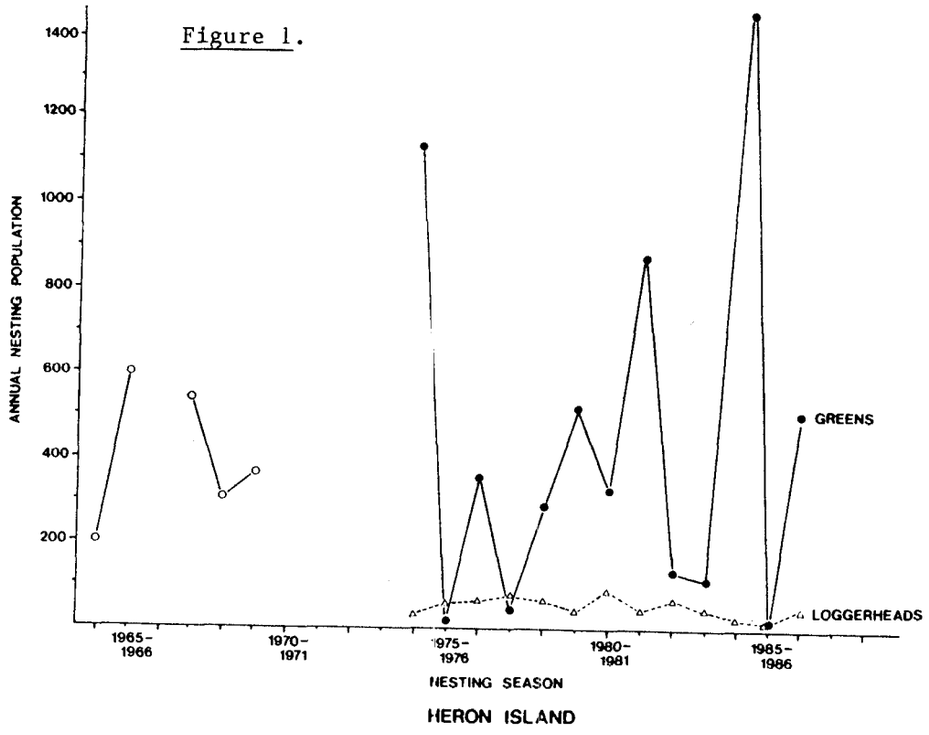


Figure 2.

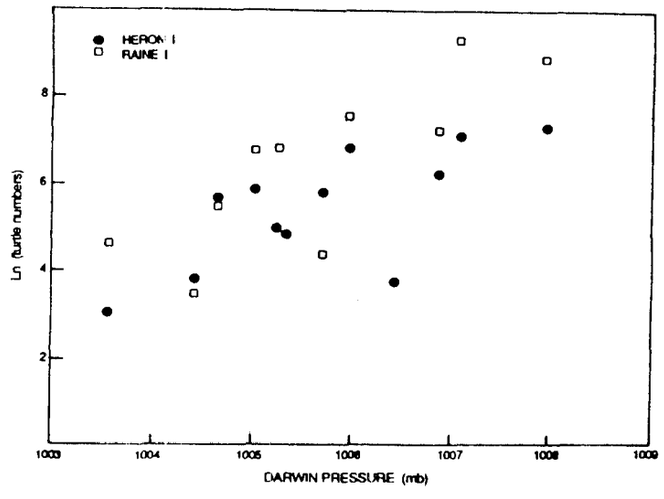
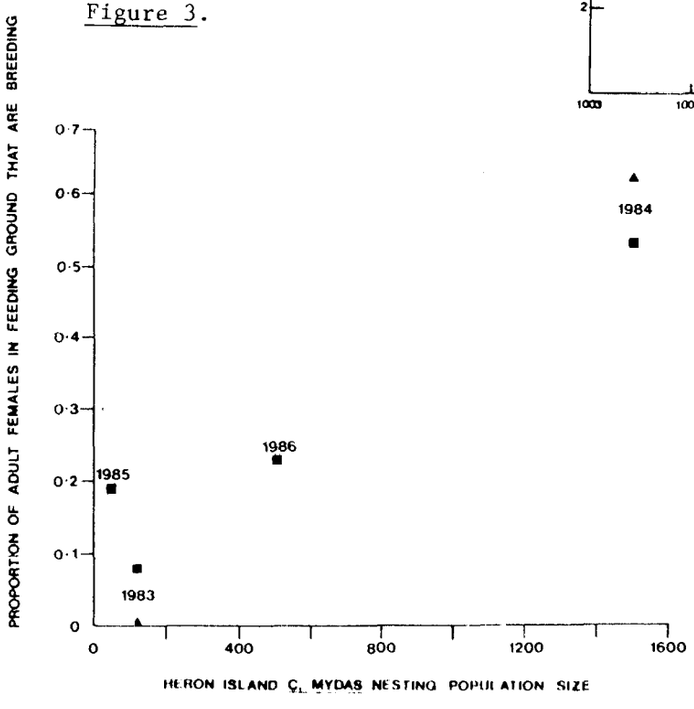


Figure 3.



FORAGING AREA FIDELITY FOLLOWING BREEDING MIGRATIONS IN CARETTA CARETTA

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The marine turtles resident on the coral reefs adjacent to Heron Island in the southern Great Barrier Reef have been under continual research since 1974 (Limpus and Walter 1980, Limpus et al. 1984, Limpus and Reed 1985). Also included among these turtles were adult female Caretta caretta that were recorded during breeding migrations away from the foraging area. These turtles are the subject of this report.

METHODS AND STUDY SITES

The turtles were captured by the rodeo capture method, tagged with one or more monel and/or titanium flipper tags and, in some instances, examined laparoscopically to determine current breeding status (Limpus and Reed 1985). Turtles were captured regularly on Heron Reef and adjacent Wistari Reef, lagoonal platform reefs within the Capricorn Group of the southern Great Barrier Reef in Queensland, from 1974 to the present time. Heron Reef has an area of approximately 28 km^2 surrounding Heron Island. Wistari Reef is slightly smaller and lies 1.1 km west of Heron Reef. Turtle nesting has been monitored on beaches and islands encompassing the major part of the nesting distribution of C. caretta in eastern Australia: annually on several islands of the Capricorn Group, including Heron Island and Wreck Island, since 1974; annually on several beaches on the adjacent mainland to the south of Heron Reef, including Mon Repos and adjacent Kellys Beach near Bundaberg and Wreck Rock, since 1968; occasionally on islands of the Swain Reefs, including Pryce Cay and Moon Cay, to the north of Heron Reef since 1976. The nesting season for C. caretta in this region extends from late October to approximately late February.

RESULTS

During 1974-1985, which was the period of most intense sampling of Heron and Wistari Reefs, approximately 300 C. caretta were captured, including nine adult female C. caretta that lived on these reefs outside of the nesting season and subsequently were recaptured at a nesting beach. The history of captures, including captures before and after the main study period, of each of these nine females is summarized in Table 1. Laparoscopic examination of some females in the latter years of the study showed that each turtle did not breed annually (turtles 2912, X54, X2031, X2606, X2777). The females inhabiting the one foraging area were not synchronized in their breeding years and bred at irregular remigration intervals. Turtles from the one foraging area were not all recorded nesting at the one rookery but dispersed throughout the 350 km north to south breeding range for the species in eastern Australia. Individuals were recorded nesting 97-192 km and in different directions from their home reefs. In addition, these females were not recorded nesting on the Capricorn Group C. caretta rookeries of Heron, Wreck, or Erskine Islands which lie within 2-16 km of the foraging area for each of these turtles.

Eight of the nine females recorded on a breeding migration from these reefal foraging areas subsequently returned at the end of their post-breeding migration to the same reef at which they were originally captured. Contact with the ninth female (turtle X198) appears to have been lost. Returns to the same reef following up to three consecutive breeding migrations by the same female (turtle 5330) were recorded. These turtles displayed a similar degree of fidelity to their home foraging area as they did to their respective nesting beaches. Each was able to locate and return to a specific reef among a large array of reefs after having travelled 97-192 km away from that reef.

DISCUSSION

The presence of an adult female sea turtle living for years within sight of a rookery used by her species cannot by itself be used as evidence for non-migratory behavior by some females. The present study

indicates that, when she does breed, she does not nest at the closest available, suitable rookery but migrates to a more distant site and subsequently returns to her home foraging area. All females inhabiting the one foraging area do not necessarily nest at the same rookery, but the one female typically returns to the same rookery for successive breeding seasons. This study has demonstrated that the failure to record each C. caretta annually at a nesting beach was not primarily the result of their changing rookeries or being missed in beach surveys but resulted from individual females not breeding annually. The fidelity to a rookery by the breeding adult sea turtle has traditionally been presented as evidence that the female returns to breed at the rookery of her birth. This study has demonstrated that at least C. caretta can have comparable fidelity to a foraging area and to a distant rookery. If she can learn to associate with one area at which she was not born during the course of her life, it is reasonable to assume that she could be capable of learning to recognize and relocate additional sites - perhaps even a rookery where she was not born. A study of the mechanism by which the adult or near adult turtle learns to recognize a specific foraging area and subsequently relocate it during a migration may provide some new insights into sea turtles navigation. Such new insights are needed for designing new experiments for testing theories to increase our understanding of sea turtle rookery selection.

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Table 1. Foraging area and nesting beach capture records for nine Caretta caretta resident on Heron and Wistari Reefs.

Tag	Capture Records
2912	**RECORDED** nesting at Mon Repos in the 1968, 1970, and 1973 breeding seasons (2 and 3 year remigration intervals). **RECAPTURED** at Heron Reef 03 Nov. 1974, 156 km from Mon Repos. Captured 17 times at Heron Reef during 1974-1984. **LAPAROSCOPIC** examination (Feb. 1984) showed she had not bred in 1981, 1982, or 1983 but she was vitellogenic in 1984. Returned to Mon Repos 16 Dec. 1984 (11 year remigration interval). Laid 3 clutches for the season. **RECAPTURED** several times annually at Heron Reef during 1985-1988, and annual laparascopic examination showed that she did not breed in these 4 years.
5330	**FIRST** tagged while nesting at Mon Repos 24 Nov. 1972. Laid at least 2 clutches at Mon Repos and adjacent Kellys Beach (approx. 4 km from Mon Repos). **RECAPTURED** once on Wistari Reef, 156 km from Mon Repos, during 1975. Recaptured nesting at Mon Repos on 14 Dec. 1975 (3 year remigration interval). Also nested at Kellys Beach. Laid at least 2 clutches for season. **RECAPTURED** once at Wistari Reef during 1976-1979. Returned to Mon Repos 10 Dec. 1979 (4 year remigration interval). Laid 3 clutches for season at Mon Repos, Bargara (a beach between Mon Repos and Kellys Beach) and Kellys Beach. **RECAPTURED** once at Wistari Reef during 1980-1982. Returned to Kellys Beach 20 Dec. 1982 (3 year remigration interval). Recorded laying only 1 clutch for season. **RECAPTURED** once at Wistari Reef during 1983-1985. Returned to Mon Repos 27 Nov. 1985 (3 year remigration interval). Recorded laying only one clutch for season.

Table 1. continued.

10779	**FIRST** tagged while nesting at Mon Repos on 16 Jan. 1974. Appears to have laid only one clutch for season. **RECAPTURED** 3 times at Heron Reef during 1975-1982. Returned to Mon Repos 09 Dec. 1982 (9 year remigration interval). Laid three clutches for season. **RECAPTURED** at Heron Reef 13 Feb. 1985. Laparoscopic examination showed she had not bred in 1983 or 1984 seasons and she was not vitellogenic in 1985. **RETURNED** to Mon Repos 16 Dec. 1986 (4 year remigration interval). Laid three clutches for season, nesting on Mon Repos and nearby Kellys Beach. Returned to Mon Repos in Dec. 1988 (2 year remigration interval). Laid three clutches at Mon Repos and Kellys Beach.
X54	**FIRST** tagged while nesting at Mon Repos on 15 Jan. 1975. Appears to have laid only one clutch for season. **RECAPTURED** 4 times at Heron Reef, 156 km from rookery, during 1975-1978. Departed Heron Reef on approximately 26 Oct. 1978. Arrived at Mon Repos on 02 Dec. 1978 (approx. 37 days later) (4 year remigration interval). Laid five clutches for season. **RECAPTURED** once at Heron Reef during 1979-1981. Returned to Mon Repos on 6 Dec. 1981 (3 year remigration interval) and recorded to lay one clutch for season. **RECAPTURED** 29 times at Heron Reef and one time at adjacent Wistari Reef during 1982-1985. Annual laparoscopic examination showed that she was not vitellogenic in 1982, 1983, or 1984, but was vitellogenic in 1985. Departed Heron Reef 24-26 Oct. 1985. Returned to Mon Repos on 30 Nov. 1985 (approx. 36 days later) (4 year remigration interval). Laid 4 clutches for season.
X198	**FIRST** tagged while nesting at Mon Repos on 15 Dec. 1974. Laid at least 2 clutches for season. **RECAPTURED** 2 times at Heron Reef, one time at Wistari Reef and 3 times at Heron Reef, 156 km from Mon Repos, during 1974-1984. Returned to Mon Repos on 3 Dec. 1984 (10 year remigration interval). Recorded laying one clutch for season. (No subsequent recaptures.)
X2031	**FIRST** tagged at Heron Reef 12 May 1975. Captured 25 times on Heron Reef during 1975-1985. Laparoscopic examination (July 1985) showed she had not bred in 1983 or 1984 but was vitellogenic in 1985. Recaptured nesting at Moon Cay on 07 Jan. 1986, 192 km from Heron Reef. **RECAPTURED** three times at Heron Reef during 1986-1987. Laparoscopic examination (Mar. 1987) showed she did not breed in 1986 and was not vitellogenic in 1987.
X2352	**FIRST** tagged at Wistari Reef 06 May 1976. Captured 4 times at Wistari Reef during 1976-1978. Recaptured nesting at Wreck Rock, 97 km away, on 20 Dec. 1978 and 17 Jan. 1979. **RECAPTURED** two times at Wistari Reef during 1979-1982. Recorded back nesting at Wreck Rock on 27 Dec. 1983 (5 year remigration interval). **RECAPTURED** at Wistari Reef 16 Aug. 1985.
X2606	**FIRST** tagged 10 May 1976 at Heron Reef. Next captured nesting at Mon Repos, 156 km distant, 11 Dec. 1976. Laid four clutches for season. **RECAPTURED** 19 times at Heron Reef during 1977-1983. Laparoscopic examination (Feb. 1983) showed that she had not bred in 1981 or 1982 and that she was not vitellogenic in 1983.
X2777	**FIRST** tagged at Wistari Reef 23 May 1977. Captured three times at Wistari Reef during 1975-1978. Recaptured nesting at Wreck Rock, 97 km from Wistari Reef on 23 Dec. 1978. **RECAPTURED** at Wistari Reef 24 Oct. 1979. Recaptured nesting at Wreck Rock on 30 Dec. 1982 (4 year remigration interval). Laid at least two clutches for season. **RECAPTURED** at Wistari Reef on 30 Aug. 1985. Laparoscopic examination showed she had not bred in 1983 or 1984 but that she was vitellogenic in 1985. (No subsequent nesting records.)

MAGNETIC ORIENTATION BY HATCHLING LOGGERHEAD SEA TURTLES

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Laboratory experiments were conducted to test the ability of loggerhead sea turtle hatchlings (Caretta caretta) to orient using the magnetic field of the earth. Hatchlings were tethered to a rotatable lever-arm apparatus which tracked swimming orientation in complete darkness. The orientation tank was enclosed by a Rubens coil that could be used to reverse the horizontal component of the geomagnetic field. All turtles were initially placed into the tank in the earth's magnetic field (coil off) with a light in the east. Hatchlings were permitted to swim toward the light for one hour or longer before it was turned off. The orientation of turtles swimming in complete darkness under one of two ambient magnetic field conditions was then monitored for several hours. Half of the turtles were tested in the unaltered magnetic field of the earth. The other half were tested with the horizontal component of the earth's field reversed by the Rubens coil.

Initial experiments indicated that turtles usually swam around the perimeter of the circular orientation tank repeatedly after lights were turned off. From time to time, however, turtles stopped circling and swam toward a specific direction for several (usually 3-10) minutes before circling again. In darkness, turtles thus typically alternated between relatively short periods of oriented swimming and longer periods of circling. A single mean angle (representing the average direction a turtle swam toward when not circling) was calculated for each of 16 turtles tested in the earth's field and 16 turtles tested in the reversed magnetic field.

Turtles were non-randomly oriented in both fields. The mean angle for the group tested in the earth's field was 42 degrees, and 14 of 16 animals had individual mean angles between magnetic north and east. The group tested in the reversed field had a mean angle of 197 degrees. Thus, when the magnetic field was shifted 180 degrees, the mean angle of turtle orientation showed a corresponding shift of 155 degrees. The distributions under the two magnetic field conditions were significantly different, indicating that loggerhead sea turtle hatchlings can detect the magnetic field of the earth and use it as a cue in orientation. The role of magnetic field detection in the migrations of sea turtles has not been determined.

ARE SEA TURTLES ATTRACTED TO PETROLEUM PLATFORMS?

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INTRODUCTION

More than 4,000 platforms are documented in the 1988 U.S. Coast Guard data base offshore of Louisiana. Current regulations require the removal of nonproductive petroleum platforms from federal waters. A common method uses explosives to shear the platform's support structures below the sediment line.

Loggerhead (Caretta caretta) and hawksbill (Eretmochelys imbricata) sea turtles have been reported to frequent hard bottoms and underwater structures. In the northern Gulf of Mexico, loggerheads are probably the most common sea turtle; hawksbills are believed to be uncommon. All sea turtles in the Gulf are federally protected species. The probability of sea turtles being near platforms, and perhaps impacted by the explosions used to remove platforms, has not been reported.

In June 1988, supported by Minerals Management Service's Environmental Studies Program, we began a 12 month study of the association between sea turtles and platforms offshore of Louisiana. Our study was primarily designed to study whether sea turtles are attracted to platforms. There are three other research questions having direct bearing on sea turtle conservation and addressed by our study: 1) are sea turtles similarly abundant among different habitats, 2) are sea turtles similarly abundant seasonally, and 3) are any other marine animals reliable indicators of habitats preferred by sea turtles?

METHODS

Five study areas, ranging from about 900 to 1300 km^2, offshore of Louisiana were selected. Areas with varying platform densities, ranging from none to many per unit area, occur in each study area. Sediment types vary among study areas. Water depths range from about 2 to 200 m but, in each study area, water depth is a constant among the differing platform density areas. One study area is east of the Mississippi River and near the Chandeleur Islands. These islands are used by nesting loggerheads. The other four study areas are west of the river, not near any known sea turtle nesting beaches, and range from near shore to about 150 km offshore.

We used data from the June through December surveys for analysis. Each study area was surveyed 4 or 5 times, depending on random selection, per month. Each survey consisted of a series of systematic transects from a single random starting location in each study area. Systematic transects insured similar coverage of the different platform density areas.

A Twin-Otter aircraft was flown at 229 m altitude and about 204 km/h ground speed. Two observers, one on each side of the aircraft, reported observations to the computer operator. Two types of sea turtles, leatherbacks (Dermochelys coriacea) and Chelonids (hard-shelled sea turtles), were easily differentiated. Chelonids were segregated to most probable species or classed as unidentified. The majority of Chelonids were either loggerheads or not identified; herein Chelonids are treated as a group. The computer was interfaced with a LORAN-C receiver and automatically recorded the study area, date, time, and location for each data record. Many observer supplied variables described the survey environment and animal behavior. A high resolution video camera, mounted in a open porthole, recorded the transect tracklines.

Line transect data analysis methods were used to estimate surfaced sea turtle abundance. For this paper we used two methods to study sea turtle association with platforms. We generated 10 repetitions of 100 random points in each study area. Correlations between the distances from each point to the nearest platform and the nearest turtle location were tested with Kendall's measure of rank association and Spearman's measure of rank correlation. The cumulative probabilities of observed and expected distances from turtle locations to the nearest platforms (Hamill and Wright, 1986, Ecology 67:952-957) were compared. We used radii increasing in 100 m increments to compare observed versus expected numbers of turtle sightings per distance interval. Evidence of attraction or repulsion was examined for significance with the Kolmogorov test statistic.

RESULTS

From June through December, a total of 142 sea turtles have been sighted. Thirteen have been leatherbacks, the other 129 have been Chelonids. Eight (62%) of the leatherbacks have been observed in one study area west of the river, usually associated with jellyfish. Surfaced Chelonid abundance was dissimilar among study areas. Seventy-eight (60%) of the Chelonids have been observed in the study area offshore of the Chandeleur Islands. In that study area, the averaged June through November density of surfaced Chelonids was 0.028 turtles/km^2, much greater than the average surfaced Chelonid densities for the same time period in the other four study areas (range 0.007 to 0.001 turtles/km^2).

Chelonids offshore of the Chandeleur Islands have been significantly associated with platforms. Both Kendall's and Spearman's tests found Chelonid locations positively correlated with platforms ($P < 0.01$). Hamill and Wright's (1986) test for dispersion indicated the association became significant in the 900-1,000 m distance interval ($P < 0.05$), and maximum significance occurred in the 4,800-4,900 m distance interval ($P < 0.001$).

Surfaced Chelonids were not associated with platforms in the other study areas (Kendall's and Spearman's tests; $P > 0.20$ for these studies). Results from the tests for dispersion indicated Chelonids were somewhat repulsed from the platforms in two of the study areas and randomly dispersed in the other study area. Too few sea turtles have been sighted in the deep water study area to allow significance testing.

Surfaced Chelonids in the study area offshore of the Chandeleur Islands have been most abundant in the southern portion, the area where platforms are most abundant. Fourteen percent of the turtles have been within 500 m of a platform, 30% within 1,000 m, and 45% within 1,500 m. West of the river, 7% of the surfaced turtles have been within 500 m, 14% within 1,000 m, and 23% within 1,500 m of the nearest platform.

If we assume adult loggerheads spend about 8% of the daylight hours on the surface (Nelson et al., 1987, NOAA Tech. Rept. NMFS 53:31), we can use a factor of 12.5 to calibrate estimated surfaced turtle abundance to total loggerhead sea turtle abundance. If we assume that the Chelonids are not territorial, that is, one turtle being near a platform does not affect the probability of another being nearby, and then randomly pick a Chandeleur Island study area platform, the probability of one or more Chelonids being within 500 m would be about 0.27, within 1,000 m about 0.50, and within 1,500 m about 0.65. West of the river, the probability of one or more Chelonids being within 500 m of a randomly selected platform would be about 0.04, within 1,000 m about 0.08, and within 1,500 m about 0.13.

DISCUSSION AND CONCLUSIONS

Offshore of the Chandeleur Islands, the greater abundance of sea turtles, along with either an attraction for platforms or an attraction for the platform area, increases the probability that a Chelonid, probably a loggerhead, will be near a platform. West of the river, because Chelonids are more uncommon and because they do not appear to be attracted to platforms or platform areas, the probability of a sea turtle being near a platform is much less, but not inconsequential.

LOGGERHEAD SEA TURTLE NESTING: KIPARISSIA BAY, GREECE

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Three species of marine turtles are found in the Mediterranean; the loggerhead turtle (Caretta caretta), the green turtle (Chelonia mydas), and the leatherback turtle (Dermochelys coriacea). Of these, only the loggerhead turtle is known to nest on the Greek shoreline. Extremely important nesting areas for Caretta were discovered in 1977 on the island of Zakynthos (Margaritoulis 1982), where the main conservation effort and research concentrate. Nevertheless, regular nesting by Caretta occurs in other areas, too. One of them is the coast of Kiparissia Bay (Figure 1) on the western Peloponnesus. This area is characterized by extensive sandy beaches and very low housing and tourist development.

During 1987, 44 km of sandy beach along the Bay were surveyed regularly using All Terrain Cycles (ATCs). Nesting started on 10 June and ceased on 24 August. During this period, 1,534 loggerhead turtle emergences, including 598 successful nestings, were recorded. Nesting concentrated in the southern part of the Bay where nesting density reached 86.8 nests/km.

A 3 km beach length, at the most turtle-frequented sector, was patrolled on foot during the night by two tagging teams. Turtles were allowed to nest and were then tagged; if the turtle was already tagged, the tag number(s) were recorded. Tags were applied to the trailing edge of the fore or hind flippers. Prior to tagging, the flippers were examined at the standard tagging sites for scars or callouses attributed to lost tags. Three types of tags were used; monel No. 49, monel No. 681, and plastic "rototags". Seventy-four adult female turtles were encountered during the season. Of these, 27 individuals were seen again during the same season. The mean inter-nesting interval was found to be 15.2 days. Prior to (or following) tagging, four carapace dimensions were measured. Mean curved carapace length was 83.1 cm (sd=4.7, n=72), which confirms further the fact that loggerheads nesting in Greece are smaller than loggerheads nesting in other parts of the world (Margaritoulis 1982).

All nests laid in a 1.6 km sample beach sector were monitored during the season to determine their fate. From 91 nests found in this sector, 44 (48.4%) had been disturbed by predators (but only three were totally destroyed) and 27 (29.7%) had been inundated at least once by seawater. The primary nest predators were the red fox (Vulpes vulpes) and stray dogs. Excavation of undisturbed nests, after termination of hatchling, showed that the percentage of emerged hatchlings was 54.9%. Most of the depredated and/or inundated nests also produced hatchlings, but their hatch rate was lower. Clutch size, determined by excavation of nests after termination of hatching, was found to be 117.7 eggs (sd=22.7, n=52 clutches). Incubation period, i.e., the elapsed time in days from oviposition until the appearance of the first hatchling on the surface, was 55.5 days (sd=6.2, n=50).

An experimental beach hatchery was established on the high beach where 10 nests (1,079 eggs) were transplanted within 12 hours of oviposition. The overall hatch rate in the hatchery was 63.7%; higher than the mean hatch rate of nests incubated in situ (54.9%). Taking into account the loss due to nest predation and inundation, the difference becomes even more significant.

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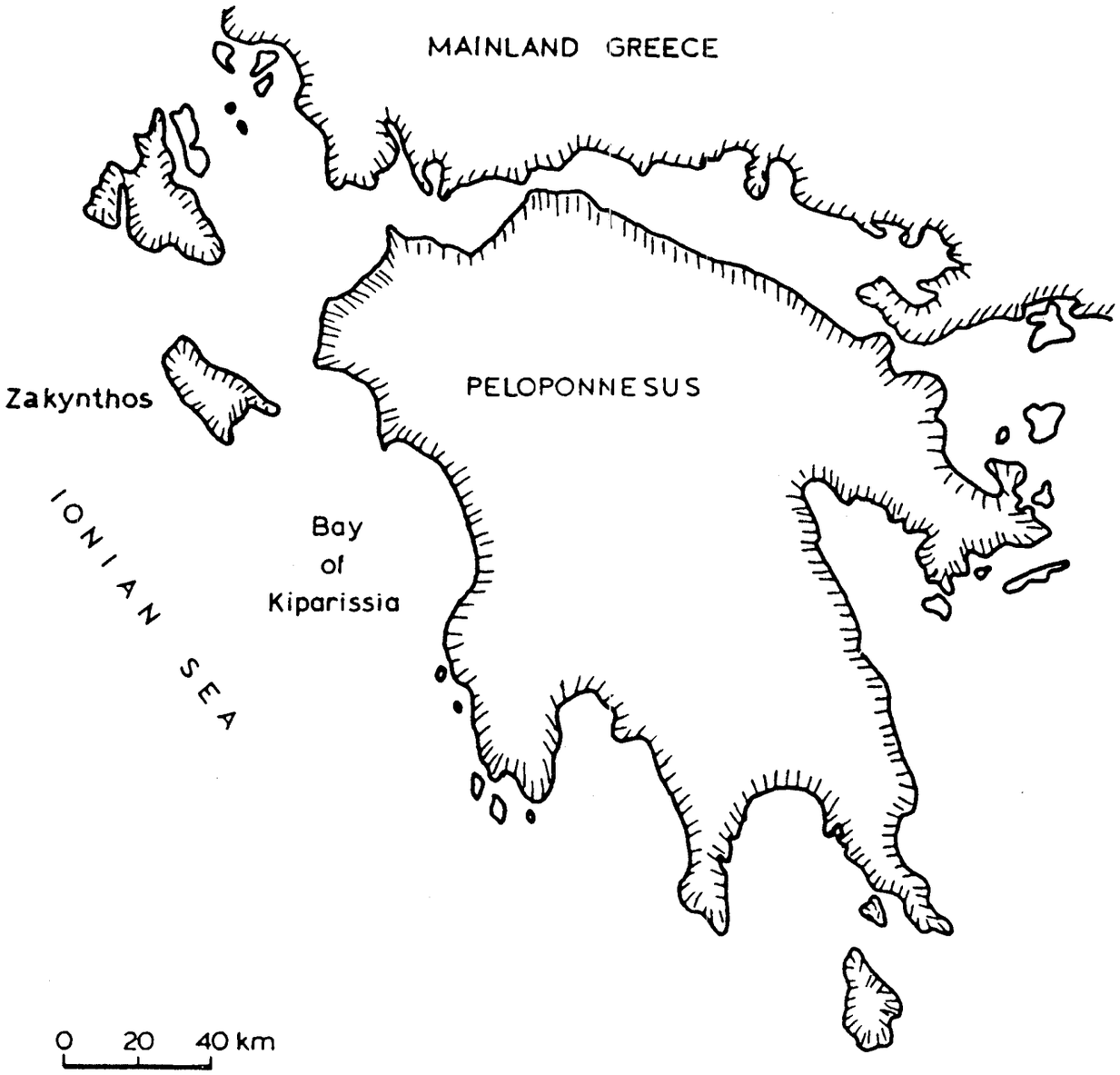

FIGURE 1. SKETCH MAP OF SOUTHWESTERN GREECE INDICATING THE POSITION OF THE BAY OF KIPARISSIA.

NOTES ON THE REPRODUCTION OF THE KEMP'S RIDLEY AT RANCHO NUEVO

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It has been observed for sometime that fecundity seems related to age. Older turtles are more prolific, in that they lay more eggs per nest and more nests per season than younger turtles. During the 1988 season, survivorship and clutch size were analyzed as a function of age (number of seasons that a female turtle is observed at the nesting beach). Hypotheses derived from these analyses must be tested with further statistical studies.

METHODS

The reproductive behavior of two age groups was analyzed during the 1988 season, the neophytes (or "young") nesting turtles and the remigrants (or "old") nesting turtles. Our sample size comprised 390 neophyte and 120 remigrant Kemp's ridley (Lepidochelys kempi) turtles and the nests and hatchlings produced by each of these groups. A turtle is considered a remigrant or "old" turtle if it nests at the Rancho Nuevo beach and bears a tagging scar or a flipper tag of any kind that is recognized as our tag. Any turtle that arrives to nest but does not have a tag or tagging scar is considered a neophyte or "young" turtle.

RESULTS

The number of eggs (clutch size) is affected by internal physiological factors, one being the age of the turtle. As in previous years, remigrant females exhibited higher fecundity than neophytes. The mean number of eggs laid per clutch by remigrants and neophytes for total visits was 104.6 and 101.5, respectively (Table 1). A better rate of hatching success for large clutches ($\geq$120 eggs) laid by remigrants was observed (8.5% for remigrants versus 73.9% for neophytes) (Table 2) indicating that older turtles may achieve more reproductive success. However, predation should also be included in these analyses to avoid biased results, but the effect of predation has not yet been measured statistically.

Individual females laid from one to three or (sometimes) four nests during the season. The mean obtained for 1988 was 1.47 nests/turtle for all females, 1.55 nests/turtle for remigrants, and 1.45 nests/turtle for neophytes (Table 1), but these ratios are expected to change each season and must be evaluated annually. From these ratios it is possible to estimate the total quantity of eggs produced annually by each age group, with remigrants and neophytes laying an average of 162.1 eggs/turtle and 146.7 eggs/turtle, respectively.

The majority of sea turtle species exhibit a relatively constant internesting interval between consecutive nestings throughout a season and for all ages of turtles, but this may not be the case with the Kemp's ridley. If we analyze the internesting interval of all Rancho Nuevo nesting females, we find the most common intervals to be 26-30 days. However, if we analyze separately for the two age groups (Figures 1A, 1B), differences of behaviour between the old and young turtles can be found. In this case, there are apparently two internesting intervals commonly exhibited by the remigrants, one internesting interval being 18-20 days and the other being approximately 38 days. This behaviour is less clear for neophytes.

Because weather at the nesting beach changes during the nesting season, from cool to warm and from dry to wet, it follows that the elapsed time of incubation is affected by these changes. Thus, nests that are laid at the beginning of the season (cool and dry) will exhibit a longer period of incubation than nests laid at the end of the season (warm and wet). We observed that the variation in incubation period is greater for

neophytes than remigrants. Furthermore, in the case of the neophytes, the nests obtained during July were maintained in polyurethane boxes and did not follow the normal pattern of incubation exhibited by the remigrants.

Mean clutch size affects the elapsed time of incubation, in that incubation time is inversely related to clutch size. Again, this behaviour is shown more clearly by the remigrant turtles than by the neophytes. Incubation time decreases at the rate of T = -0.032 days for each increment of five eggs in the clutch, and this rate is valid for clutch sizes of 25-150 eggs, resulting in a range of 48-55 days of incubation.

In addition, incubation success is directly related to clutch size for another reason, in that the proportion of hatchlings increases directly with the number of eggs in a clutch up to an optimal range between 102-111 eggs. Smaller clutches are, perhaps, more vulnerable than larger clutches to the wetness or dryness of the weather. Similarly, in larger clutches (> 106 eggs/clutch), the weight of the upper layers of eggs may damage the lower layers. Therefore, during the 1988 season, all Rancho Nuevo clutches in excess of 119 eggs were subdivided for incubation to enhance the hatching success rate of the larger clutches (Table 2) which normally exhibit lower hatching success rates than medium sized clutches. In previous seasons, mean hatching success for all nests was $\leq$70%, while mean hatching success of the larger clutches was $\leq$60%.

The mean number of hatchlings per nest is related to an optimum elapsed time of incubation as well as to clutch size. In 1988, optimum hatching success occurred within a range of 48-52 days for neophyte ridleys and 50-53 days for remigrants. Over and under these ranges, hatching success decreased.

Hatching success varies with season. In 1988, the best yield was obtained from those nests laid during May, but a clear difference between neophytes and remigrants for this behavior was not apparent. Remigrants but not neophytes exhibited higher hatching success in May relative to other months. May and the beginning of June were also the months when the "old" turtles exhibited the highest nesting frequency. Hatching success was affected adversely by the weather; April was cold and dry and July had heavy rains.

In summary, remigrant ("old") Kemp's ridleys exhibited higher fecundity than neophyte ("young") animals because of a more condensed (short) nesting season, larger clutch sizes, and shorter internesting intervals between consecutive nestings (Table 1), but the vagaries of weather also play a big part in overall hatchling production. It is also necessary to investigate whether the nest site chosen by remigrants is, in general, more fit than the average nest site chosen by neophytes. If so, a behavior pattern of this kind would be expected to affect the differential survival rates of the two age groups.

Table 1. Relation of egg and hatchling production, between neophyte ("young") and remigrant ("old") Kemp's ridley turtles during the 1988 Rancho Nuevo nesting season.

	1st Nesting Visit			2nd Nesting Visit			3rd Nesting Visit			Total Visits		
NEOPHYTES	Nests	Eggs	Hatchlings	Nests	Eggs	Hatchlings	Nests	Eggs	Hatchlings	Nests	Eggs	Hatchlings
Total	271	27352	21393	96	10080	8241	25	2347	1675	392	39779	31309
Mean		100.93	78.94		105.00	85.84		93.88	67.00		101.48	79.87
R.F.	1.00	1.00	1.00	0.354	0.37	0.39	0.092	0.09	0.08	1.446	1.45	1.46
REMIGRANTS												
Total	80	8329	6464	34	3722	2903	10	916	736	124	12967	10103
Mean		104.11	80.80		109.47	85.38		91.60	73.60		104.57	81.48
R.F.	1.00	1.00	1.00	0.425	0.45	0.45	0.125	0.11	0.11	1.55	1.56	1.56
ALL TURTLES												
Total	351	35681	27857	130	13802	11144	35	3263	2411	516	52746	41412
Mean		101.65	79.36		106.17	85.72		93.23	68.89		102.22	80.26
R.F.	1.00	1.00	1.00	0.37	0.39	0.4	0.10	0.09	0.09	1.47	1.48	1.49

R.F. (relative fecundity) = Proportion (relative to 1st nesting visit) of nests, eggs, and hatchlings produced on first, second, and third nesting visits and (cumulatively) for total visits.
Number of nests is equivalent to number of turtles except in the case of total visits.

Table 2. Relative fecundity between neophyte ("young") and remigrant ("old") Kemp's ridley females and between large and small clutch sizes during the 1988 nesting season. Clutches > 120 eggs were divided in half prior to reburial

		Clutch Size Categories		
		(All) Clutches	(<120) Eggs/clutch	(>120) Eggs/clutch
NEOPHYTES	Total Clutches	390	330	60
	Total Eggs (E)	39536	32046	7490
	Mean Eggs/clutch	101.37	97.11	124.83
	Total Hatchlings (H)	31250	25711	5539
	Mean Hatchlings/clutch	80.13	77.91	92.32
	%S [100*(H/E)]	79.04	80.23	73.95
REMIGRANTS	Total Clutches	120	95	25
	Total Eggs (E)	12568	9352	3216
	Mean Eggs/clutch	104.73	98.44	128.64
	Total Hatchlings (H)	10028	7287	2741
	Mean Hatchlings/clutch	83.57	76.71	109.64
	%S [100*(H/E)]	79.79	77.92	85.23
ALL TURTLES	Total Clutches	510	425	85
	Total Eggs (E)	52104	41398	10706
	Mean Eggs/clutch	102.16	97.41	125.95
	Total Hatchlings (H)	41278	32998	8280
	Mean Hatchlings/clutch	80.94	77.64	97.41
	%S [100*(H/E)]	79.22	79.71	77.34

%S = Mean Survival rate of hatchlings

Fig. 1A: Elapsed Time in Days Between Nesting Kemp's Ridley Neophytes, Rancho Nuevo, 1988

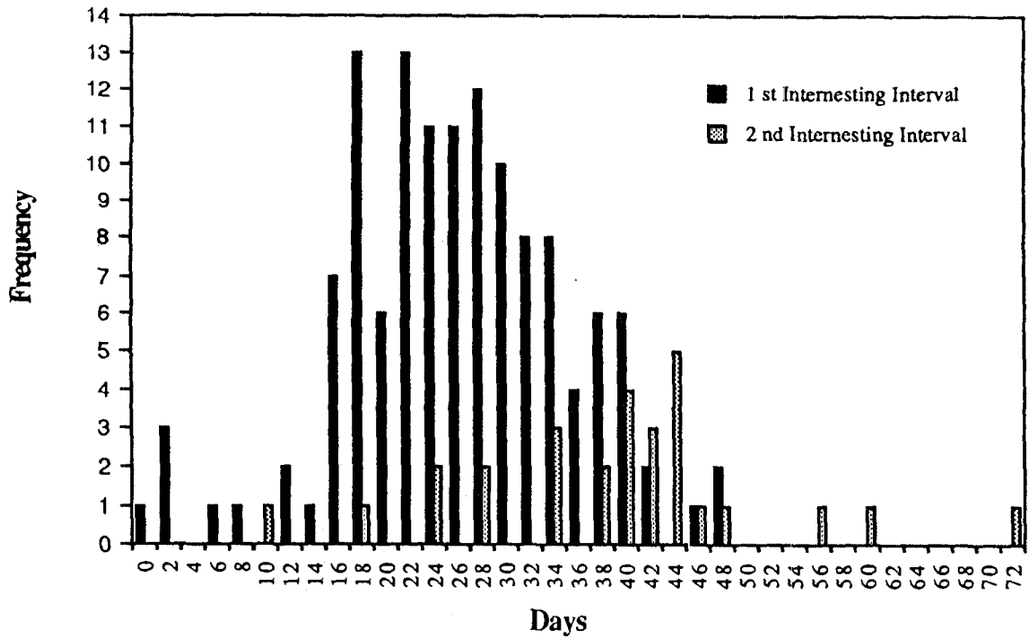
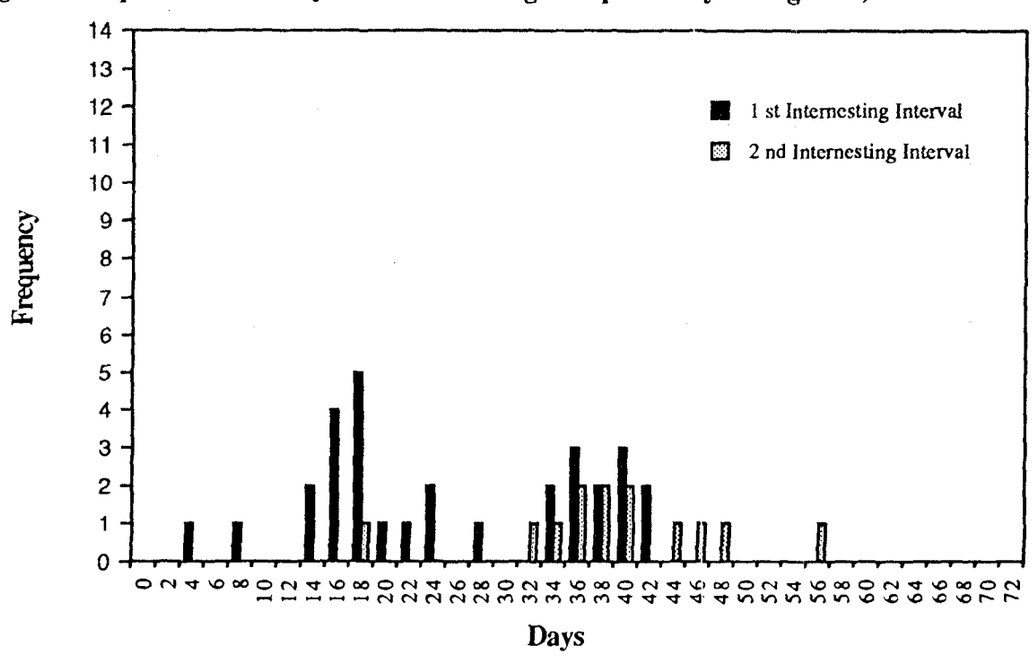


Fig. 1B: Elapsed Time in Days Between Nesting Kemp's Ridley Remigrants, Rancho Nuevo, 1988



LONG-TERM TRENDS IN SEA TURTLE NESTING ON HUTCHINSON ISLAND, FLORIDA

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Hutchinson Island, a barrier island 36 km in length located on the southeast coast of Florida, has long been recognized as an important rookery for loggerhead turtles. Systematic sea turtle nesting surveys began on Hutchinson Island in 1971 when the island was relatively undeveloped. During the 18-year study period (1971-1988), considerable coastal construction has taken place. In this paper we relate several aspects of coastal development to the spatial distribution of loggerhead nesting on the island and examine the long-term trend in loggerhead nesting.

In 1971, nine survey areas (each 1.25 km in length) were established along Hutchinson Island. These areas were monitored for nests and non-nesting emergences (false crawls) five mornings per week (Monday through Friday) throughout the nesting season. Surveys were conducted every other year from 1971 through 1979. In 1981 a number of changes were made to the program. Rather than monitoring just the nine survey areas, the entire Atlantic coastline of the island was monitored using 36 survey areas each 1 km long; the original nine areas were retained for comparative purposes. In addition, 1981-1988 surveys were conducted seven, rather than five, days per week and on an annual, rather than every other year, basis.

Spatial trends in nesting may be related to conditions encountered by turtles prior to or after emerging on the beach. Since the distribution of total emergences on Hutchinson Island followed the same trend as the distribution of nests (Figure 1), the observed spatial patterns apparently resulted from conditions affecting emergence rates rather than conditions encountered by turtles after they emerged.

Extremely low emergence rates in the northernmost areas may be related to coastal development in those areas. Areas A and B are highly developed and characterized by little or no dune and very sparse vegetation. These conditions may result in an unacceptable horizon for reproductive females (Hughes 1974) and thus may explain low emergence rates in these areas. Also, Areas A and B and the northern portion of Area C have historically been characterized by intense beachfront lighting. Since these areas are highly accessible to the public, it is probable that beachfront lighting made human activity on the beach more conspicuous to turtles and therefore more of a deterrent to emerging. A similar combination of lighting and human activity was apparently responsible for conspicuously low numbers of emergences and nests in Area Z. This area includes a motel with intense beachfront lighting adjacent to a large public beach which was also illuminated.

The effects of lights and human activity on turtles were also investigated in the vicinity of a power plant near the center of the island. During years of power plant intake and discharge pipe installation, emergence rates were reduced on beaches adjacent to the power plant. Apparently, lights and nighttime construction activities deterred turtles from emerging. However, after construction activities were completed and all structures were removed from the beach, no effect on sea turtle nesting was indicated during years of power plant operation. This lack of effect is attributable to the following factors: 1) the power plant is located more than 0.5 km west of the beach, 2) there is a vegetated dune between the plant and the beach, 3) there is no beachfront lighting in the vicinity of the plant, and 4) access to the beach is limited at night. Thus, potential disturbances to turtle nesting behavior were either eliminated or minimized after construction activities were completed.

Similar conditions may explain why emergence and nesting rates were generally high on the southern half of the island where considerable development exists. Much of the development in this area is buffered by vegetated dunes and beachfront lighting is minimal in most areas. Though nest densities have been high on the developed southern half of the island, this situation is subject to change. Additional residential structures are being built and occupancy rates of existing structures continue to increase. Associated increases in human activity on the beach at night are inevitable and may result in a decrease in nest densities. To date, the use of erosion control structures which may deter turtles from nesting has been limited on Hutchinson Island. However, because of the dynamic nature of the island's Atlantic coastline, there is the potential for increased impacts on nesting from future erosion control measures.

Long-term trends in annual nest counts may provide information concerning the suitability of beaches for sea turtle nesting. Prior to establishing the long-term trend in nesting on Hutchinson Island, we had to resolve differences in methodologies between the 1971-1979 and 1981-1988 surveys. Since the same nine survey areas were monitored throughout both periods, we used nine-area nest counts as the basis for examining long-term trends. Nine-area trends paralleled whole-island trends between 1981 and 1988 and were assumed to have represented whole-island trends throughout the entire study. Analysis of annual data collected from 1981 through 1988 indicated that every-other-year nest counts were not biased towards high or low nesting and, therefore, 1971-1979 data could be combined with 1981-1988 data to establish the long-term trend in nesting. Finally, we had to address the lack of weekend monitoring during the earlier surveys. We found that the proportion of nests recorded on weekends during 7-day/week surveys (1981-1988) remained constant from year to year. We therefore used this proportion to estimate total nesting from 5-day/week nest counts (1971-1979).

Estimates for 1973 through 1979 (1971 data were in a format that precluded calculation of estimates) were combined with recorded data for 1981 through 1988 to establish the 16-year trend in loggerhead nesting (Figure 2). When the data were fit to a linear regression model and tested by means of a t-test, no significant ($p \leq 0.05$) increase or decrease in nesting was indicated. Though no long-term decline in nesting has been indicated during this period of coastal development, increases in human activity on the beach at night as well as additional erosion control measures are expected in the future and may negatively impact nesting. It is imperative, therefore, that systematic sea turtle nesting surveys continue on Hutchinson Island.

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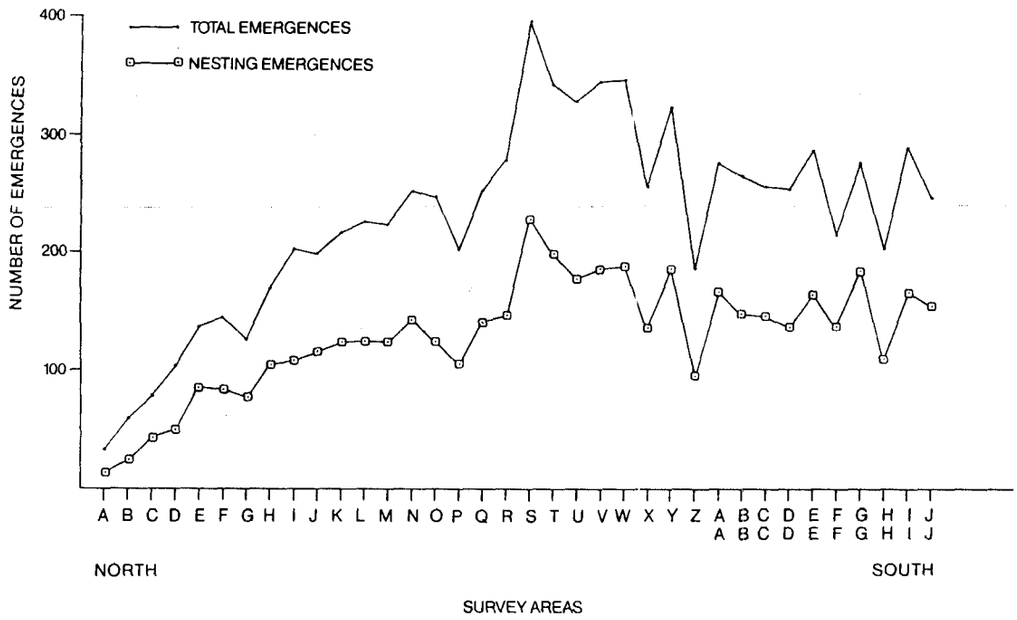

Figure 1. Mean annual numbers of loggerhead emergences (total and nesting) for each of the thirty-six 1-km-long areas comprising the Atlantic coast of Hutchinson Island.

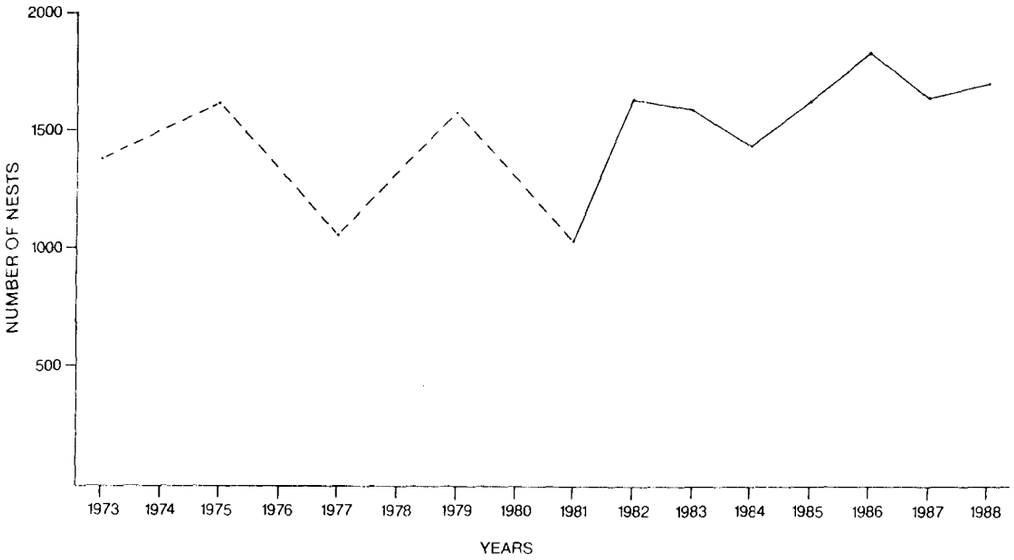

Figure 2. Annual numbers of loggerhead turtle nests in the nine 1.25-km-long survey areas, Hutchinson Island. Numbers for 1973-1979 are estimates; numbers for 1981-1988 are recorded values (see text).

A METHOD FOR EVALUATING THE EXCLUSION OF JUVENILE SEA TURTLES FROM TURTLE EXCLUDER DEVICES (TEDs)

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INTRODUCTION

The incidental capture of sea turtles in shrimp trawls is a significant cause of sea turtle mortality. All sea turtles in United States waters are Federally listed as endangered or threatened. Current regulations require the use of Turtle Excluder Devices (TEDs) in specified waters during certain seasons. Regulations requiring TED use in other areas are pending.

TEDs evolved from simple webbing barriers to solid deflector grids and more complex "trap door" devices (Watson and Seidel 1980, ICES, CM 1980/B:31). Currently, six TED designs have been certified for commercial use. A candidate TED must exclude 97% of captured turtles when tested near Port Canaveral, Florida USA. Turtles which are captured during certification tests have been primarily large loggerhead turtles (Caretta caretta). Concern over TED effectiveness on small turtles, in particular the endangered Kemp's ridley (Lepidochelys kempi), prompted the need to conduct our study.

We studied the efficiency of six TED designs. Major research questions were: 1) were the TEDs similar in ability to exclude small turtles?, 2) was the time the turtles spent in the TED similar among TEDs?

METHODS

We used underwater observation and videography to document TED performance. Six currently certified TEDs were selected representing three categories of TED design (Table 1). A commercial shrimp trawler was used to test TED-equipped trawl nets in water 6-7 m deep just offshore of Panama City, Florida. The trawling speed was 4.5 km/h. Each TED was installed in a 19.8 m (65 ft) headrope length trawl in accordance with the TED manufacturers specifications. Frame and grid TED designs were tested with accelerator funnels. Designers of TEDs were invited to participate in the trials and, at the end of the study, efforts were made to enhance the turtle exclusion abilities of some TEDs.

We obtained 150 juvenile green sea turtles (Chelonia mydas) from Clearwater Marine Science Center (Clearwater, Florida) and used them as surrogate wild small sea turtles. The turtles were about two years old and had a mean carapace length of 34 cm. A total of 20 turtle releases comprised each TED test. Each TED test was divided into two release trials (10 turtles per trial). Order of TED trial was randomly selected.

Turtles were kept in an open water enclosure in St. Andrews Bay. Each morning turtles were removed from the pen and placed aboard the vessel. Turtles were maintained on board in a covered holding tank partially filled with circulated sea water. Once offshore, individual turtles were placed in a weighted bag and sent down a messenger wire. A diver at the mouth of the trawl released the turtle behind the nets leading edge. Once in the TED, if the turtle did not escape within two minutes, the turtle was manually released. Data recorded included: time from turtle release to TED encounter, time from encounter to escape or removal, subjective turtle vitality and water turbidity rankings. Chi-square tests and Fisher's Exact Probability tests were used to compare the exclusion abilities of the six TED designs. A one-sided k-sample Smirnov test was used to compare the length of time turtles spent in the TEDs.

RESULTS

The Chi-square test for differences in probabilities indicated that not all TEDs were similar in small turtle exclusion ($P < 0.001$, Table 1). Comparison between TEDs for small turtle exclusion found two dissimilar groups of TEDs (Table 2). The Morrison, NMFS [National Marine Fisheries Service], and Georgia top-opening TEDs were similar and fairly efficient in excluding small turtles. The Georgia bottom-opening, Parrish, and Saunders TEDs comprised the other group which were similar and relatively less efficient in small turtle exclusion. The times small turtles spent in the TEDs were not similar among TEDs. Significantly less time was spent in the more efficient TEDs. Most escaping turtles escaped in the first minute after TED encounter. Post testing modification to some TED designs seemed to improve their exclusion efficiencies.

DISCUSSION and CONCLUSIONS

When captured in trawls, sea turtles look for openings. In our study, the relatively clear water may have enhanced turtle escapement. We wanted to ensure that no turtles were killed by our experiment and some turtles might have escaped if they had been left in the TED for more than two minutes. The juvenile green turtles were in good health and generally very active, but it is not known how their vitality would compare to wild juvenile turtles. Our experiment indicated that currently certified TEDs are not equally efficient in small turtle exclusion. Further research using this technique could improve the exclusion efficiency of present and future TEDs. Reducing juvenile sea turtle mortality caused by shrimp trawls may enhance the survival of sea turtles.

Table 1. Comparison among TEDs for ability to exclude small turtles. Twenty turtles were used to test each TED. TEDs were not similar in exclusion abilities (Chi-square test = 25.8, 5 df, P < 0.001).

TED TYPE	NUMBER OF TURTLES ESCAPED	RETAINED	PERCENT ESCAPED
Soft TEDs			
Morrison	20	0	100
Parrish	11	9	55
Rigid Frame with Door			
NMFS*	19	1	95
Saunders	10	10	50
Simple Grid			
Georgia Top Opening	18	2	90
Georgia Bottom Opening**	13	7	65

* NMFS = U.S. National Marine Fisheries Service
** The Georgia Jumper was tested with an accelerator funnel which is not recommended by the designer.

Table 2. Comparisons between TEDs for efficiency of small turtle exclusion. Probability values are results of Fisher's exact probability tests and test the hypothesis: the TEDs are similar in small turtle exclusion abilities. We accept the hypothesis if P < 0.05, the Morrison, NMFS, and Georgia Top Opening TEDs were similarly efficient. The Georgia Bottom Opening, Parrish, and Saunders TEDs were similarly less efficient.

TED TEST	NMFS	GA TOP	PROBABILITIES: GA BOTTOM	PARRISH	SAUNDERS
MORRISON	0.05	0.24	< 0.01	< 0.01	< 0.01
NMFS		0.38	0.02	< 0.01	< 0.01
GA TOP			0.05	0.01	< 0.01
GA BOTTOM				0.21	0.16
PARRISH					0.24

OCCURRENCE OF LEATHERBACK TURTLES (DERMOCHELYS CORIACEA) IN THE BRITISH ISLES IN 1988 WITH REFERENCE TO A RECORD SPECIMEN

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This paper presents a very preliminary analysis of British Isles turtle records received to date for 1988. Previously, only 2-3 individual turtles were recorded (1987), all in the English Channel, although fair numbers of jellyfish were present. An enormous influx of medusoids characterized 1988, especially Rhizostoma octopus and Cyanea sp., moving into the South-Western approaches, the Celtic Sea, and the English Channel. The first sighting of a leatherback turtle (Dermochelys coriacea) was in June, 40 miles northwest of Bishop Rock, and no additional sightings were reported until 1 August. From then until 2 October, a total of 24 sightings and strandings were received, all in the southwestern sea areas. Of 11 strandings, six mortalities were directly attributable to entanglement in fishing nets or lines. Another five strandings were too decomposed to assess cause of death. Although ship propeller damage was apparent, the animals may have been struck after death. One live specimen was recorded on a beach at Llangranog, Wales, on 10 September; it returned to sea before dawn on 11 September.

This number of sightings in 1988, including male and female individuals all in excess of six feet carapace length, is almost equal to the total number of records for the same region up to 1970, as reported by Brongersma (1972). Interestingly, no records for 1988 have been collected from the North Sea, Scotland, or Northern Ireland, although 31 records for these areas were reported up to 1970. No species of turtle other than leatherback were reported in any of the regions. Lazell (1980) links movements of leatherbacks off the North American coast northwards to Iceland and Norway with the frequency of Cyanea sp. The 1988 occurrence of leatherbacks in the British Isles is obviously linked to the concentration of medusoids. The main concentration of European sea turtle records in the past, however, has been in the Bay of Biscay, especially in the Loire-Gironde (Chante-Maritime) (Duguy 1986). The 32 French records for 1985 were collected primarily in August and September, the same period as for the British 1988 records.

A cursory look at published records up to 1970 (Brongersma 1972; Figure 32) shows different occurrence peaks between the northern (British) areas and central areas. One may postulate that the record influx in the southern part of the northern zone in 1988 represents those animals normally recorded off the mid-French coast. This can be tested when the French records for 1988 become available. This explanation for the observed distribution may be too simple, however. It could be that the leatherbacks normally off the coast of North America came across in larger than usual numbers in 1988 on a more southerly Gulf Stream track, following movements of a major food source. It may be that there is a correlation with broader oceanographic shifts, the southwestern areas of Britain being affected both by the Gulf Stream and the Mediterranean Lusitanian influences. When more data are available, this can be checked, and it may be useful to examine records of turtles and some of the procellarid shearwaters to see if occurrences in peak years match. The 1988 records of leatherbacks were distributed as follows: Eire (2), Wales (9), Bristol Channel (3), Cornwall (3), South Devon/Dorset (7).

It was one of these specimens which created tremendous publicity in Britain and elsewhere, as the animal proved to be the largest authenticated leatherback ever recorded. The turtle publicity gained in this manner induced three additional sightings from yachtsmen. The 'record turtle' was a male who died when it became entangled in whelk fishing lines four miles off Porthmadog, Gwynedd, Wales, on the afternoon of 22 September 1988. It was dead when cut from the winch lines by fishermen and was washed ashore at Harlech Beach, opposite the castle, where it was found on 23 September. Because the turtle was so fresh, the National Museum of Wales agreed to collect it so that both tissue samples and morphology could be studied. Approximately 36 hours after death, the animal was transferred to cold store at -10°C. While being transferred, it was lifted by weighing crane (since checked for accuracy!) and was found to weigh

18cwt (= 2,016 pounds, or 916 kg). It was not measured immediately because the primary objective was to freeze the animal. The specimen was measured after defrosting and prior to necropsy.

Total length over carapace (nose to tail) =113.5 in (291 cm).
Dorsal width (flipper tip to flipper tip) =108 in (277 cm).
Ventral length (nose to tail) =101 in (259 cm).
Ventral width (flipper tip to flipper tip) =99 in (254 cm).
Body depth (max. anterior) =37.5 in (96 cm); body width (max. anterior) =56 in (144 cm).
Flipper length (wrist to tip) =36 in (92 cm).
Nuchal\ carapace points =35 cm.
Carapace (median dorsal curve) =159 cm. (This is a correction from the curved carapace length reported in Eckert and Luginbuhl 1988, of 256.5 cm).
Carapace (paramedial to carapace edge; not tip) =148 cm.
Carapace (straight ventral width) =96 cm.

Carapace measurements were taken after the internal organs had been removed and are, therefore, smaller over the curve but possibly greater on the straightline width than what would be expected before the animal was eviscerated. [Note: carapace was measured along the top of the median carapace ridge, as opposed to alongside the ridge as is standard.] The work on the carcass was directed both for tissue sampling and for eventual display. Dr. John Davenport and Dr. David Holland of the School of Ocean Sciences, University College of North Wales Bangor took samples of fat, heart, lung, muscle, and other tissues for heavy metals, PCBs, and chlorinated hydrocarbon analyses. These results are expected in two months and will be published with additional measurements. The lungs were found to be collapsed and completely hemorrhaged. The heart was preserved in formalin, and the gut was measured and preserved along with its contents. Gut measurements were as follows: esophagus =184 cm; stomach (proximal) =37 cm; stomach (central) =77 cm; stomach (distal) =53 cm; small intestine =863 cm; large intestine =238 cm; rectum =52 cm. No large cestodes were found, but preliminary findings include jellyfish in the esophagus, a piece of polyethylene 9 in x 6 in (23 cm x 15 cm) compressed into a very small ball and found directly posterior to the stomach in the small intestine. Also found was a circular ball of unknown content at the ileo-caecal junction, as reported by other workers. Ventral skin ossicles were removed hopefully to assist in aging. A four hour video has been made. With the help of Chris Luginbuhl of the David Luginbuhl Research Institute for Endangered Species, Jim Hubbard and Ann Heimann filmed and color photographed the necropsy to preserve a complete record.

Work on the specimen continues. The flippers have been molded in silicon rubber, and the carapace, skin, and skull are now being carefully degreased as a single unit. If all problems are solved, the actual specimen will be the centerpiece of an exhibition in December 1989. It is hoped that such an exhibition will increase people's knowledge of turtles and the need for conservation of these animals and of the marine environment.

ACKNOWLEDGEMENTS

I am especially grateful to the British Museum of Natural History and to Roger Penhallurick of the Truro Museum, Cornwall, for access to their records and to the former for assistance from staff for the necropsy.

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SEA TURTLES IN LONG ISLAND SOUND, NEW YORK: AN HISTORICAL PERSPECTIVE

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The Okeanos Ocean Research Foundation has been studying the occurrence, distribution and behavior of sea turtles in Long Island, New York waters since 1985. During the four years of intensive research, Okeanos has encountered many more sea turtles than were previously reported, or expected, from this region. Although sea turtles were found to be common in Long Island waters, there existed a possibility that this abundance represented a new phenomenon of sea turtle distribution.

The objective of this study was to search historical records for any indications of sea turtles in Long Island waters prior to our studies. We were specifically interested in determining differences or similarities between historical patterns of occurrence, abundance, and distribution and current patterns.

Sources of historical information on Long Island sea turtles were widespread and varied. Museums and archives throughout New York State provided specimens, old manuscripts and scientific publications. These well-documented records provided good quantitative data from which graphical analyses could be performed. In addition, other more qualitative sources such as photographs, personal letters, logbooks and non-scientific writings were examined. All of these sources were useful in determining past usage of Long Island water by sea turtles.

The information presented here includes only sea turtles of the taxonomic family Cheloniidae.

The earliest record of a sea turtle in Long Island was a carapace of a small Kemp's ridley or a loggerhead uncovered in a prehistoric Indian archaeological site (Fig. 1). Many more records of turtles were found for the early 1900's. In a general account of reptiles in Long Island (Engelhardt 1913), loggerhead and green turtles are noted as drifting up from the Gulf States during the summer months. Murphy (1916) described loggerheads, hawksbills and green turtles as regular summer visitors to the Long Island area; he reported finding five small loggerheads on the same beach in one day in late November. During the same period, Latham (1969) reported many observations of sea turtles on the east end of Long Island. Walking just a few miles of beach, he often saw 4 to 6 loggerheads and Kemp's ridleys per year. In 1924, Latham encountered 103 dead Kemp's ridleys and loggerheads on a 3 mile stretch of beach in one day.

Although the Kemp's ridley was described by Garman in 1880, it is likely that this species was confused with the loggerhead and the hawksbill in the early 1900s. Hawksbills were listed as common, but we have only been able to verify one specimen from New York waters. In retrospect, Latham wrote that he did not recognize the Kemp's ridley as a distinct species prior to 1925. Since then he noted that Kemp's ridleys and loggerheads were both common in eastern Long Island.

Loggerheads and Kemp's ridleys historically occurred throughout the Long Island Sound and along the south shore, especially in the New York Harbor (Fig.2). De Sola (1931) reports that the Kemp's ridley was the sea turtle species most commonly found in New York Harbor and that the loggerhead was the second most common.

The historical data include records up to the early 1970's. This provided a continuum to which our current data could be added. Since 1985, we have encountered more than 280 sea turtles in Long Island waters and more than 220 of these have been Chelonid turtles (Figs. 3,4). Overall, the Kemp's ridley has been the most frequently encountered, followed by the loggerhead.

The current distribution of Kemp's ridleys and loggerheads resembles the historical distribution. These turtles are frequently encountered in the New York harbor and surrounding area and regularly occur along the Long Island Sound. There is also a heavy representation of Kemp's ridleys on the northeastern end of Long Island. This pattern is strikingly similar to the historical distribution pattern.

Major changes have occurred in the Long Island area over the past century, and these have affected the habitats in which sea turtles have occurred. Given these changes, one might expect to find corresponding differences in patterns of sea turtle utilization in this area. Instead we found many similarities in abundance, timing, distribution and size structure between past and present sea turtles of Long Island. It is possible that these turtles have not been able to adjust their behavior despite changing conditions. In light of other current research, however, it is likely that the sea turtles in Long Island waters are unaffected by, or have adapted to the environmental changes and successfully utilize Long Island waters.

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Fig.1 Chelonid Sea Turtles In Long Island Prior To 1973

Year	Species	Number	Source
Pre-1600	*Lk* or *Cc*	1	Latham
1827	*Cc*	1	Chase
1900-1910	*Cc*	2	Murphy
	Lk	1	Davis
	Lk or *Cc*	1	Latham
1911-1920	*Cc*	2	Murphy
	Cc	8	Murphy
	Lk	1	Museum (LIMNH)
	Lk or *Cc*	2	Latham
1921-1930	*Lk*	3	Museum (AMNH & SIIAS)
	Lk or *Cc*	104	Latham
1931-1940	*Ei*	1	Museum (NYSM)
	Cc	1	Museum (NYSM)
	Lk	1	Museum (NYSM)
1948	*Lk*	1	Museum (AMNH)
1950-1960	*Lk*	3	Museum (AMNH & NYA)
1970-1972	*Lk*	2	Museum (AMNH & NYSM)

Fig.2 L.kempi and C.caretta in Long Island prior to 1973

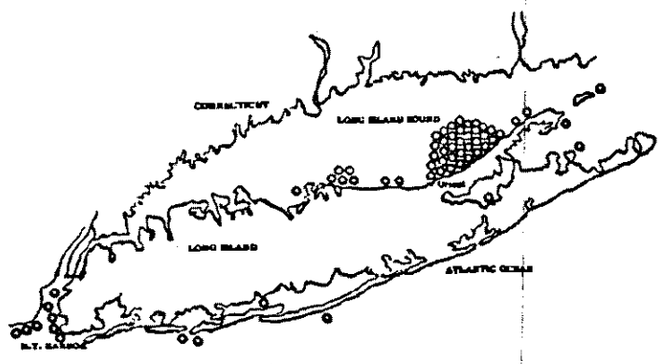

Fig.3 L.kempi ★ and C.caretta ☆ in Long Island 1985 - 1988

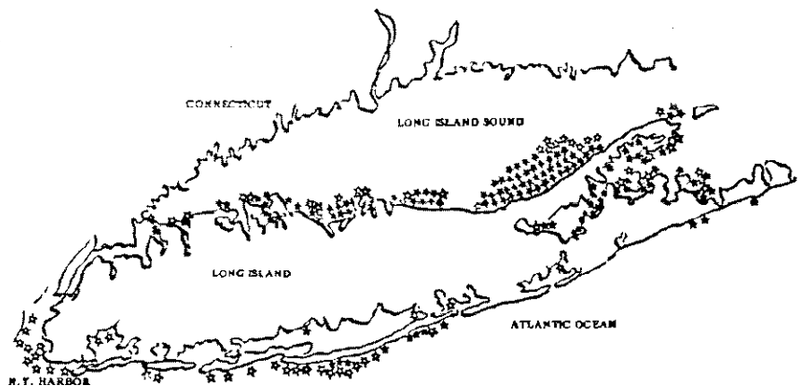

Fig.4 Chelonid Sea Turtles in Long Island, New York 1985 - 1988

	1985	1986	1987	1988
Chelonia mydas	3	3	8	0
Caretta caretta	15	22	31	20
Lepidochelys kempi	41	39	38	4

EFFECTS OF BEACH NOURISHMENT ON SEA TURTLES

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Nourished beaches provide important nesting substrate for a large percentage of the four species of sea turtles which nest along the United States coastline. Sand density (compaction), beach shear resistance (hardness), beach moisture content, beach slope, sand color, sand grain size, sand grain shape, and sand grain mineral content can be potentially changed by beach nourishment. These physical changes in the sand could also potentially have negative effects on the nesting activities of these threatened and endangered animals.

Harder or more compact nourished beaches result primarily from angular, finer grain sand dredged from stable offshore borrow sites; whereas, less compacted beaches result from smoother, coarse sand dredged from high energy locations (e.g., inlets). Hardness of beaches can be measured for differences in shear resistance (ability to penetrate the sand) with a cone penetrometer (cone index values). Figures 1 and 2 show a survey of shear resistances of 15 natural beaches and 10 nourished beaches along the east coast of Florida. Only four of the 10 nourished beaches were extremely compact. These four beaches, Jupiter Island, Pampano, John U. Lloyd, and Haulover, had shear resistances in excess of 750 cone index values. Based on observations of these hard beaches, the compacted characteristic can last from one to seven or more years after nourishment depending on the rate at which the beach is eroded and reformed by weather and waves.

When nourished sand is taken from offshore borrow sites, it may have a very dark gray color. This sand color may affect ambient sand temperatures and thus affect incubation time and sex ratios of hatchlings. Although scarps also form on natural beaches, steep scarps may occur as a result of nourishment when an abrupt transition occurs between the steep fill slope and a flatter natural offshore slope.

Beach nourishment may result in sea turtle nest burial, increased number of false crawls or decreased number of nests, a change in hatchling sex ratios, or impingement of turtles in the dredge. In addition, beach nourishment may affect nest contents, location, depth, and excavation. Adult females may be subjected to increased physiological stress since it takes longer to dig a nest cavity in hard nourished beaches (Figure 3).

Most of the negative effects of beach nourishment can be corrected by the use of management techniques such as nest relocation, tilling of compacted beaches, use of naturally compatible sand for nourishment, smoothing of scarp formations, and careful equipment selection and placement.

Figure 1. Sheer resistance measurements in cone index values at the depth interval 12 inches below the beach sand surface for the following 10 Florida east coast beaches: 1) Fernandina, 2) Jetty Park, 3) Hutchinson Island, 4) St. Lucie Inlet, 5) Jupiter Island, 6) Boca Raton, 7) Pompano, 8) John U. Lloyd, 9) Haulover, 10) Key Biscayne.

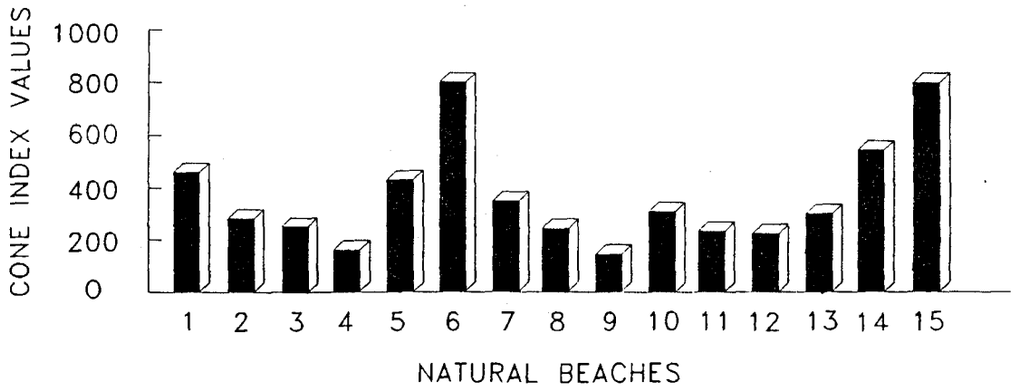

Figure 2. Shear resistance measurements in cone index values at the depth interval 12 inches below the beach sand surface for the following 15 Florida east coast beaches: 1) Little Talbot Island, 2) Canaveral National Seashore, 3) Melbourne Beach, 4) Sebastian Inlet, 5) Vero Beach, 6) Hutchinson Island, 7) Ft. Pierce, 8) St. Lucie Inlet, 9) John D. MacAuthor SRA, 10) Hobe Sound NWR, 11) Jupiter Island, 12) Highland Beach, 13) Boca Raton, 14) Port Everglades, 15) Golden Beach

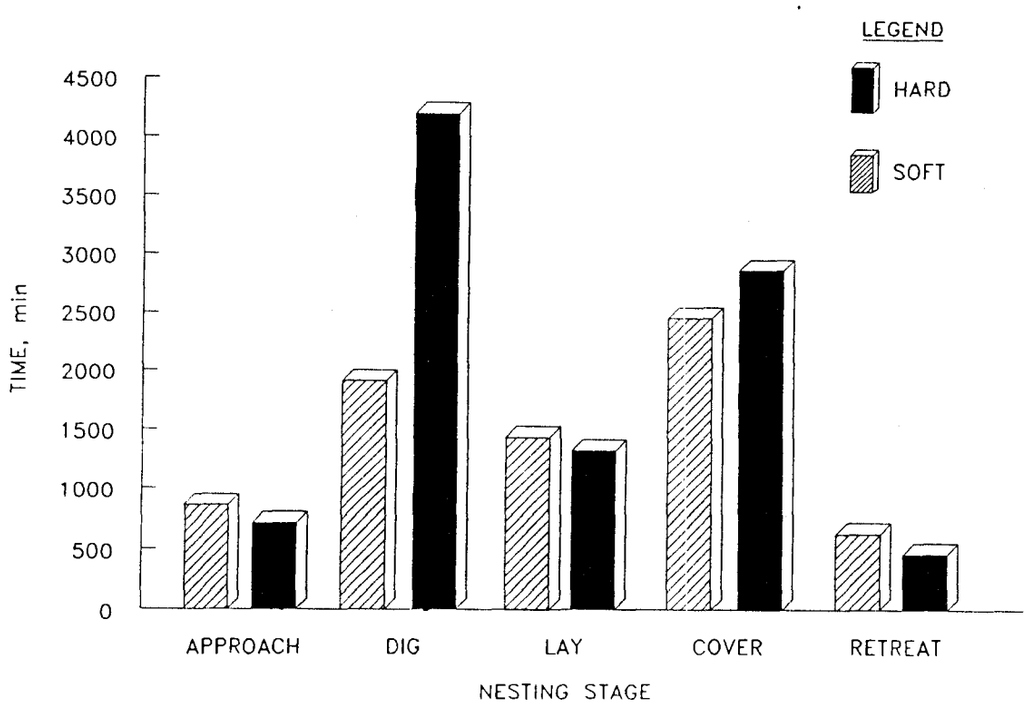

Figure 3. Comparison of time (minutes) in each nesting stage for hard nourished sand and softer natural sand.

MANAGEMENT IMPLICATIONS OF RECENT HATCHLING ORIENTATION RESEARCH

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Artificial lighting has a definite effect on correct hatchling orientation for sea turtle species. These lighting sources may include streetlights, beach lights, home lights, beach vehicles, and even flashlights. Hatchlings are disoriented by these light sources and may even be drawn out of the water after entering the ocean. Many coastal communities have developed "lights out" ordinances as a management alternative to the problem. Although an unlighted beach is the easiest to monitor, least costly, and best condition for the sea turtles, this is not always the most practical and safe option.

Shading of lights is recognized as a management alternative for beachfront areas which must have lighting. Although this would allow the use of already existing lights, monitoring and enforcing these regulations would be extremely difficult. Since hatchlings have been found to be disoriented by extremely low light intensities, hatchlings would still potentially be disoriented by shaded lights unless the intensities were reduced to levels impractical for human use.

Our results indicate that properly positioned lights which exclude the blue wavelengths ($\leq$530 nm) could be used, even at high intensities, on the beach and not disorient hatchlings. Low pressure sodium vapor lights are the only lights commercially available which completely exclude the blue spectral bands. Low pressure sodium lights are monochromatic, emitting only the yellow wavelengths (589-590 nm). The two low pressure sodium lights tested (18 and 55 watts) would be the wattages generally used for beach lighting.

Existing lights potentially could be used if filters were available which excluded wavelengths shorter than 530 nm and would adapt to fit over the different types of lights. At present, no filters of this type are known to exist. Preliminary tests show long wavelength lights (low pressure sodium) will override the effects from shorter wavelength lights if the long wavelength lights are at a higher intensity. This may also be a management alternative after additional tests are conducted.

The yellow incandescent "bug" lights predominately emit the longer wavelengths, although, they also emit very small amounts of the shorter (blue) wavelengths. The 100 watt "bug" light tested did not significantly disorient the hatchlings at a low irradiance level (0.3×10^{14} quanta/sec/cm^2). Yellow incandescent floodlights have the full spectral range of visible light even though the bulb is yellow. The yellow flood lights are not a filtering light, therefore, these should not be used as a source of long wavelength lights.

Since hatchlings orient away from lights which exclude the shorter wavelengths, these lights could also be a potential for hatchling disorientation if improperly positioned along the beach. More tests need to be conducted on the correct positioning of these lights for beach use. Studies which investigate the effects of long wavelength lights on green and leatherback turtle hatchlings, as well as adults of all sea turtle species, are critically needed before large-scale use of long wavelength lights on turtle nesting beaches is considered.

When making management decisions on beachfront lighting, the options should be implemented in the following order:

1. turning the light off;
2. replacing existing lights with low pressure sodium/"bug" lights;
3. shading lights such that no light reaches the beach;
4. covering existing lights with long wavelength emitting filters; and
5. overriding short wavelength lights with long wavelength lights of higher intensity.

NEST TEMPERATURES AND DURATION BETWEEN PIPPING AND EMERGENCE IN THE LOGGERHEAD SEA TURTLE IN SOUTHEASTERN NORTH CAROLINA

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The interval between pipping and emergence has been reported to be 1-14 days with an average of five days (Kraemer and Bennett 1981, Demmer 1981, Mrosovsky 1988, Neville et al. 1988, Webster and Gouveia 1988), but no field methodology has been developed to document when pipping occurs. Demmer (1981) monitored the behavior of hatchlings in nests using a glass cover and noted that most hatchlings in the clutch pip together. Neville et al. (1988) compared nest temperatures at the top and middle of the nest to soil temperatures at similar depths. The temperature in the middle of the nest was parallel to and consistently warmer than the temperature at the top of the nest once metabolic heat became evident, usually mid-way through incubation. Five days before emergence there was an unexpected change in temperatures where the top became warmer than the middle. This fluctuation was believed to signify the onset of emergence due to the additional metabolic heat generated by the upward movement of hatchlings in the nest cavity.

The purpose of this investigation was to develop a field technique base on nest temperatures that would predict when pipping occurs. Data were collected on Bald Head Island, North Carolina, during the 1988 nesting season. Four randomly chosen control "nests" (containing no eggs) were equipped with thermocouples at the soil surface and at depths of 5-65 cm at 10 cm intervals. They were monitored twice daily (5-7 AM and PM) from June to October with a Bailey Bat-12 microprobe thermometer calibrated to the nearest 0.1°C. Thermocouples were placed in the top and middle of 18 loggerhead nests laid between 2 June and 22 July and were monitored twice daily (5-7 AM and PM) throughout incubation. When top and middle nest temperatures did not react predictably to changes in ambient soil temperatures at similar depths, a small vertical hole was dug adjacent to the nest in the AM to confirm that pipping had commenced, following the procedure of Kraemer and Bennett (1981).

The period of time between pipping and emergence is shown in Table 1. Variation between AM and PM observation is usually one day and probably represents the time of day when pipping begins and variability among nests. Inasmuch as sea turtles use temperature as the cue for emergence from the nest (Mrosovsky 1968, Nevile et al. 1988), it seems reasonable to believe that the pipping process would be cued by temperature also. Demmer (1981) indicated that pipping was not related to ambient soil temperature, but he did not relate pipping to daily variation in nest temperatures. The mean interval between pipping and emergence, based upon AM and PM analyses, is 5.7 and 5.9 days, respectively, in North Carolina, almost a full day more than has been previously recorded (Mrosovsky et al. 1984, Neville et al. 1988, Webster and Gouveia 1988). There is distinct seasonal variation in these data as well. The time interval between pipping and emergence is greater in nests with longer incubation durations and less in nests with shorter incubation durations, as predicted by Webster and Gouveia (1988).

In conclusion, nest temperatures can be used to determine the time interval between pipping and emergence in loggerhead sea turtle nests because of intrinsic variations in nest temperatures.

ACKNOWLEDGEMENTS

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Table 1. Predicted interval (in days) between pipping and emergence based on changes in nest temperatures on Bald Head Island, North Carolina.

DATE LAID	NEST NUMBER	INCUBATION DURATION	NUMBER DAYS BEFORE HATCH	
			AM TEMP.	PM TEMP.
1 June	6	75	12	11
3 June	9	75	8	6
6 June	12	69	4	7
13 June	25	64	8	9
19 June	32	67	9	7-9
20 June	34	63	3	4
25 June	51	61	6	5
26 June	53	63	3	2-4
29 June	57	60	4-6	6
2 July	65	58	3	4
5 July	82	58	-	-
6 July	87	53	4	5
13 July	100	63	6	6-8
13 July	106	65	-	5
16 July	107	64	3	4
17 July	109	60	3	4
18 July	117	64	7	-
22 July	132	63	7	7
MEAN =		63.6	5.7	5.9

SEA TURTLE REPRODUCTIVE CHRONOLOGY: THE MODEL AND THE QUESTIONS

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Because sea turtles deposit multiple clutches in a nesting season and because they often skip one to several years between nesting migrations, the chronological relationship between mating, fertilization of ova and nesting has been an interesting question. Carr and Hirth (1962) saw female Chelonia mydas being mounted as they returned to the water after nesting. On the other hand, in the same species Booth and Peters (1972), Bustard (1972) and Ulrich and Owens (1974) observed functional mating only prior to nesting. In separate reviews Frazier (1971), Ehrhart (1982) and Owens (1980) each concluded that the bulk of the observational data available supported the idea that mating occurred during a distinct receptive period prior to nesting. At Cayman Turtle Farm, female C. mydas are now well documented to enter a receptive period of a few days about 30 days prior to the first nest (Wood and Wood 1980, Comuzzie 1987). Rostal (unpublished data) has made similar observations in a captive colony of Lepidochelys kempi.

The work of Licht and our group has also provided an increasingly more refined understanding of the endocrine and reproductive events in the production of the several clutches of eggs. The following "Model" is presented as an approximation of the chronological events as we now interpret them.

A. After suitable gametogenesis on the feeding ground, a distinctive testosterone peak is correlated with migration away from the feeding ground in both sexes.

B. Either during the migration or near the nesting grounds a female enters her receptive period in which one or more males mates her for up to several hours each.

C. During the following week or more the sperm move up the very long oviducts (4.5 m or longer) and lodge in albumin glands where they are stored to fertilize each subsequent ovulation of the season (see Solomon and Baird 1979, Gist and Jones 1987).

D. Luteinizing Hormone and progesterone surge dramatically, resulting in a very rapid ovulation from both ovaries. In only 24-36 hours the follicles are expelled from the ovaries, fertilized (presumably in the infundibulum of the oviduct), the albumin coat is secreted in the mid oviduct, the protein membranes are deposited on top of the albumin and the eggs are transported to the base of the oviduct where calcium secretion occurs.

E. Calcium secretion appears to be the rate limiting step, requiring about 10 days for completion of the eggs (note exceptions below).

F. During the calcification phase, final growth of the next largest set of follicles has occurred in the ovaries.

G. Within a few hours after oviposition of the clutch, the next ovulation surge occurs to refill the oviducts. Stored sperm fertilize the follicles as they enter the oviducts and the egg cycle is repeated until the ovaries are exhausted of large sets of follicles. With each ovulation there are a few mature follicles which do not ovulate. These become the characteristic dark colored atretic follicles which are slowly reabsorbed.

Two obvious exceptions to this pattern occur. First, in Dermochelys the egg cycle is faster, with calcification apparently taking only 5-7 days. Second, in the Lepidochelys species, the eggs are prepared at the same speed as the other genera, however the females may retain the eggs in the base of the oviduct to wait for the behavioral cues involved in the arribada. Even though the eggs may be in the oviducts much longer than in other species, they do not appear to experience extra calcification. The Lepidochelys females appear to move quickly through the egg cycle so that their next clutch will be ready whether the arribada is sooner (14 days) or later (30-40 days).

Questions: Harry and Briscoe (1988) used isozyme electrophoresis to describe multiple genotypic ratios within clutches from Caretta females. This seems to be strong evidence for multiple paternity within a season for an individual female. On the other hand, they also suggest that mating may have taken place after nesting in Caretta since the ratios changed in subsequent clutches from the same female. We believe a more reasonable explanation may be that all mating occurred prior to the first clutch, but sperm from different males may not be equally available during each sequential ovulation. Thus the different males would have variable percentages of fertilizations in each clutch depending on where their sperm were stored in the oviduct.

Alvarado and Figueroa (1988) have recently published a very interesting study of the black turtles (Chelonia agassizi) in Michoacan, Mexico. They report several lines of evidence that mating in this species may occur either before or after nesting. Several individuals which were tagged while nesting were later captured while mating, nesting females have fresh claw scars on their carapaces throughout the nesting season and males are generally much more obvious late in the nesting season than at C. mydas nesting areas. Since these observations do not appear to fit the above "Model", two suggested explanations come to mind. First, it is possible that the reproductive chronology of C. agassizi is strikingly different from other sea turtles. Second, an unusually skewed sex ratio dominated by males may give the impression of altered mating patterns when actual effective mating is still as suggested in the model. Regardless of what is happening, this population represents an unusually interesting situation which should be carefully evaluated.

ACKNOWLEDGEMENTS

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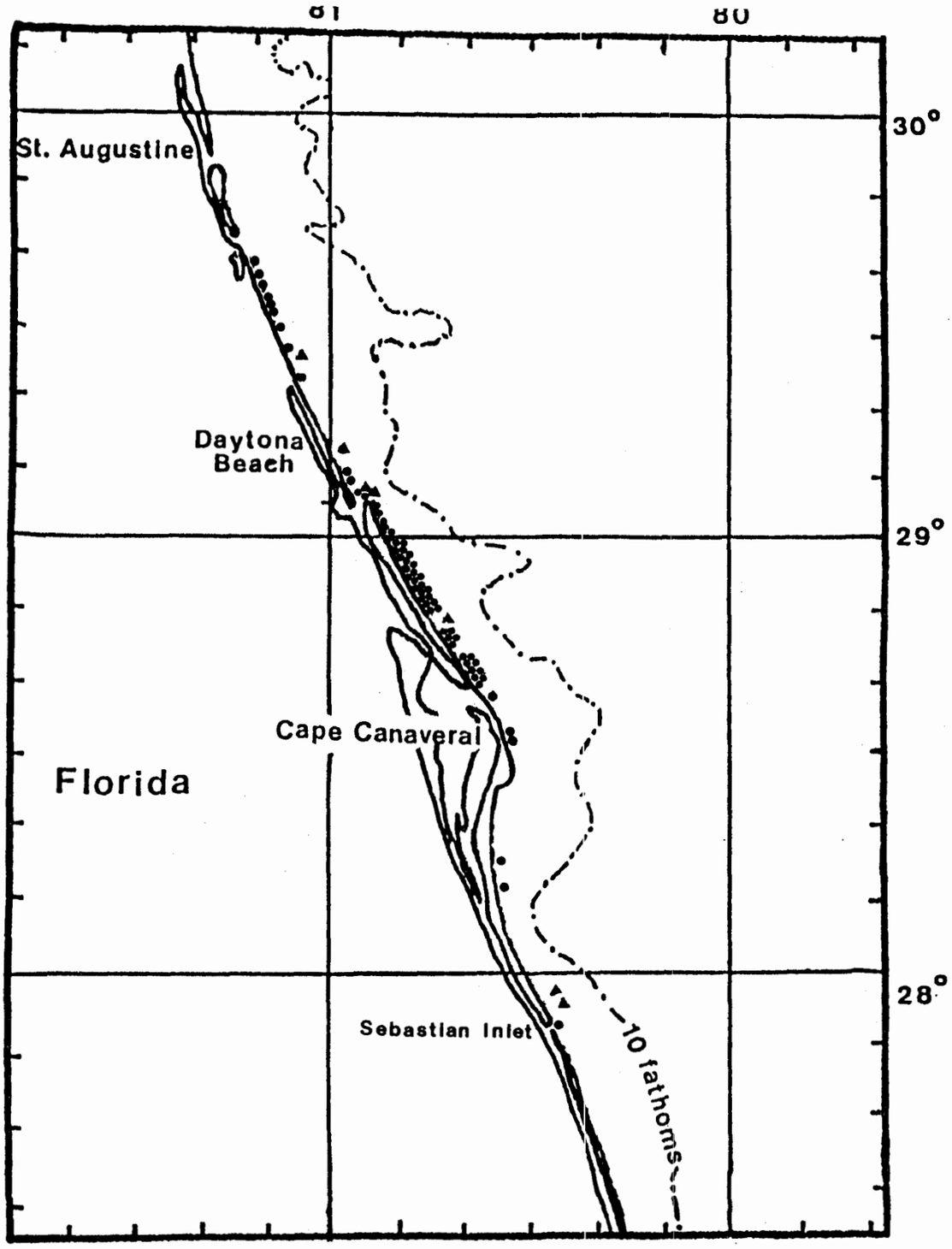

LEATHERBACK TURTLE SIGHTINGS - 22 FEBRUARY 1988
Tracklines at 1/4 mile and 1 1/2 miles parallel to coast
Solid dots indicate sightings along trackline 1/4 mile from coast
Triangles indicate sightings along trackline 1 1/2 miles from coast

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FEEDING ECOLOGY OF THE LOGGERHEAD SEA TURTLE IN THE NORTHWESTERN GULF OF MEXICO

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The loggerhead (Caretta caretta) is the most common sea turtle in the northwestern Gulf of Mexico (Rabalais and Rabalais 1980) yet, despite its abundance, surprisingly little is known about its activities or movements in this portion of its range. This is due in part to the lack of areas in which sea turtles are usually studied. There is no nesting population that can be followed from year to year, nor are there any known feeding grounds where they can be observed. The one place where turtles can be found with any certainty or regularity is washed ashore dead on the beach. These carcasses can be salvaged and when utilized can provide a great deal of information. From 1986-1988, the gut contents of 88 loggerheads found stranded along the south Texas coast were collected to identify food items, to determine principal or preferred prey species and, most importantly, to relate this information to the turtles' environment and identify foraging areas.

The esophagus, stomach and intestinal tract of each turtle were removed during necropsy. Gut contents were rinsed over a fine-mesh sieve and preserved in 10% buffered formalin. Food items were sorted in the laboratory, identified to the lowest taxon possible, and baked in a drying oven for 24 hours to obtain dry weights. Samples were collected from turtles stranded during every month of the year except for January and February. The majority (93%) of the turtles were subadult and adult animals (7% were post-hatchling and advanced pelagic stage turtles) and most were females (73% female, 19% male, 8% unknown).

Because the feeding habits of the young loggerheads collected during the study were distinct from that of the subadult and adult loggerheads, data from the two groups were analyzed separately. Qualitative data collected from the gut contents of the 6 smaller turtles (Ttable 1) indicate that small loggerheads in the northwestern Gulf of Mexico associate with Sargassum. These turtles are feeding at or near the surface of the water column and the likelihood that they will encounter marine debris is quite high. Quantitative data collected from the gut contents of 82 larger loggerheads (Table 2) indicate that the larger turtles are feeding primarily in a benthic environment, but on some occasions they feed at the surface as is shown by the presence of jellyfish, floating vegetation and floating debris.

The loggerhead fed upon a wide variety of food items but, in general, only a few of the food items were eaten in any great quantity. Sea pens (Virgularia presbytes) and crabs were the major food items. Sea pens were eaten by both males and females and were present in loggerheads stranded throughout the year. The average amount ingested per turtle was 303 g (0.7 lb) and ranged from as little as 0.04 g to as much as 2,648 g (6.0 lb). The sea pen is a Cnidarian that lives anchored in sandy substrate and occurs in dense stands or beds. Little information is available concerning its depth distribution in the northwestern Gulf of Mexico. Data collected from a cruise aboard the NOAA [National Oceanic and Atmospheric Administration] ship 'FERREL' in October 1988 indicate that sea pens occur primarily in shallow water. Sea pens were collected from 12 of the 44 stations sampled. Eleven of those 12 stations were located in 9 m of water, one was in 18 m. Sea pens were never collected from water deeper than 18 m.

The calico crab (Hepatus epheliticus), spider crab (Libinia spp.) and purse crab (Persephona mediterranea) were the most common species of crabs fed upon by the loggerheads. The depth distribution of these crabs supports the belief that the loggerheads are foraging nearshore. This nearshore area, rich in invertebrates is also an important feeding area for the Kemp's ridley sea turtle (Lepidochelys kempi). The gut contents from 104 Kemp's ridleys stranded in the same study area consisted mostly of crabs (96% of the bulk; Donna Shaver, personal communication). Shaver found that the ridleys were feeding on the same crabs as the loggerheads, but in addition also fed heavily on the blue crab (Callinectes sapidus) and the speckled

crab (Arenaeus cribrarius), crabs that are characteristic of the surf zone. These food-habits data are very supportive of Hildebrand (1983, personal communication) who contends that loggerheads in this area are most abundant in waters out to 18 m deep, while ridleys occur in slightly shallower waters. We need to focus our attentions on these nearshore areas if we are to reduce the mortality of loggerheads and the critically endangered Kemp's ridley sea turtle.

ACKNOWLEDGEMENTS

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Table 1. Qualitative description of the food items found in the gut contents of young loggerhead sea turtles found stranded along the south Texas coast. Carapace length measured straight-line.

TURTLE ID #	DATE STRANDED	CARAPACE LENGTH	FOOD ITEMS
CC-20-86	2 September	5.2 cm	Sargassum, decapod larvae and Litiopa melanostoma
CC-46-87	??	16.0 cm	Sargassum, feather, wood and piece of plastic bag
CC-5-88	17 April	9.2 cm	Janthina, Sargassum, jellyfish, pieces of balloon, latex rubber, aluminum foil and hard plastic
CC-10-88	23 April	15.2 cm	Sargassum, feathers, wood, stomatopod larvae, decapod larvae
CC-12-88	17 April	13.9 cm	Sargassum, Janthina, styrofoam
CC-13-88	8 April	30.0 cm	Sargassum, jellyfish, styrofoam

Table 2. Quantitative description of the general food items found in the gut contents of sub-adult and adult loggerhead sea turtles found stranded along the south Texas coast (n=82). % Occurrence = the percentage of the turtles that had fed on that food item. % Bulk = relative volume of a food item; calculated from the summed dry weights.

FOOD ITEM	% OCCURRENCE	% BULK
SEA PEN	56.1	58.7
CRAB	87.8	28.8
MOLLUSK	80.5	6.6
DEBRIS	51.2	0.4
DIOPATRA	47.6	0.6
BARNACLE	35.4	0.6
FISH	30.5	1.4
SARGASSUM	30.5	0.2
VEGETATION	28.1	<0.1
SEA PANSY	20.7	0.2
WHIP CORAL	20.7	<0.1
ANEMONE	18.3	0.7
MANTIS SHRIMP	15.9	0.2
PENAEID SHRIMP	12.2	0.5
JELLYFISH	11.0	0.6
UNIDENTIFIABLE	29.3	0.5
OTHER	24.4	0.1

STATUS OF PROPOSED EAST-CENTRAL FLORIDA SEA TURTLE REFUGE

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A State/Federal/private effort is underway to provide permanent protection for 15 km of the approximately 34 km of high density sea turtle nesting habitat between Melbourne Beach and Wabasso Beach, on the Atlantic coast of east-central Florida. The U.S. Fish and Wildlife Service proposes to purchase 5.9 km of nesting habitat in northern Indian River County and 9.1 km in southern Brevard County. The State proposes to purchase or otherwise protect 5.9 km within Indian River County and 0.6 km in Brevard County, both segments within the proposed Federal project boundaries. Within this area, loggerhead sea turtle (Caretta caretta) nesting averages 475 nests/km in Brevard County and 140/km in Indian River County. Approximately 35-40% of green sea turtle (Chelonia mydas) nesting in Florida and 25 percent of loggerhead turtle nesting in the southeastern United States occurs in southern Brevard and northern Indian River County. The Federal proposal received U.S. Fish and Wildlife Service Director's approval in December 1988, and detailed planning to meet other administrative requirements begins in February 1989. Federal funding for acquisition is currently unavailable. The State land acquisition proposals were approved by the Governor and Cabinet in August 1988 and subsequently (December 1988) were ranked sufficiently high to qualify for available funding. Appraisals and surveys have been initiated on 2.4 km, with acquisition anticipated to begin during the summer of 1989. In the meantime, the Nature Conservancy has begun negotiations with the owner of the largest single proposed tract (0.6 km) in Brevard County in an attempt to secure its protection until the State can re-purchase it.

SEA TURTLES AND STRUCTURE REMOVALS IN THE GULF OF MEXICO

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The Gulf of Mexico OCS Region currently has approximately 23.7 million acres under 4,748 leases. Over 3,650 oil- and gas-related structures with approximately 7,400 producing wells are located on the 1,585 producing leases. It has been projected that as many as 2,000 offshore structures may cease production and be scheduled for removal in the next 20 years (National Research Council 1985). Though new structures may be emplaced on future producing leases, economic conditions will determine the number of replacements.

The requirement to remove obsolete structures on the OCS originates from legal and regulatory mandates. Section 22 of the current lease form requires removal of all structures within one year after termination of the lease. Title 30 CFR 250.143 contains structure removal and site clearance requirements.

If explosives are used during structure-removal operations, sea turtles that are near the detonations may be harmed. The Minerals Management Service consults with the National Marine Fisheries Service (NMFS) through Section 7 provisions of the Endangered Species Act of 1973 (16 U.S.C. 1531-1543), as amended. The consultations are conducted to minimize potential impacts to these endangered species and to establish an incidental take for the proposed activity. Consultations were initially conducted on a case-by-case basis. Since may of the operations are similar, a "generic" consultation was established on 25 July 1988. Several limitations were established for a proposal to be considered under the "generic" consultation. These limitations consist of the following:

1. Each explosive charges is less than 50 pounds (60 pound backup),

2. Detonations limited to groups of 8 or less with a minimum of 900 milliseconds (0.9 seconds) between each detonation,

3. Charges must be set 15 feet below the mud line, and

4. High velocity explosives with a detonation rate of 7,600 meters per second or greater must be used.

The NMFS requires the following mitigative measures under the "generic" consultation:

1. Qualified observers must monitor the area around the site prior to, during, and after detonation of charges. Observer coverage begins 48 hours prior to detonation of charges. If sea turtles are observed and thought to be "resident," pre- and post- detonation diver surveys must be conducted.

2. A 30-minute aerial survey must be conducted within one hour before and one hour after each blasting episode.

3. If sea turtles are observed within 1,000 yards of the structure prior to detonating charges, detonations will be delayed until sea turtles are moved at least 1,000 yards from the blast site. The aerial survey must be repeated.

4. Detonation of explosives will occur no sooner than one hour following sunrise and no later than one hour prior to sunset. Justifiable modifications may be considered on site.

5. During all diving operations, divers will look for sea turtles and marine mammals. Sightings must be reported.

6. Scare charges should be avoided and are allowed by approval only.

A National Environmental Policy Act of 1969 (42 U.S.C. 4321-4347), as amended, review is conducted on each of the structure-removal proposals. A programmatic environmental assessment was prepared to assess the spectrum of potential impacts from structure removals and to allow "tiering" of site-specific environmental assessments (SEA's). The SEA's are prepared on each proposal and contain the operational details for the individual environmental evaluations.

In calender year (CY) 1987, 81 structure-removal applications were approved and 23 structures were actually removed. To date in CY 1988, 94 applications have been approved and 89 structures have been removed.

WIDECAST: IMPLEMENTATION OF A CARIBBEAN INITIATIVE

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WIDECAST is an acronym for the "Wider Caribbean Sea Turtle Recovery Team and Conservation Network". WIDECAST was chartered in Santo Domingo, Republica Dominica, in 1981 at a meeting of Wider Caribbean non-governmental organizations (NGOs) on Living Resources Conservation for Sustainable Development of the Wider Caribbean. The Minutes of that Meeting note that a "recommendation for the establishment of a Wider Caribbean Sea Turtle Recovery Action Plan was approved in the context of the concept of sustainable use of species and ecosystems and conservation of genetic resources as stated in the World Conservation Strategy ... The relevant NGOs should prepare a Wider Caribbean Sea Turtle Recovery Action Plan in coordination with the IUCN SSC Sea Turtle Specialist Group who would be asked to serve as a scientific advisory committee in support of the Plan. The Recovery Plan should be consistent with the Strategy for Conservation of Living Marine Resources and Processes in the Caribbean Region, the World Conservation Strategy, and the Action Plan for the Caribbean Environment Programme."

The Wider Caribbean Sea Turtle Recovery Team was established at that time to prepare this "Recovery Action Plan". The 11 member Team[1] and its supporting Network (ultimately including a WIDECAST "Country Coordinator" in each of the 39 government regions in the Wider Caribbean) constitute an experimental demonstration project designed to show what can be achieved in endangered species international planning and implementation through collective non-governmental conservation group action in cooperation with governments and intergovernmental bodies. The Country Coordinators and the in-country WIDECAST networks are the heartbeat of the WIDECAST effort. Conservation, like most issues of national pride and stewardship, is nurtured from within; it cannot be commanded from the outside. Recognizing this, WIDECAST sees itself as "regional scaffolding"; that is, a structure to support the national efforts of NGOs and governments and, further, to integrate these efforts into a collective regional response to a common problem, the disappearance of sea turtles.

Anyone can participate in WIDECAST. The network includes scientists, conservationists, fishermen, educators and students, government employees, civic and church groups, boat captains and SCUBA divers, and representatives of national and international NGOs. The WIDECAST philosophy recognizes that a powerful voice for the conservation of endangered species exists within the citizenry of all nations. However, concerned people must be provided with a structured approach in order to be heard, particularly on matters of international scope. These are not new ideas. The IUCN-commissioned "World Conservation Strategy" and other landmark documents also speak eloquently to these points. WIDECAST choose sea turtles as a focus because they are critically endangered throughout the Caribbean and because it is very easy for people to identify with them.

While WIDECAST is autonomous and self-regulating, it is strongly supportive of other regional conservation initiatives, including the Caribbean Conservation Association (CCA), the Western Atlantic Turtle Symposium (WATS), and the UNEP Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region ('Cartagena Convention') with its attending Action Plan for the

[1] current members of the WIDECAST Team: Lic. Ana Cecilia Chaves (Coast Rica), Karen Lind Eckert (USA), Jacques Fretey (France), John Fuller (Antigua), Molly Gaskin (Trinidad), Julia Horrocks (Barbados), Maria Teresa Koberg (Costa Rica), Sally Hopkins Murphy (USA), Peter C. H. Pritchard (UK), Georgita Ruiz (Mexico); the 11th position is currently open.

Caribbean Environment Programme. At the Third Intergovernmental Meeting on the Action Plan for the Caribbean Environment Programme (Cancún, Mexico, 24-26 April 1986) WIDECAST was highly praised by the governments of the Wider Caribbean. As a result, a 3-year contract was awarded WIDECAST in support of the drafting of a Sea Turtle Recovery Action Plan to include sea turtle management recommendations to each of the 39 government regions of the Wider Caribbean.

The objective of Phase I of the WIDECAST effort is the completion of this Sea Turtle Recovery Action Plan which will be comprised of 40 chapters (we call them volumes), a initial overview and then one volume for each of 39 government regions[2] in the Wider Caribbean. Each volume is written in four sections; for - example, the volume for Barbados (entitled, WIDECAST Sea Turtle Recovery Action Plan for Barbados) includes I. Introduction, II. Status and Distribution of Sea Turtles in Barbados, III. Stresses on Sea Turtles in Barbados, and IV. Solutions to Stresses on Sea Turtles in Barbados. Each section includes subsections detailing specific areas of concern (sand mining, reef destruction, inadequate law enforcement, etc.). Each volume is thoroughly reviewed by in-country persons, as well as the WIDECAST Team as a whole and the IUCN Sea Turtle Specialist Group. Upon completion, the entire Plan (including all 40 chapters) will be submitted to the UNEP Caribbean Environment Programme (CEP) Office in Kingston, Jamaica. The Secretariat of the CEP will then formally transfer to each Caribbean government the overview document, as well as the relevant national Recovery Plan volume.

By summarizing known distribution data, identifying threats to sea turtle survival, and indicating gaps in the data, each volume of the Recovery Plan is uniquely suited to guide in-country sea turtle research and conservation into the next decade. The WIDECAST effort represents the first time that sea turtle management recommendations have been systematically developed over so broad a political and geographic range. And we believe that the effort is a landmark with respect to linking local initiative to national and regional policy. Phase II of the WIDECAST program will involve supporting local and regional efforts to implement management recommendations made by the Sea Turtle Recovery Action Plan, and efforts to increase our knowledge of sea turtle distribution and status in the Wider Caribbean.

[2] Anguilla, Antigua & Barbuda, Aruba, Bahamas, Barbados, Belize, Bermuda, Brazil, British Virgin Islands, Cayman Islands, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, French Guiana, Grenada, Guatemala, Guadeloupe, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Monserrat, Netherlands Antilles, Nicaragua, Panama, Puerto Rico, St. Kitts & Nevis, St. Lucia, St. Vincent, Surinam, Trinidad & Tobago, Turks & Caicos, USA, U.S. Virgin Islands, and Venezuela.

COMPREHENSIVE MANAGEMENT PLAN FOR TORTUGUERO, COSTA RICA

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At Tortuguero, on the Caribbean coast of Costa Rica, is the largest nesting ground of green turtles in the Caribbean. Between about 5 and 50 thousand female green turtles nest at Tortuguero each year (Carr, Carr and Meylan 1978). The average nesting population is about 15 thousand. Since 1956 the Caribbean Conservation Corporation (CCC) has supported research and conservation activities at Tortuguero. This work and many of its results are familiar to all of you.

Turtles distribute from Tortuguero all over the Caribbean and the long term management and conservation of the species must include the maintenance of this, the only remaining large aggregation in the region.

It is very difficult to discern the trends in this population. There is a substantial increase in number of turtles recorded this decade compared with the early 1960's but variations in effort and wide interannual fluctuations make interpretation difficult. Several lines of evidence suggest that the population is still well below its carrying capacity and is probably still recovering from over-exploitation earlier this century. The density of nesting females is 6-44 /km/night, 1-3 orders of magnitude less than unexploited populations in the Indian Ocean (Ross 1979) and Australia (Limpus 1981). The incidence of nest destruction by laying females is only 1-2% (Fowler 1979).

Analyses of survival between 1959 and 1972 (Bjorndal 1980) indicate that human predation away from the nesting beach continues to limit population recovery. There is still a legal harvest of 1600+ turtles a year in Costa Rica, and we know that at least 2.5% of neophytes tagged each year are caught by fishermen elsewhere. This population continues to merit our concern and require active conservation.

The CCC has been actively conserving this population, and trying to react to the most immediate needs and threats. We now recognize that conserving the sea turtle population is part of the larger problem of maintaining the ecological and economic stability of the whole region including the turtle beach, the adjacent village, and nearby ecosystems of forest and river estuary.

The pristine rainforest of the Caribbean lowlands is greatly threatened as a result of increasing numbers of people, improved access, and the demands of the human population for economic well-being. Short-term exploitation is destroying the resource base of the region. The CCC believes that short-term economic gain by direct exploitation of these fragile resources is both economically and ecologically disastrous. Commodity use of sea turtles may be appropriate in some places, but we believe it would be counter-productive at Tortuguero.

A clutch of turtle eggs is worth about $8.00 retail in San José and perhaps 1/5 of that on the beach. In contrast, we estimate that the same clutch of eggs is worth 100-250 times that much if used as a focus of tourist activity. There is a clear desire of people at Tortuguero to 'cash in' on the tourist boom, but the experience of these people is that economic booms are short-lived (e.g., lumber, turtle meat, bananas). It is necessary to develop the infrastructure to enable a long-term non-consumptive use of these resources.

To meet this need, the CCC has embarked on a large scale management plan for the Tortuguero region in conjunction with the Costa Rican National Park Service, Fundacion Nacional (Costa Rica) and the U.S. Agency for International Development. This plan includes:

- A regulatory plan for land use and land acquisition to preserve present values and quality.

- An Environmental and Interpretation Center to provide information for visitors and training for local people. A first step is our information kiosk.

- Coordination with the Park Service for approved and ecologically sound visitor access.

- Improvement of facilities for visiting scientists and educational groups.

- Acquisition of a wildlife corridor to join the Park with the Barra del Colorado wildlife management area.

- Land management research, analysis and implementation for the upper watershed involving protection of riparian zones and experimental agro-forestry.

- Continuation of research on the turtle population to maintain and evaluate conservation action.

- Training for regional turtle managers.

These efforts are neither cheap nor fast. The CCC has invested > $1,000,000 and 30 years of effort at Tortuguero and we expect it will take even greater commitments of energy and money to continue.

We believe that a comprehensive program recognizing local needs for economic stability will ensure the preservation of the whole Tortuguero ecosystem including the turtle population. In addition to conserving this turtle population, we believe that the solutions we develop at Tortuguero will be transferable to many other locations.

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POPULATIONS OF ATLANTIC RIDLEY SEA TURTLES (LEPIDOCHELYS KEMPI) IN APALACHEE BAY, FLORIDA, COASTAL WATERS

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A total of 106 Kemp's ridley sea turtles, (Lepidochelys kempi), was captured, measured, tagged, and released from 1984-1988 in Wakulla and Franklin counties, Florida. Turtles ranged from 20.3 to 57.9 cm straight line carapace length (mean 36.4 cm), and weights ranged from 635 grams to 13.7 kg. All turtles were immature and were captured in all months of the year. Turtles taken in winter were significantly larger than those taken in summer. Carapace epibionts and mud stains suggested that two individuals had over-wintered. Turtles were taken over sand, mud, and seagrass bottoms and at depths ranging from 30 cm to 32 m. A significant length-depth relationship was observed. The smallest turtles were taken from depths < 9 m. Four recoveries were made, three of which returned to their point of capture upon release. Offshore occurrences during winter months to depths > 30 m for three individuals were observed.

OFFSHORE ORIENTATION BY LOGGERHEAD HATCHLINGS

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Hatchling loggerhead sea turtles emerge from nests at night, crawl down the beach, enter the ocean and swim directly away from shore. Light cues are known to guide their movements from the nest to the surf zone. However, the stimuli directing the orientation of swimming hatchlings are unknown. Others have hypothesized that the brighter seaward horizon, the experience of the down-beach crawl, contact with the surf zone, or wind-directed waves could serve as guideposts. Here, we report that surface waves (oceanic swells and waves produced by local winds) are important orientation cues for hatchlings once they loose contact with land. Close to shore, however, hatchlings may use different cues, at least during the day.

METHODS

Hatchlings were captured from relocated nests just prior to emergence, kept in empty styrofoam coolers, and taken within 12 hours by small boat to locations ranging from 100 m to 13 nautical miles (NM) from shore at Ft. Pierce, Florida. Each individual was tethered within a floating circular orientation "cage"; its swimming direction was recorded at 1-minute intervals over a 10-minute period before the cage was retrieved and the hatchling replaced by another subject. Wind direction and speed, as well as the direction of approach for surface waves were recorded while experiments were in progress. We distinguished between swells (caused by prevailing winds) and waves (produced by variable local winds), as hatchling orientation was affected by both of these surface wave stimuli. Rayleigh tests were used to determine mean headings and significance levels for groups of hatchlings tested at one time and location.

RESULTS

Hatchlings tested during the night at locations 0.9-6.0 NM from shore consistently swam to the East (E) or Southeast (SE). Mean headings for hatchling groups were strongly correlated with direction of surface waves. Swells from the SE were always present at night, even in the absence of wind. Wind-generated waves most commonly approached from the S; when they did, mean headings were typically between those of approaching waves and swells. On one evening, the wind shifted from the S to the W while tests were in progress. Before the shift, hatchlings headed SE; afterward, they were equally divided between individuals orienting toward the waves and those which responded to the swells.

During the day, hatchlings tested 0.7 or more NM from shore behaved much like those tested at night; their orientation appeared directed by waves, swells, or both when they were simultaneously present. On two testing days, we released hatchlings when neither waves nor swells were evident. Neither group showed a statistically significant tendency to swim in a particular compass direction. However, when tested again later that day (after surface waves produced by onshore breezes were evident), both groups were significantly oriented in offshore directions.

Hatchlings tested during the day within 100 m of shore were strongly oriented to the E even when swells were absent or waves approached from the S or W.

DISCUSSION

Our data indicate hatchlings tested at distances of 0.7 NM or more from shore consistently swim into surface waves, whether these are generated by swells, waves, or both. Hatchlings behaved as if both stimuli were equivalent; i.e., they did not prefer one form of surface stimulus to another.

For such an orientation system to function effectively, surface waves must reliably indicated offshore directions. On Florida's east coast, where prevailing winds are from the SE, this is usually true. Prevailing winds are reinforced by afternoon sea breezes from the E or SE. These arise as a consequence of land heating near shore. Together, prevailing winds and sea breezes generate swells strong enough to persist through the night, even if winds shift or disappear after sunset. Since loggerhead hatchlings typically enter the ocean between dusk and midnight, swells are important guideposts.

Waves generated by local winds, in contrast, are much less reliable as cues. At night, land cooling can lead to the generation of offshore winds (land breezes) which, when they meet prevailing winds, typically generate breezes from the S or SW. By continuing to respond to swells even in the presence of erratic winds and the waves they produce, hatchlings reduce the influence of waves upon their orientation response. Since land breezes are usually weaker than the prevailing winds, they rarely come directly from the W at night (they did so on only one evening out of the 13 in which we ran experiments).

Surface waves may be reliable guideposts during the initial portion of hatchling migration (i.e., the 24-hour "frenzy" period). Their utility at greater distances from shore is unknown. On nesting beaches north of Florida, prevailing winds are from the SW. Sea breezes are also produced at these latitudes but the extent of their influence, especially with regard to offshore distances where they might affect swell and wind propagation directions, remains to be determined. It is, however, likely that on all continental shorelines, sea breeze winds generated by afternoon land heating lead to the formation of persistent nocturnal, onshore swells. These might reliably direct hatchlings at least several kilometers away from the coast and to the relative safety of deeper waters by daybreak. At that point, other orientation mechanisms (such as those dependent upon a magnetic compass; see Lohmann, this volume) may become primary.

During the day, surface waves did not appear necessary for hatchling seaward orientation when they were tested within 100 m of shore. The cues of importance are unknown. Visual detection of shoreline features is but one of several possibilities. Thus for loggerhead (and other sea turtle) hatchlings, orientation cues used while swimming may depend upon where hatchlings are located. Hatchlings may use different cues near the beach, immediately after contact with land is lost, and in the open sea.

EVALUATION OF THE CONSERVATION TECHNIQUES UTILIZED AT MEXIQUILLO BEACH, MICHOACAN, MEXICO, FOR DERMOCHELYS CORIACEA AND LEPIDOCHELYS OLIVACEA DURING THE 1986-1987 NESTING SEASON

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INTRODUCTION

Because the proportion of marine turtle nests plundered on Mexiquillo Beach had approached 100% in recent years, it became necessary to implement a conservation program whose principal objectives are to: 1) protect a significant number of nests and nesting females; 2) contribute to the understanding of the many biological aspects of marine turtle populations in the area; and 3) evaluate conservation techniques used on the program. The species of interest in this study are the leatherback sea turtle (Dermochelys coriacea) and the olive ridley (Lepidochelys olivacea).

STUDY AREA

The Mexiquillo Beach is located 80 km to the northwest of the city of Lázaro Cárdenas, Michoacán, on the Pacific coast of Mexico. It is approximately 17 km in length, with the first 5 km (the portion located towards the southeast) representing the center of our investigations.

METHODS

The study site has been divided into two areas, Area I for natural incubation of in situ nests and Area II within which nests are relocated to the hatchery. All nests laid outside of Area I are collected in plastic bags and transported to a hatchery located within Area I (eggs natually laid within Area I are not moved). In order to evaluate the techniques used to collect and rebury the eggs of relocated nests, a comparison of the hatching success of relocated and in situ nests was achieved using the Z statistic. Hatching percent is equal to the number of hatchlings that emerge without assistance, divided by the clutch size and multiplied by 100. An estimate of total hatchling production in the study area is calculated based on the number of nesting crawls, taking into account the proportion of 'false crawls' (unsuccessful nesting attempts) and using values for hatching success (hatchlings produced and hatchlings released) obtained during the study period. A series of other parameters were measured concurrently with our conservation work, including temperature and humidity at the study site.

RESULTS AND DISCUSSION

The nesting season for the olive ridley begins in July. The end of the ridley nesting season in October corresponds with the beginning of the leatherback nesting season. The end of the leatherback nesting season is in February. During these months the temperature ranges 17°-36° C, with an average relative humidity of 87%. Based on observations of 5,021 leatherback crawls and 502 ridley crawls, a positive correlation between a peak nesting night and the phase (waxing and waning) of the moon was observed for both species. The frequency of false crawls increases at the end of the nesting season. This phenomenon, in lieu of any other reason for its occurrence, may be related to the physiological condition of the turtle, given the seemingly extensive amount of energy that must be expended by the turtle while emerging and crawling to a nesting site on the beach.

It also has been observed that the turtles have a preference for nesting within an area of the beach represented by a band of habitat located seaward of the berm crest and approximately 20 m in width. During the nesting season, there is an annual accretion of sand that adds another 40 m of beach width. Because the emerging turtles still seek the original 20 m band, there is almost no loss of nests from erosion, which is why Mexiquillo Beach provides such high quality nesting habitat for the production of hatchlings.

Estimating the Production of Hatchlings

Because of the protection effort provided by the project, 54,785 leatherback hatchlings (2,238 nests) and 4,883 ridley hatchlings (93 nests) were able to emerge successfully and reach the sea. If all of those nests had been allowed to develop in situ, based on the mean number of eggs per clutch and mean hatching success under natural conditions, an estimated production of 54,518 leatherback hatchlings and 5,479 ridley hatchlings would have been realized. Thus, we are able to say that our management techniques are adequate, as can be seen from a comparison of the means of the two methods (Table 1). Furthermore, if we extrapolate these figures to the number of verifiable nesting crawls, we are able to estimate a total of 145,753 leatherback hatchlings and 29,574 ridley hatchlings that should have been produced on Mexiquillo Beach. We can deduce, therefore, that 62.6% of the leatherback nests were plundered. Although this proportion of plundered nests seems high, it is, in fact, a noticeable reduction when compared to previous seasons when the proportion of plundered nests approached 100%. The continuous participation of student and volunteer groups and several local children interested in our turtle conservation program helped significantly with achieving our important goals.

Applying the test of significance of the Z statistic to in situ and relocated nests, it can be seen that hatching success of natural (in situ) nests (51.83%) is significantly greater than relocated nests (49.30%),

where $Z(c) = 2.9$; $Z(t) = 1.96$; $Z(c) > Z(t)$ at $P = 0.05$.

From these results it should be possible to evaluate the effectiveness and applicability of relocating nests to a hatchery, and then to be able to ask the salient management question, "Is this technique the most appropriate for protecting the nests?" The answer would be "yes" if the intensive take of eggs occurring in the area is a motivating part of the decision. However, we must not forget other issues that caution against a hatchery management plan, such as natal beach imprinting, temperature modulation of sex ratios (Anon. 1984, Bull and Vogt 1979), and lethal damage to embryos as a result of moving the eggs (Limpus et al. 1979). Even if we take the greatest of care to minimize these deleterious factors by carefully selecting the site of the hatchery and by promptly reburying the eggs to avoid the damaging effects of movement, to expand the area of beach where nests are allowed to develop in situ still appears to be the better management decision, but it will require exhaustive vigilence and more personnel on the beach to protect the nests.

Simulating the look of a pilfered nest with telltale marks applied to the turtle crawl has proved very successful for protecting tests. This is achieved by placing an "X" in the sand on a crawl or, even better, leaving a few nonviable eggs lying around the nest site, both indications that a nest has been pilfered. In so doing, we have been able to reduce to 50% the probability that a nest will be pilfered, being careful not to give away the credibility of the trick (misleading marks and egg traces) by employing it when conditions for collecting eggs are inappropriate and the egg collectors are not present on the beach. By means of these methods, hatchlings from nests laid outside of our protected study site have been protected and allowed to develop naturally and without the need for relocation.

Hatching Success

Variations in hatching success occur at different times during the nesting season. We encounter the highest period of leatherback hatching success for nests laid toward the end of the second half of November (Figure 1) and the highest period of ridley hatching success for nests laid in December (Figure 2). We also

encounter hatching success < 10% for both species during certain periods of the season. For ridleys, low hatching success occurs in those nests present on the beach during September, a time when cyclonic storms inundate the study area. For leatherback nests (natural and hatchery), there is a tendency for increased mortality of very small embryos (±10 days of development) during September, October, and the first half of November and of term embryos (±50 days of development) from nests laid during March. Throughout the nesting season, embryos may be found dead at different stages of development, but the cause and timing of mortality is never as clear as the two examples discussed above.

Throughout the season, as much as 50% of the eggs of both species may not produce viable young. We believe that much of the nonproductivity of the eggs and the mortality of the embryos may be caused by one or both of the following reasons. First, physiological conditions inherent in the adult females or in the embryos may negatively affect development. Second, environmental causes such as excessive moisture during the months of September and October or severe drought during March and April may also be affecting viability. With the experience and knowledge gained from our work, we have assembled a plan to focus our research efforts more efficiently and to guide us in the selection of different management techniques that may be used, such as the relocation of nests to incubators or polyurethane boxes. Our goal is to ensure that an adequate production of hatchlings will be achieved now and in the future.

ACKNOWLEDGEMENTS

The results presented here have been gathered under the auspices of the Program for Conservation and Research of Marine Turtles located in the southern sector of Michoacan State. We wish to express our very great appreciation to the Michoacan Delegation of SEDUE and for their facilities that have been made available to us. We want to thank the student co-workers that have assisted us from the Department of Sciences at UNAM. We thank Biologists Carlos López S., Javier Tellez S., and Lourdes Gonzalez P. for their input. Finally, we extend our special appreciation to the Sea Turtle Center (Nevada City, California) for the financial support they have provided to us.

This abstract has been translated from the original Spanish by James I. Richardson.

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Table 1. Fate of nests by leatherback (Dermochelys coriacea), olive ridley (Lepidochelys olivacea) and black turtles (Chelonia agassizii) at Mexiquillo Beach, Michoacan, Pacific coast of Mexico.

Category	Dermochelys	Lepidochelys	Chelonia
In Situ Nests	1,129	09	0
Relocated Nests	1,109	84	1
Total Nests	2,238	93	1
Hatchlings Released	54,785	4,483	50
Estimated Hatchlings	54,518	5,479	50
Total Crawls	5,021	-	-
Percent False Crawls	4.48%	-	-
Study Area Nests (4.5 km)	4,796	-	-
Estimated Hatchlings *	145,753	-	-
Percent Pilfered Nests	62.6%	-	-

* Estimation of hatchlings is based on the average percent hatching success of in situ nests.

Figure 1.

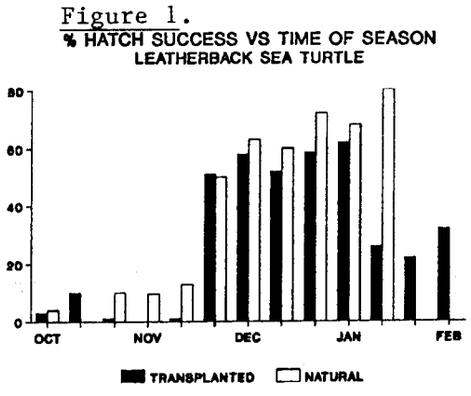
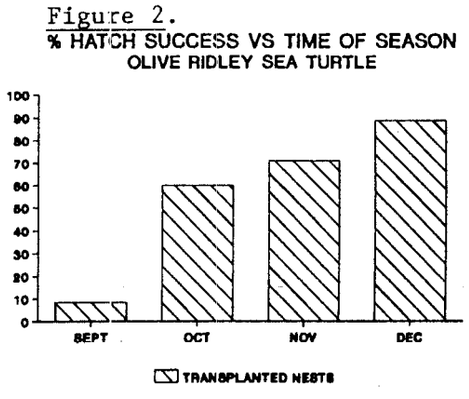


Figure 2.



1988 FALL/WINTER STRANDINGS OF MARINE TURTLES ALONG THE NORTHEAST FLORIDA AND GEORGIA COASTS

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Unprecedented numbers of Kemp's ridley turtles (Lepidochelys kempi) and significant numbers of loggerhead (Caretta caretta) and leatherback (Dermochelys coriacea) turtles stranded on the beaches of northeast Florida and Georgia during the last quarter of 1988. Of 588 total strandings documented in this area by participants of the Sea Turtle Stranding and Salvage Network (STSSN) during 1988, 201 (34%) occurred during the months of October, November, and December. The species composition during this thirteen week period was: 90 loggerheads, 79 Kemp's ridleys, 17 leatherbacks, 3 green turtles (Chelonia mydas), and 12 unidentified turtles. Fourth quarter Kemp's ridleys comprised 80.6% of all Kemp's ridley strandings reported during 1988 (N=98). This paper primarily focuses on the 79 Kemp's ridleys stranded during October-December 1988.

The carcasses which washed ashore during this period were typical of stranded sea turtles documented from this area and other areas since the establishment of the STSSN in 1980. The majority of the carcasses were moderately to severely decomposed and exhibited the normal range of external carcass anomalies such as flipper damage, minor carapace damage, etc. They did not exhibit external lesions, tar or oil fouling, nor were they generally characterized by a heavy epizoa load or severe emaciation which might indicate chronic debilitation. Additionally, these carcasses were not generally characterized by severe external trauma such as that exhibited by the three Kemp's ridleys recovered from the dredges working in the St. Mary's entrance channel from 6 November through 10 December 1988.

The size distribution of stranded Kemp's ridleys documented during this event is consistent with that described by Henwood and Ogren (1987) for trawler captured Kemp's ridleys in the Cape Canaveral area between 1978 and 1984. Mean curved carapace length of our 65 measured individuals was 41.25 cm (range 22.8-57.2 cm, sd=7.61). There were no adults represented, consistent with the apparent confinement (except for very rare occurrences) of sexually mature individuals to the Gulf of Mexico.

Strandings of Kemp's ridleys in the study area occurred during all weeks, with strandings events shifting progressively southward during the entire thirteen week period. This shifting temporal pattern of Kemp's ridley strandings most likely illustrates the nearshore southerly migration of the species along the southeast U.S. coastline and, in general, the southerly migration of the shrimping fleet.

Monthly trends in strandings of Kemp's ridleys for 1988 vs. 1980-1987 are shown in Figure 1. Total Kemp's strandings during the period 1980-1987 is 112, vs. 98 for 1988 alone. While the frequency of Kemp's strandings during 1988 was significantly higher than previous years, the monthly and seasonal trends are consistent from year to year with the highest peak occurring during the period October-December and a secondary peak observed during the summer months. These data indicate that the overwhelming majority of Kemp's strandings during the period 1980-1988 are not resulting from disease or other non-periodic activities (e.g., dredging) but are primarily the result of trawling activity which varies in intensity of effort but does not vary significantly in seasonality.

Data on northeast Florida shrimping effort measured as the number of trips was provided by the National Marine Fisheries Service (NMFS). Figure 2 depicts total 1988 strandings (by month) for northeast Florida and shrimp trawling effort over the same time period. The trend of increased strandings during increased levels of trawling effort is clear. The six months during which the greatest frequency of strandings were reported coincides with the six highest levels of monthly shrimping effort (July-December).

TED REGULATIONS

In response to the unprecedented high levels of Kemp's ridley strandings in northeast Florida, and after an examination of historical stranding patterns and the distribution of shrimp trawling effort, the Florida Marine Fisheries Commission promulgated an emergency TED [Turtle Excluder Device] rule on 24 January 1989. The rule requires all trawlers fishing in Florida state waters north of the Brevard/Volusia County line to utilize TEDs as of 1 February 1989 and is in effect for 90 days. Additionally, the Florida Marine Fisheries Commission will consider permanent year round TED regulations for this area. The National Oceanic and Atmospheric Administration promulgated a similar emergency rule effective 9 March 1989 requiring TEDs on all shrimp trawlers fishing in northeast Florida and southeast Georgia waters (NMFS statistical zones 29 and 30) for a period of 240 days. Permanent federal regulations require TED usage in this area annually from 1 May through 31 August and do not encompass the fall/winter white shrimp fishery. The data presented herein strongly indicate that TEDs should additionally be required in all Georgia and Florida waters during the season of greatest ridley abundance in order to adequately protect this species and all other threatened and endangered marine turtles.

ACKNOWLEDGEMENTS

The collection of stranding data is possible only through the efforts of STSSN participants. We extend our sincere appreciation to all participants who collected and contributed data referenced in this paper.

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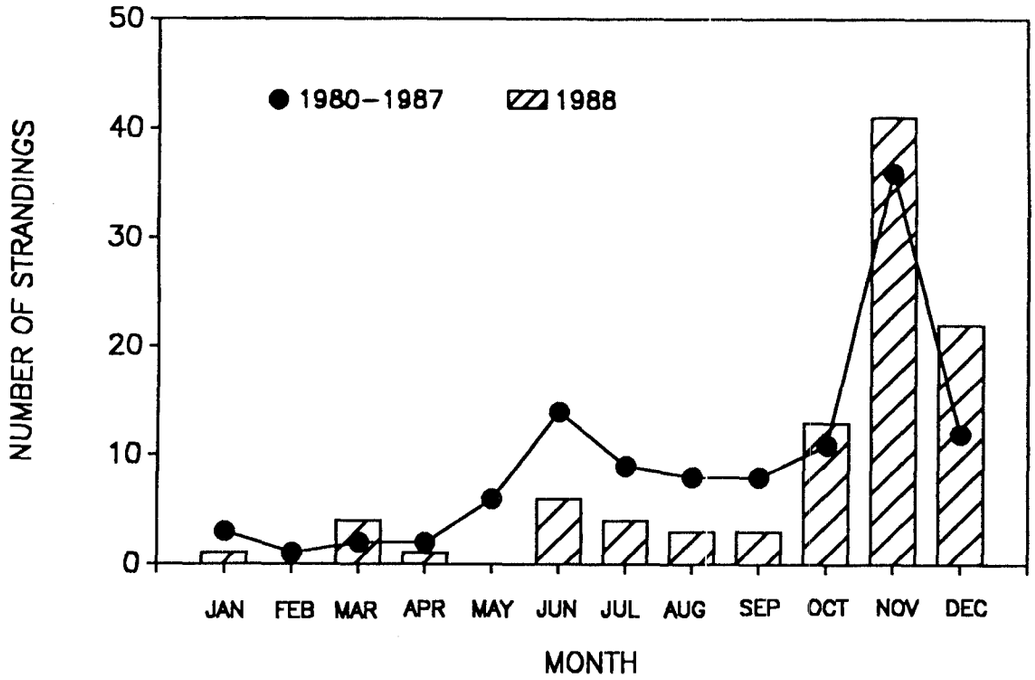

Figure 1. Monthly frequencies of marine turtle strandings reported from northeast Florida and Georgia (Zones 29,30,31). Data for 1980-1987 (N = 112) vs. 1988 (N = 98).

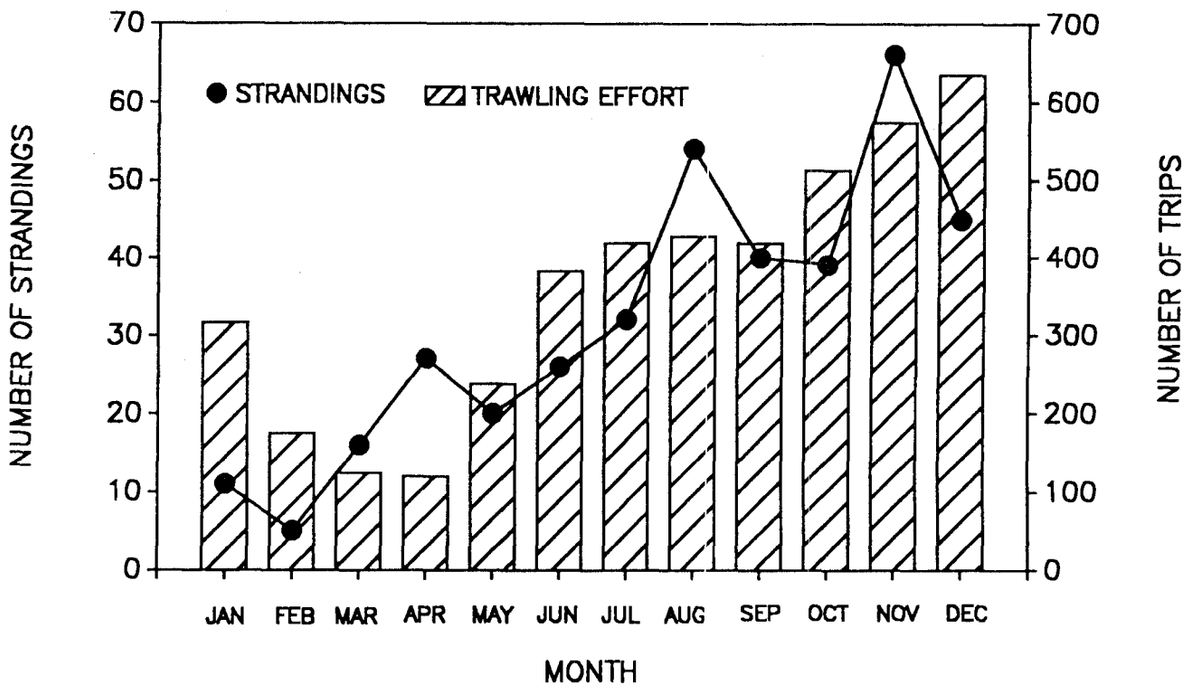

Figure 2. Marine turtle strandings vs. shrimp trawling effort (number of trips) reported from northeast Florida (Volusia - Nassau Counties), 1988.

RESULTS FROM ELEVEN YEARS OF INCUBATING KEMP'S RIDLEY SEA TURTLE EGGS AT PADRE ISLAND NATIONAL SEASHORE

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An international multi-agency program to restore and enhance the Kemp's ridley sea turtle (Lepidochelys kempi) population began in 1978. A portion of this program was an experimental attempt to establish a secondary breeding colony of this species at Padre Island National Seashore (PAIS), Texas, USA. Each summer, approximately 2,000 eggs (20 clutches) were collected at Rancho Nuevo, Mexico, packed in Padre Island sand in styrofoam boxes, and shipped to Padre Island.

From 1978 through 1988, 22,507 eggs were sent to Padre Island (Table 1). The overall hatching rate during the 11 years was 77.1%. Yearly hatching rates ranged from 12.1-91.6% (Table 1). All live hatchlings were released on the beach at Padre Island, crawled down the beach and entered the surf. They were allowed to swim approximately 5-10 m and were recaptured using aquarium dip nets. A total of 278 hatchlings (1.7%) escaped in the surf during release and 381 hatchlings (2.2%) died at Padre Island either prior to or after release (Table 1). From 1978 through 1988, 15,875 recaptured hatchlings were transported to the National Marine Fisheries Service laboratory for one year of 'headstarting' (Table 1).

A number of parameters were monitored for the Kemp's ridley eggs and hatchlings. Data were collected to evaluate incubation conditions and clutch and year class viability and to improve management techniques.

Beginning in 1982, incubation temperatures were measured twice daily at Rancho Nuevo and once an hour at Padre Island. A variety of techniques were used to determine the sex of dead individuals and older captive turtles that had been headstarted (Shaver et al. 1988). Males predominated in most of the earlier year classes. After 1984, incubation facilities and practices at Rancho Nuevo and Padre Island were modified in an attempt to raise incubation temperatures and increase the proportion of females produced. A preponderance of the turtles examined from the 1985-1988 year classes were identified as females (Shaver et al. 1988).

Incubation duration was defined as the total number of days from nest deposition to hatching detection. Yearly mean incubation durations ranged from 46.7-52.0 days. Incubation periods and percent females for all 1982-1988 year classes in which 10 or more individuals were positively identified to gender ($n=31$) were correlated ($y = 772.343 - 14.643x$, $r^2 = 0.61$, $P < 0.001$).

Mean temperatures during the middle third of the incubation period and percent females for all 1982-1987 clutches in which 10 or more individuals were positively identified to gender were correlated in an attempt to derive the first estimate of a pivotal temperature for Kemp's ridley (Shaver et al. 1988). The pivotal temperature was estimated to be 30.2°C, with 95% confidence intervals from 29.9-30.5°C. A beach temperature profile survey was undertaken during the summer of 1986 to examine temperatures at which Kemp's ridley sea turtle eggs would incubate if laid on PAIS (Shaver et al. 1988). Temperatures were compared with simultaneously measured temperatures at Rancho Nuevo and the estimated pivotal temperature for Kemp's ridley. Clutches undergoing their middle third of incubation early in the nesting season at Padre Island or Rancho Nuevo should produce primarily males, later portions of the season primarily females, and middle of the season a mixture.

A total of 3,902 unhatched eggs from the 1980 and 1982-1988 year classes were examined to quantify fertility rates and embryological stages of development at time of death (Shaver and Chaney in prep.). Data were grouped according to thirds of incubation during which death occurred. Significantly more embryos ceased development during the first third of incubation in 1983 than during the first third in any other year (Newman Keuls' Multiple-Range Test, $P = 0.01$). Excessive sand moisture and/or sand or box fungal contamination probably caused the low hatching success and high early-stage mortality in the 1983 year

class (Shaver and Chaney in prep.). Significantly more embryos ceased development during the last trimester of incubation in 1987 than in any other year (Newman Keuls' Multiple-Range Test, P = 0.01). High (> 38.0°C) and excessively fluctuating incubation temperatures prior to shipment to PAIS probably caused the relatively low hatching success (64.3%), high late-stage mortality, and other anomalies in the 1987 year class. A markedly similar pattern of embryonic death was found in 1982, 1984, 1986 and 1988 year class eggs, with highest mortality early in incubation and lowest mortality in the middle of incubation. This pattern may be typical for Kemp's ridley.

Straight-line carapace length and weight were recorded for each hatchling from the 1983-1988 year classes. Mean straight-line carapace lengths and weights of the 1984-1988 year classes were significantly different from one another, with the 1987 year class being the smallest and lightest (Newman Keuls' Multiple-Range Test, P = 0.01).

Beach patrols have been conducted for nesting wild and headstarted sea turtles and nests have been protected and monitored. Although a number of tracks, nesting turtles and nests have been found on the Texas coast during the past 10 years, no confirmed headstarted L. kempi have nested on Padre Island to date. Efforts have been made to educate the public about the Kemp's ridley sea turtle project, sea turtle conservation and the need to report sea turtle sightings. Pursuant to a decision made by the Kemp's Ridley Sea Turtle Working Group in 1986, no additional Kemp's ridley eggs will be transferred from Rancho Nuevo to Padre Island after 1988. However, PAIS will continue public education efforts, beach patrols for nesting turtles and protection and monitoring of sea turtle nests laid in Texas.

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Table 1. General results of 1978-1988 Kemp's ridley incubation and imprinting at Padre Island National Seashore.

Year	Number clutches from Rancho Nuevo	Number eggs from Rancho Nuevo	Number (percent) eggs hatched	Number (percent) hatchlings died at Padre Island	Number (percent) hatchlings lost during release	Number hatchlings to Galveston	Mean incubation period (days)
1978	17	2,191	1,931 (88.1)	64 (3.3)	19 (1.0)	1,848	51.5
1979	20	2,053	1,769 (85.7)	15 (0.9)	93 (5.3)	1,661	52.0
1980	32	2,976	2,502 (84.1)	14 (0.6)	65 (2.6)[a]	1,611	50.5
1981	23	2,279	1,898 (83.3)	11 (0.6)	19 (0.8)	1,868	48.3
1982	20	2,017	1,563 (77.6)	5 (0.3)	34 (2.2)	1,524	51.0
1983	18	2,006	242 (12.1)	10 (4.1)	2 (0.8)	230	52.0[b]
1984	19	1,976	1,792 (90.7)	239 (13.3)	9 (0.5)	1,544	51.1
1985	20	1,978	1,664 (84.1)	13 (0.8)	25 (1.5)	1,623[c]	48.8
1986	22	2,011	1,776 (88.3)	1 (0.1)	16 (0.9)	1,759	46.7
1987	20	2,001	1,288 (64.3)	5 (0.4)	1 (0.1)	1,282	47.6
1988	10	1,019	933 (91.6)	4 (0.4)	4 (0.4)	925	46.9
Total	221	22,507	17,358 (77.1)	381 (2.2)	287 (1.7)	15,875	49.7

[a] Calculated excluding 810 hatchlings from 11 clutches intentionally released into the Gulf of Mexico.

[b] Calculated based only upon the 9 clutches that hatched.

[c] Calculated excluding 69 hatchlings from a Padre Island natural nest head started at the Galveston NMFS laboratory.

POSSIBLE EFFECTS OF ARTIFICIAL FOODS ON SEA TURTLE HEALTH

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While it appears an obvious fact that animals in captivity live under different conditions from those in the wild, the corollary assumption that captive conditions are generally healthier (i.e., no predators or parasites, an abundance of food) is not necessarily true. Such conditions are invariably different, and this is especially true of diets. The increasing use of soybean products as protein substitutes in formulated foods for captive animals such as sea turtles may present some surprising hidden dangers. Soybeans contain high levels of the phytoestrogens diadzein and genistein (Walz 1931). These two plant estrogens in turn may be found in commercially prepared animal diets containing soy products (Setchell et al. 1987).

The problem is that exogenous estrogens can exert biological activity. The fate of ingested estrogens is dependent both on the animal species and the estrogen's structure. In mice and men, at least, exogenous estrogens are generally broken down by intestinal microflora or degraded in the liver to be excreted in the urine as glucuronides (Figure 1). Some exogenous estrogens, however, are similar enough in structure to endogenous species that they pass into the bloodstream and exert biological activity. Problems arise when circulating estrogen levels are too high, creating undesirable or even pathological effects (Gosselin et al. 1987). Phytoestrogens may lead to false conclusions in blood hormone assays: for example, if exogenous estrogens are mistaken for endogenous ones. Pathological effects include liver diseases induced by thrombosis and hypercoagulation. Phytoestrogens also may strongly depress the hypothalamic-pituitary-gonadal axis, leading to the depression of ovulation, an increased frequency of ovarian cysts, or possibly the depression of male sexual competence (Gosselin et al. 1987).

These possibilities become an area of concern when working with endangered species such as sea turtles, especially where captive breeding or hatchling release programs are in effect. While turtles in the wild consume a variety of prey items, animals in captivity commonly receive only commercially prepared feed of which soybean meal is the primary constituent. This raises the question, "Are the phytoestrogens in soy-based food acting as an exogenous source of estrogens in the blood, and thus potentially available for biological activity?" A preliminary experiment was performed based on the hypothesis that if the estrogens detectable in the blood were in fact phytoestrogens from soy-based food, then fasting the animals for a short period would lead to a decrease in detected plasma estrogen levels. This in fact did occur with plasma levels dropping from approximately 22.0 pg estradiol/ml to nearly 12.0 pg/ml over a 10 day period. While the results are preliminary and are not statistically significant, they do indicate a need for further study. If phytoestrogens are enhanced in turtles fed artificial food, then we must pay serious attention to the potential health and reproductive problems in these and other captive animals.

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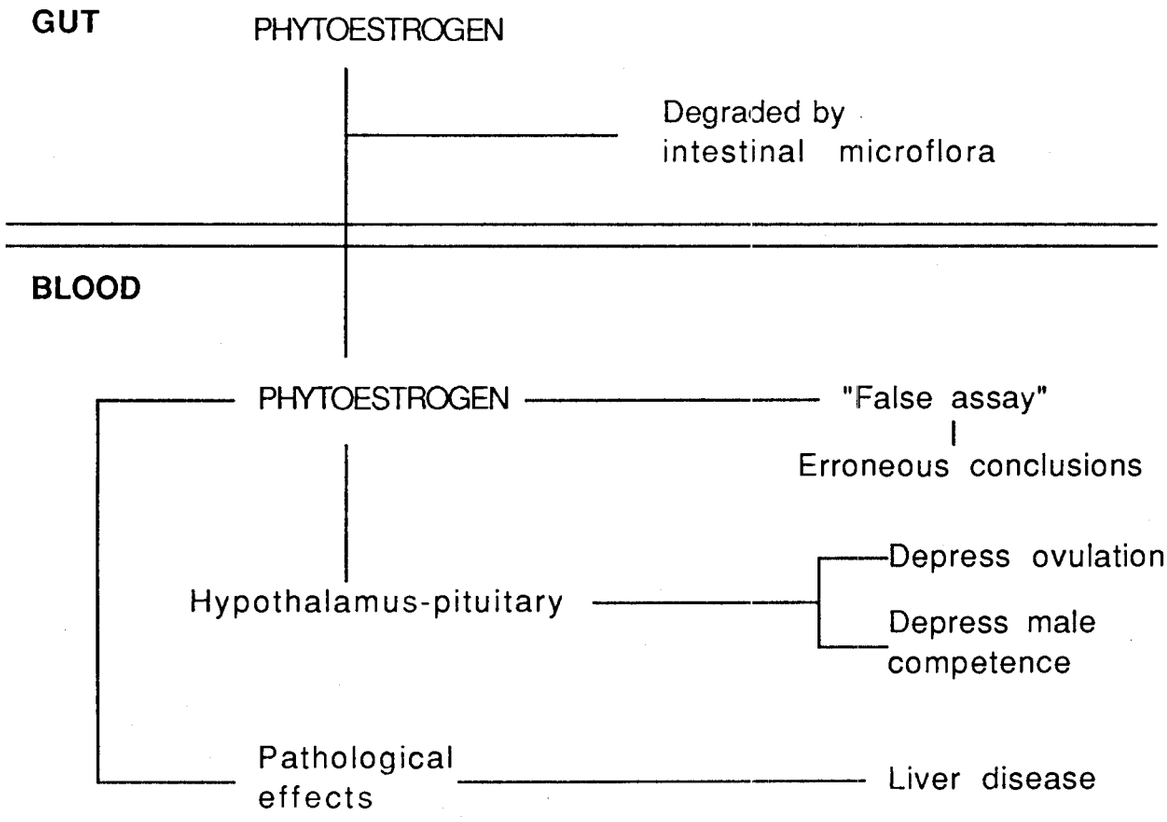

Fig.1 Fate and effects of ingested phytoestrogen

TRAUMA TO STRANDED SEA TURTLES ON CUMBERLAND ISLAND, GEORGIA, DURING 1986 AND 1987

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A few years ago we first reported that some stranded sea turtles on Cumberland Island, Georgia, had suffered severe trauma to the skull and that some of the stranded sea turtles may have been debilitated by trauma and therefore more likely to die in fishing gear. Consequently, we initiated an investigation of trauma to stranded sea turtles and attempted to define the amount of trauma suffered, determine if the trauma was correlated with species, size, sex, or date of stranding, and determine the cause, kind, extent, and time of trauma.

Of the 133 sea turtles stranded on Cumberland Island during 1986 and 1987, loggerheads (Caretta caretta) and Kemp's ridleys (Lepidochelys kempii) were most common (117 and 12, respectively) while green turtles (Chelonia mydas) and leatherbacks (Dermochelys coriacea) were few (2 each). One loggerhead was removed from the beach before we could examine it, 14 loggerheads were in such poor condition they provided only minimum information, and one ridley was illegally taken by a National Park Service ranger and was later found discarded with the head missing. Of the 119 turtle carcasses useful for study, 84 (71%) had suffered some sort of trauma prior to necropsy. Since we did not regularly prepare appendicular skeletal material, antemortem trauma was not fully assessed.

We were unable to correlate trauma with sex of animal, species of turtle, size of turtle, or date of stranding, except that ridleys show a seasonal pattern of stranding. The seasonal pattern may be an artifact induced by size, as discussed below.

Of the animals with trauma, postmortem trauma was found in 65%, antemortem, 44 %, and trauma judged to have taken place at the time of death, 4%. Most postmortem trauma was attributed to sharks. Of those loggerheads with heads, 24% (17/70) had suffered antemortem damage, of which 11 were assigned to unknown causes, 5 to severe impact, and 1 to a blow with a sharp object. Antemortem trauma to the heads of all species combined was 23%.

Shark damage was greatest to limbs. Thirty-six percent of loggerhead carcasses were missing limbs attributable to shark attack, while 32% of all species suffered removal by sharks.

The most frequent kind of damage was removal (and often related to sharks); fractures and lacerations were the next most frequent kinds of trauma. Severe impacts and unknown causes were responsible for most fractures and lacerations.

Of all loggerheads with partial or complete digestive tracts, 44% contained intact shrimp and/or fishes which we believe were obtained in shrimp trawls. Only 14% of the ridleys had such items. We believe our indirect evidence of association with shrimp trawls makes association of antemortem trauma to human activities quite likely.

The ramifications of these data are many. The high frequency of shark attack on carcasses could skew size distributions of stranded sea turtles since small turtles might be more likely to be totally consumed when sharks are present. The seasonal stranding pattern of smaller individuals, especially ridleys, may reflect shark abundance rather than size structure of the nearshore sea turtle assemblage. Conversely, ridleys may be more abundant when sharks are less abundant.

Sharks removed limbs from 32% of the carcasses, reducing any chances of discovering flipper-tagged animals. As we suggested last year at these meetings, the optimal location for a transponder tag is not the flipper, but the shoulder because it is likely to survive shark attack.

Of particular concern is the frequency of antemortem trauma and the possible correlation to subsequent mortality. That so many sea turtles have survived such damage, only to die later in a subsequent event, suggests a high probability of multiple encounters with sources of trauma. It will be especially enlightening to determine if such trauma is reduced when use of turtle excluder devices by shrimp trawlers becomes mandatory.

ACKNOWLEDGEMENTS

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THE GREEN TURTLES OF AVES ISLAND

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Aves Island in the eastern Caribbean (15°40'15" N and 63°37'00" W) is a small sandy island with fringing reef. The island is located approximately 300 km from Puerto Rico, 200 km from Dominica, and 648 km from La Guaira, Venezuela. Since 1979, the Foundation for the Defense of Nature (FUDENA) has been studying the Aves Island green turtle population by monitoring, tagging, and measuring the adult females that arrive on the island to nest. From 1984 to 1988, there have been FUDENA research personnel present on the island during the entire nesting season (February to November). In 1982, the nesting season was monitored except for November. In 1979, 1980, 1981, and 1983, the turtles were monitored for only three or four months during the nesting season. There have never been personnel present on Aves Island in December and January, because few or no turtles arrive to nest at this time of the year.

The present work summarizes data on nesting periodicity, seasonality, remigration intervals, and long distance tag returns. It is important to point out that the information gathered over the last ten years is only now being entered in the computer. Thus, much of the analysis in this paper is based just on the 1985, 1986, and 1987 season reports.

Aves Island is a calcareous sand island on a beach-rock platform bounded to the north, east, and south by a fringing reef. It is in the shape of a human footprint. A topographic survey carried out by the Dirección de Hidrografia y Navegación (Comandancia General de la Marina) in 1983 showed that the island had an area of 4.2 ha, a length of 664 m (N-S), and a width (E-W) that varied from 33 m at the center of the island to 272 m at the northern end. The maximum elevation was 3.72 m above mean sea level.

RESULTS

Nesting Behavior

Figure 1 shows the seasonal distribution of green turtle nesting activity observed during 1985, 1986, and 1987. The nesting season begins in February, peaks in August, and ends in November. Figure 2 is a compilation of the internesting intervals (n=1714) recorded during 1985, 1986, and 1987. Turtles appearing within six or fewer days after last being seen were noted as re-emergences following an unsuccessful nesting attempt.

A majority of the turtles represented by the first peak in Figure 2 renested after intervals of 10-14 days (60.57%). The predominant interval was 11 days (20.30%), followed by 12 days. The mean internesting interval was 15.98 days (sd=8.58). This value is greater than mean internesting intervals recorded elsewhere for green turtles (see Mortimer and Carr 1987 for a review of these values) and is caused by the occurrence of some very long internesting intervals at Aves Island.

Estimates of mean number of clutches laid per female (Figure 3) were calculated from 1985, 1986, and 1987 data. A majority (55.2%) of females lay 1 or 2 clutches, and the mean number of observed clutches per turtles is 2.61 (sd=1.48)

The most commonly observed remigration intervals for Chelonia mydas at Aves Island are 2 and 3 years. Remigration intervals have been recorded for 157 turtles (Figure 4) since 1979. Nineteen turtles were observed on three nesting seasons (double remigrants) and four have been observed on four nesting seasons (triple remigrants).

Long Distance Movements

Since 1979, a total of 1,975 turtles have been tagged at Aves Island. At the present time, a total of 25 long distance recoveries have been recorded. Ten of these recoveries were turtles tagged by Rainey between 1973 and 1976 (Carr et al. 1978). All of the recoveries have taken place in the Caribbean Sea, except for one recovery along the Atlantic Ocean on the coast of Brazil. Caribbean recoveries have come from Mexico, Nicaragua, Cuba, the Dominican Republic, Puerto Rico, St. Kitts, Grenada, Las Islas de Tortugas (Venezuela), and Guyana. This information, although scarce, indicates that Aves Island is an important nesting ground for a significant portion of the Chelonia mydas population in the Caribbean.

Population Estimates

Due to the small area of Aves Island, almost all the turtles that arrive on the beach are counted (observed). Investigators check the entire perimeter of the island every 1.0-1.5 hours. Since 1984, investigators have been present throughout the nesting season, so stock assessment counts during those years have been quite accurate. There seems to be a cycle occurring on alternate years, with a greater number of females (in excess of 400 individuals) in some years, followed by years with fewer turtles (300 individuals or less). The number of turtles nesting in 1988 was 400-500 individuals, further supporting the above idea.

ACKNOWLEDGEMENTS

The information gathered since 1979 has been made possible thanks to the work of the following investigators: J. Laiz, E. Weil, D. Bone, J.L. Gomez (who worked 8 years on the island), F. Herrera, J. Marques, A. Fernandez, A. Chavial, P. Contreras, L. Gorrin, R. Rivera, V. Blanco, L. Gomez, H. Gonzalez, I. Mendoza, P. Vernet, and E. Lopez.

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FIGURE 1.

Annual distribution of nesting activity
1985-86-87

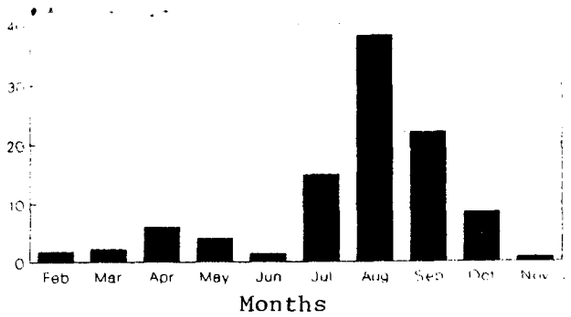


Figure 2.

Emergences time intervals
1985-86-87

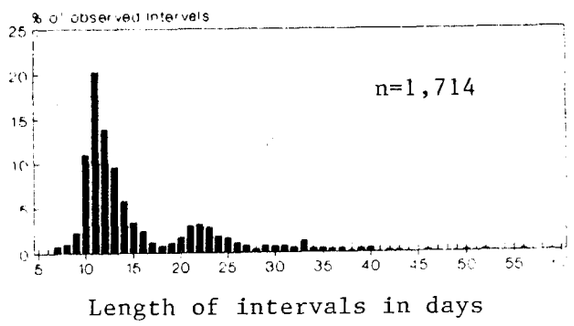


Figure 3.

NUMBER OF NESTING PER FEMALE
1985-86-87

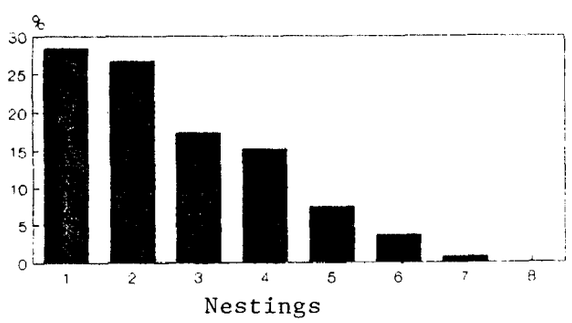
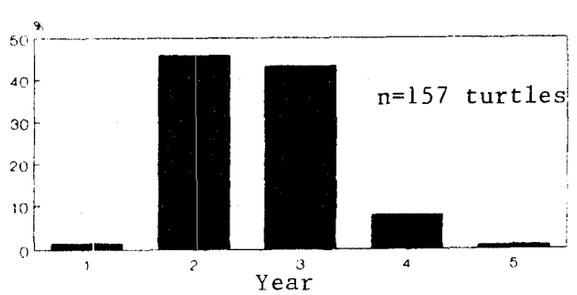


Figure 4.

REMIGRATION INTERVALS IN YEARS
Between sucessive nesting seasons
ISLA DE AVES



GROWTH RATES OF JUVENILE KEMP'S RIDLEYS AND THEIR MOVEMENT IN NEW YORK WATERS

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During the summer and fall of 1988, sonic and/or radio transmitters were attached to seven Kemp's ridley turtles released in the waters surrounding Long Island, New York. Four of these turtles were rescued "second year" animals (mean straight-line carapace (SLC)=37.0 cm) which had been cold-stunned during November and December of 1987 and held for approximately 7 months in the Aquarium of Niagara Falls, New York. The remaining three turtles, "first year" animals, (mean SCL=29.4 cm) had transmitters attached immediately upon their capture in the Long Island Sound/Peconic Bay area. Because it was impossible to simultaneously track several turtles, four were selected for intensive monitoring while the others were tagged and released with plans to re-establish contact at a later date. The four turtles continuously tracked were monitored for 7, 25, 26 and 89 days, respectively. All turtles which were closely monitored had sonic transmitters attached. Two of the sonic transmitters contained depth sensors which made it possible to precisely locate the turtles' positions in the water column.

For five out of seven turtles for which data were available, the direction of movement at the point of last contact was eastward. One radio transmitter which had broken free from a turtle was found on a beach located on the south shore of Long Island. Because currents in the area would not transport a freely floating object to this area, it was assumed the tagged turtle left the sound/bay area and was in the Atlantic south of Long Island prior to transmitter separation. The farthest distance traveled by a turtle was 193 km. This turtle, a second year animal, traveled 60 km westward, moved northward along the Connecticut shore, and was found alive 82 days later in a cold-stunned condition approximately 40 km from the eastern tip of Long Island.

The mean distance traveled by a ridley in this area was 8.3 km/day, with most of this movement occurring during daylight. Total distances traveled were 5-26 times the final net displacement distance. In one experiment to compare the behavior of a first and second summer animal, one of each was tracked simultaneously. During the 25 days of monitoring both showed similar behavior and occupied similar habitats, on some occasions occupying the same habitat concurrently. During this experiment the first summer turtle also simultaneously occupied an area with another transmitter equipped second summer turtle.

A first year turtle outfitted with a depth sensing transmitter was monitored during 78 dives over a period of 13 days. Maximum dive depth was 12.5 m; in over 75% of the dives the turtle was within two meters of the bottom as determined by comparing telemetered depth information and fathometer readings. Fecal samples obtained from recaptured turtles and stomach analyses from cold-stunned animals revealed that 75% of the samples contained crab parts. The slow-moving spider crab (Libinia sp.) was the most common prey item. The mean growth rates for three freely-swimming animals was 547.7 g/month (Figure 1). Five cold-stunned animals held in a 10,000 gallon tank showed no mean weight increase for the initial three months post-stunning (January-March) (Figure 2). Weight gains during the next four months had a mean of 321 g/month. Although turtles did not increase in mass during the initial period of captivity, they did exhibit continuous increases in carapace length (mean=0.29 cm/month) (Figure 3). Carapace lengths increased 2.8 times faster in the field than in captivity. It is not known if this disparity in growth rates was due to recovery from cold-stunning, adjustments associated with captivity, or seasonality effects.

Radio and sonic telemetry has been an effective tool to not only determine turtle location but also to directly observe the behavior of the turtles both at and below the surface. The ability to recapture specific individuals at desired times can greatly facilitate diet and growth studies. Based on the rapid growth rates of the freely swimming Kemp's ridleys we studied, these animals are successfully exploiting the resources available to them in the marine habitats surrounding Long Island, New York.

ACKNOWLEDGEMENTS

This research was supported by a grant from the New York Department of Environmental Conservation Return a Gift to Wildlife Program, and the Okeanos Ocean Research Foundation. We wish to thank the commercial fisherman of Long Island and numerous volunteers for their assistance in locating animals. A special thanks to the staff of the Aquarium of Niagara Falls, especially Director Al Clifton and Senior aquarist Glen LaPlaca. Our thanks to Okeanos personnel, especially Research Director Sam Sadove, our boat captain Les Kiehn, biologists Rob Johnston and Vinny Burke, and tracking assistants Brigitte Baumann and Pam Vacheron.

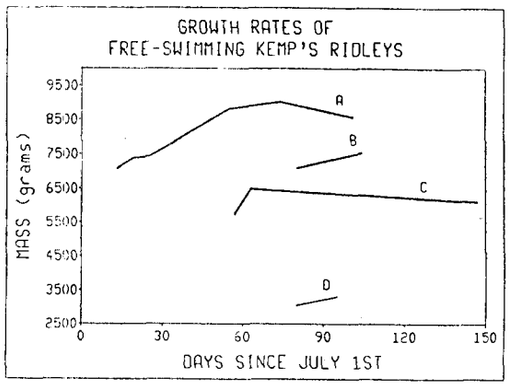

Fig. 1. Field growth rates determined by multiple recaptures. Turtles A, B, and C were second season animals, turtle D was a first season animal. Turtle C was recovered suffering from hypothermia.

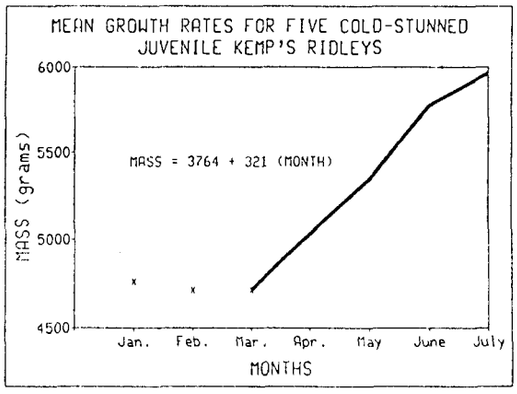

Fig. 2. Changes in mass of five captive K. ridleys. Regression equation is for data included in solid line.

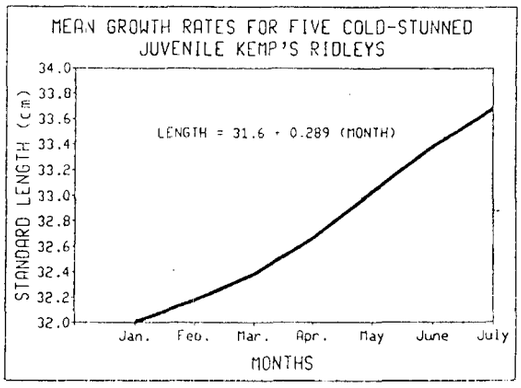

Fig. 3 Changes in standard carapace length of five captive K. ridleys. Monthly means are averaged from weekly readings.

STATUS AND CONSERVATION OF SEA TURTLES IN SRI LANKA

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STATUS AND DISTRIBUTION

Of the seven species of sea turtles in the world, five species are confirmed nesters on beaches in Sri Lanka, an island situated east of the southern tip of India. At the beginning of the century, Sri Lanka was considered to include prime nesting beaches (rookeries) for all sea turtle species nesting in the Indian Ocean (Deraniyagala 1953). Sea turtles were abundant and distributed throughout the country. Current estimates indicate that the populations are small and declining rapidly. However, no precise numerical evidence as to population sizes and trends are available at this time. Historically, Deraniyagala reported that Sri Lanka was the major breeding ground for the leatherback sea turtle (Dermochelys coriacea) in the Indian Ocean (Deraniyagala 1953). Currently this species is rare with infrequent nesting (Frazier 1975). The loggerhead (Caretta caretta) is the rarest of sea turtles in Sri Lanka. The hawksbill (Eretmochelys imbricata) was once very abundant in southern Sri Lanka, but recent numbers from the area are extremely low (Mager 1985). Green turtles (Chelonia mydas) are reported as uncommon with a greatly reduced population throughout the island (Frazier 1975). In terms of nesting and occurrence, the olive ridley (Lepidochelys olivacea) is the most common. Contrary to Deraniyagala (1953), the 'flatback' (Natator depressa) is not found in Sri Lankan waters (Limpus 1988).

EXPLOITATION AND HABITAT DESTRUCTION

The biggest threat to sea turtles in Sri Lanka is exploitation. All five species are exploited, but not in equal quantities nor for the same purposes. Currently exploitation is for meat, eggs and shells. Such products are used for their nutritional, medicinal and cultural values. These products are collected by fishermen and their families for sale at local and international markets. Turtle flesh is believed to have strong medicinal powers. Turtle meat also serves as a cheap source of protein among the coastal people of Sri Lanka. However, it is not the primary source for any individual. Similarly the eggs are consumed as an aphrodisiac and for nutritional purposes. On a majority of beaches, 100% percent of all eggs laid are collected.

The exploitation of meat and eggs in Sri Lanka was previously described by authors as strictly for subsistence purposes (Salm 1976, Frazier 1980). However current exploitation is directed only towards the local market. The exploiters are primarily fishermen by profession. To these people, the meat and eggs are not a primary source of protein, nor is the income from the sale of such products their sole livelihood. The income only serves as an additional bonus to their fishing. Large quantities of eggs and meat are collected from these fishermen by local fish dealers and transported to local markets to be purchased as delicacies.

Tortoiseshell is the most valued of turtle products in Sri Lanka. Carapace scutes are used in the manufacture of curios, jewelry and display ornaments; scutes from the plastron are used for furniture inlay. Although tortoiseshell items had great cultural and social significance during the early and mid-1900's, current exploitation is exclusively for the international market. In Sri Lanka tortoiseshell items are currently an important part of the tourist trade. The government of Sri Lanka participated in the industry through the Tortoise Shell Industrial School, which has now been closed due to a shortage of raw materials. Tortoiseshell items are sold openly to tourists at state and private emporiums. Hawksbill populations have been devastated by the tortoiseshell industry. The largest nesting concentration of this species on the southern coast of Sri Lanka has been totally destroyed for this purpose. Not only have all the nesting adults been removed, juveniles with carapace measurements of 40-50 cm and scute yields of 0.85 kg are now being extracted. The present returns are therefore about four times less per turtle than they were at the turn of the century.

In addition to exploitation, the development of coastal areas has imposed great pressures on sea turtle habitats. Tourist resorts and settlements have reduced nesting space and increased artificial lighting on the beaches. In addition, the mining of beach sand and coral for construction purposes has caused the erosion of prime nesting habitat and the accidental catch of sea turtles by the fishing industry is widespread (most of the meat is sold clandestinely at the fish markets).

CONSERVATION EFFORTS

Ironically, under the Fauna and Flora Protection Ordinance, sea turtles are protected in Sri Lanka. Sri Lanka is also a signatory of CITES. The lack of implementation of the law and conservation policies has been attributed to a shortage of trained law enforcement personnel, to obsolete, inconsistent and insufficient clauses, and to a lack of administrative support and political coordination. Management efforts have been limited to hatcheries, most of them initiated by private parties. Unfortunately, most of the hatcheries were manned by personnel who lacked training in sea turtle biology or hatchery management and hatch success at these facilities rarely exceeds 25%.

The situation in Sri Lanka indicated that for the conservation of sea turtles a joint recovery effort by relevant government and nongovernmental agencies was urgently needed. To meet this urgent need, several organizations (National Aquatic Resources Agency, Sri Lanka Environmental Congress, March for Conservation) established the National Sea Turtle Survey of Sri Lanka. However, all government agencies and nongovernmental organizations associated with sea turtles have not joined the Survey. The Survey will be responsible for the national policy for the conservation and management of sea turtles in Sri Lanka. The policy will include the implementation of scientific studies, identification of problem sites, initiation of action plans, evaluation and coordination of management efforts, and the establishment of a grassroots conservation network.

The Survey should harness the support of over 130 nongovernmental and 17 governmental agencies nationwide to establish an effective network. Established organizations should be tapped for sea turtle education and other specialty support. Survey and network participants need to train fishermen and present hatchery employees in the correct techniques for research and management. The use of hatcheries as education centers and tourist attractions should be pursued as an income source to the sea turtle program. The Government should be pressured to abide by national laws and international conventions. Some efforts to survey beaches, study hatchery management, evaluate laws and propose recommendations, and educate the public are currently underway. These efforts should be encouraged by the international sea turtle community in order to ensure the protection of the dwindling sea turtle populations of Sri Lanka.

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SO MANY TURTLES, SO LITTLE TIME: UNDERESTIMATING FECUNDITY AND OVERESTIMATING POPULATIONS?

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In deriving population density and abundance estimates for a species, adequate sampling regimes must be met in order to obtain non-biased population parameters. The sampling of sea turtle populations generally occurs at rookeries for that proportion of reproductive females nesting in a given year. Acknowledged problems inherent to adequately sampling these populations include tag loss, incomplete capture-recapture records, variation in remigration schedules, variable female reproductive output, and unrecorded nesting events occurring outside the sampling area. Despite these reasons, a common approach for annual population assessment is to count tracks, nests, or female turtles on nesting beaches (Carr 1980). Meylan (1985) indicates the additional difficulties associated with estimating size of nesting populations by these methodologies since "remigration intervals, average numbers of nests per season per female, and the ratio of successful to unsuccessful emergences are all poorly known." Rookeries with high nesting densities often have population estimates which are multiplicative and are based on track counts (Pritchard 1982), but which ignore or make assumptions concerning clutch frequency as a calculating factor. Net rates of reproduction, R_0, are derived from survivorship and reproductive output data (Wilbur and Morain 1987). Female reproductive output is a function of clutch size and frequency and although estimates of mean clutch size and remigration intervals can be obtained by even infrequent beach surveys, accurate clutch frequency data is highly dependent upon the frequency of beach patrols (Frazer and Richardson 1986). Fecundity data has been incorporated in both age-specific fecundity models (Frazer 1984) and demographic models (Bjorndahl 1980, Crouse et al. 1987). Fecundity data resulting from a saturation tagging project for Caribbean leatherback sea turtles, Dermochelys coriacea, is presented and compared to other published estimates for the species. The alternative use of fecundity data (when available) is discussed as a divisive factor for obtaining annual population estimates from track counts.

The reproductive biology of leatherback turtles has been intensively monitored by a saturation tagging project in the northeastern Caribbean. Turtles were studied at Culebra National Wildlife Refuge, Isla de Culebra, Puerto Rico from 1984-1987. The rookery supports only a minor Caribbean nesting population (Carr et al. 1982), but is unique in being patrolled frequently to insure that all nesting females are double-tagged and each subsequent nesting at the study site recorded during the season. The practice of double-tagging helped to alleviate tag loss, a common occurrence with the soft-skinned leatherback. Leatherbacks require at least an hour to complete a nesting sequence and so patrols were scheduled at hourly intervals each night of the nesting season (1 April-8 July). The shortness of the study beaches (both < 2.4 km), lack of nearby alternative nesting habitat (91%-100% of all nesting in archipelago occurred on study site), and frequency of coverage resulted in a high probability of encountering each female to verify all seasonal nesting events. A very complete census of individual turtle data was obtained in this manner. All recorded annual nestings for an individual were calculated as observed clutch frequency (OCF), following the methodology of Frazer and Richardson (1985).

Data recorded for individual nest frequency are presented that indicate new upper limits to the species' fecundity. Annual OCF averaged over the four year period was 6.1 nests per female (range 5.2-7.0, sd=0.74). Most estimates of intraseasonal nesting frequency are based on return intervals following an initial tagging and overlook nesting that occurs outside the study site. Additionally, the initial tagging of a female may not occur until one or more clutches have been deposited. Missed nestings due to incomplete beach coverage result in an underestimate of annual reproductive output per individual. OCF's are seen to be underestimates of the true reproductive output. Although the population for Culebra (≈20 per year) is substantially less than populations utilizing larger yet less thoroughly patrolled beaches, a saturation tagging program yielded a higher percentage of encounters with nesting females and resulted in fecundity estimates greater that previously reported.

The discovery of higher mean clutch frequencies for leatherbacks suggests that fecundity for additional turtle species may also be underestimated at beaches which cannot be intensively sampled. Fecundity as referred to in this note represents only the number of annual clutches per female and not the total number of eggs per clutch for which abundant data already exist. Higher fecundity maxima for additional species have been established as a result of saturation tagging projects: seven clutches for Caretta caretta in Georgia (Lenarz et al. 1981), eleven clutches for Chelonia mydas in Malaysia (Hendrickson 1958), and six clutches for Eretmochelys imbricata in Antigua (Corliss and Richardson, unpubl. data) have been recorded. Recent information provided for Rantau Abang, Malaysia, by Chua (1988) indicates that D. coriacea will on occasion deposit up to twelve clutches per season, but no information on average nesting capability has yet been provided. Ehrhart (1982) has noted the difficulty in quantifying fecundity despite the volume of available data. Fecundity maxima are reflective of optimal acquisition of energy reserves to meet demands imposed by reproductive expenditures and may not be as valuable a metric for comparison as are mean fecundity values. A comparison of data from several leatherback rookeries indicates that the rookeries with most complete levels of coverage; i.e., Puerto Rico (Tucker 1987), St. Croix, U.S. Virgin Islands (Eckert and Eckert 1984), and Mexico (Sarti et al. 1987) all have higher estimates of female fecundity (6.1, 4.9, and 5.7 nests per female, respectively) than recorded for leatherback beaches with less coverage; i.e., Costa Rica (Hirth and Ogren 1987), French Guiana (Fretey and Girondot 1988), and Malaysia (Chua 1988) with 2.7, 2.8, and 2.9 nests per female, respectively. It is interesting to further note that the percentage of total nesting occurring within study site boundaries at the first three rookeries mentioned are estimated at ≈91%, ≈60%, and ≈95%. Data on nest site fidelity and degree of beach coverage at the latter three rookeries are unavailable. Sampling effort expended as a proportion of the population quantified would intuitively be directly proportional. Despite several orders of magnitude difference in abundance and density at major vs. minor rookeries, data obtained via intensive, tagging studies of relatively small but thoroughly covered populations have great utility.

Nesting behavior for the Culebra population was not found to be significantly different than at other major rookeries. It is then reasonable to maintain that the different values recorded for fecundity are representative of sampling effort expended per female. The lack of information concerning annual mean reproductive capacity for many leatherback rookeries underlines the need for consideration of the implications of these findings, particularly when population estimates are based upon nest or track surveys rather than time/energy consuming verification of individual female nesting histories involving a virtual census rather than a sample. Saturation tagging data for leatherbacks suggests that multiplicative world population estimates may be overestimated, although it is difficult to say to what degree. Although it is recognized that leatherbacks from different geographic regions may eventually be found to be heterogeneous in their behavior and variable in fecundity, estimates of leatherback abundance may be less than previously thought. As surveys of seasonal track counts can be divided by a mean value for female fecundity, an abundance estimate for the annual nesting population may be calculated. This value in turn would be multiplied by the estimated proportion of females nesting for each season based upon remigration intervals to give a total number of reproductive female for a given rookery.

Many rookeries exist that have higher nesting densities but they may not be as spatially limited to available nesting habitat as are smaller insular populations. Without sufficient personnel to tag and thereby quantify the frequency of individual nestings, saturation tagging studies and the gleaning of individual nesting histories are precluded. Although not all beaches or populations lend themselves to this strategy, the benefits of gleaning "census" information can validate its use on a beach capable of supporting the substantial logistic effort required to undertake a saturation tagging population study.

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ASSESSMENT OF JUVENILE GREEN TURTLES AND THEIR HABITAT IN BROWARD COUNTY, FLORIDA WATERS

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Divers frequently encounter juvenile green sea turtles (Chelonia mydas) along the hardbottom reef areas of Broward County, Florida. Habitat related research has been pursued in other areas of the state by Carr and Caldwell (1956) in the Cedar Key area and Mendonca and Ehrhart (1982) within the Indian River system. The current study is the first to study the population of juvenile green turtles and its foraging and resting habitat in Broward County, Florida.

The offshore sea floor of Broward County consists of a series of limestone ledges running parallel to the shore. The first of these ledges begins approximately 75 m offshore, and is continuous for the duration of the county coastline. Offshore depths range from 7 m or less for nearshore sites to 20 m for those reefs farthest seaward.

METHODS

Three primary study tools were utilized to produce information on this population. Capture of sleeping or swimming juvenile turtles was accomplished by using SCUBA apparatus at night. Turtles thus captured were brought to the surface, examined, tagged with #681 Inconel tags, measured and released. Dive entry was accomplished from shore or from a small inflatable boat. Approximately one mile of hardbotton area off central Broward County was surveyed at least twice a week as weather permitted. A similar area at the north end of the county was also surveyed on a regular basis. Diurnal SCUBA surveys were conducted to document behavior patterns of green turtles during the day, and to locate algae species and determine relative abundance of these food sources.

Necropsies were performed upon stranded juvenile green turtles. Stomach contents from 18 turtles stranded in Broward County of the same size class as those tagged were taken for analysis.

RESULTS

One hundred and five juvenile green turtles have been captured and tagged during nocturnal diving surveys conducted between 1 March 1986 and 31 December 1988. Four juvenile hawksbills were also captured. Capture success rate was 45% with a calculated effort of 4.08 man hours per capture. June and October were peak capture months; September and December resulted in the fewest captures.

Curved carapace lengths (notch-to-tip) for captured turtles ranged from 26.4-67.0 cm. The majority of the population falls between the 30 cm and 60 cm size categories. Turtles < 35 cm are more frequently captured in the spring months.

Recaptures were made for 25 green turtles for a total recapture rate of 23.8% Homing behavior was displayed by one green turtle, tagged in August 1987. After spending 5 months at a rehabilitation facility, this animal was released in May 1988 and, within three weeks, returned to the original capture site 10 miles to the north of the release point.

Growth rates for green turtles, calculated for recaptures with at least one month total interval, ranged from 0-0.48 cm per month. The average growth rate was 0.24 cm per month. Comparable growth rates have been recorded for juvenile green turtles in the Hawaiian Archipelago (Balazs 1982). Bjorndal and Bolten (1988) reported a decrease in growth rates with an increase in size. Rates may be dependent upon nutritional value of diet (Balazs 1980, 1982).

Stomach contents from the 18 necropsied green turtles were analyzed by Steve Blair of Dade County, Florida, Department of Environmental Resource Management and Dennis Russell of Seattle Pacific University. Algae of the family Gelidiaceae, in particular Pterocladia, Gelidium, and Gelidiella species, were identified as the predominant food consumed in the 17 samples containing algae. Gracillaria, Bryothamnion, and Hypnea species were also ingested in significant amounts. One turtle had exclusively ingested seagrasses of Thalassia testudinum, Syringodium filiforme, and Halodule wrightii, and one stranding had been feeding on both algae and sea grasses.

Daytime SCUBA surveys resulted in the observation of juvenile green turtles feeding upon algae, usually at the base of soft corals. Turtles were also observed engaged in this activity at night. All algae identified in stomach contents are common to Broward County offshore areas, however, there are no known seagrass beds offshore or in the two estuarine areas of Port Everglades and Hillsboro Inlets. Results of four surveys in the main study area to determine algal density indicate a predominance of Gelidiaceae (85%), Pterocladia spp. most common, on the substrate with Dictyopteris sp. (15%) also occurring. It appears that turtles are engaging in highly selective feeding behaviors, cropping primarily those algae desired. Hypnea spp. were also present in two green turtles sampled. Mortimer (1982) and Balazs (1987) note consumption of this species by turtles in their respective study areas. Bryothamnion seaforthii, also a food of choice, and Hypnea spp. are common to areas of sand and reef rubble inshore of the first reef.

CONCLUSIONS

Diurnal and nocturnal SCUBA surveys indicate that the reef areas of Broward County, Florida, serve as an important development habitat for juvenile green turtles. The presence of substantial numbers of green turtles engaged in both feeding and resting activities support this conclusion. Samplings of algae indicate the availability of considerable biomass of desirable forage for these turtles.

None of the captured or stranded turtles evidenced papillomas. Although the size class of this population has been observed to be between 25 and 65 cm (over the curve), duration of residency for these animals is unknown at this time. Future surveys will hopefully shed some light on this question. The source of recruitment to the population and their ultimate destination is unknown, as is the relationship of the nesting population to the juveniles.

The quality of this habitat should be maintained. At present, there are several threats to the integrity of this habitat. Recreational diving pressure may be displacing green turtles from optimal forage and resting sites. Boating activities are also disruptive and appear to be a major cause of mortality to the population. Future beach renourishment projects need to be monitored closely so as to prevent impact upon food sources. We will continue this study to monitor the population and its habitat as long as it is feasible.

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BEACH LIGHTING AND THE SEAWARD ORIENTATION OF HATCHLING SEA TURTLES

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To determine the role of color and intensity in how, and the extent to which, artificial light affects hatchling sea turtle orientation, I conducted a series of experiments both under controlled laboratory conditions and on a dark nesting beach. In the laboratory, the behavioral sensitivity of newly emerged loggerhead (Caretta caretta) and green turtle (Chelonia mydas) hatchlings to light color and intensity was determined using a modified T-maze. Hatchlings placed within the T-maze could respond toward a window transmitting light from a standard lamp (same intensity and color throughout the experiment) or a window transmitting light varying in color and intensity with each treatment. Monochromatic light for the latter window was generated using interference filters (total bandwidth 10 nm). Intensities at each wavelength were varied with neutral density filters and measured as photon flux with a spectroradiometer. Five colors (360, 400, 500, 600, and 700 nm) and five intensities (logarithmic scale) constituted 25 treatments. Thirty loggerhead hatchlings from each of 30 clutches and ten green turtle hatchlings from three clutches were run individually per treatment.

Loggerhead hatchlings displayed equally strong preferences for light at 360, 400, and 500 nm. At these wavelengths, a positive relationship was observed between intensity and preference. No significant preference for 600 or 700 nm light was seen. Green turtles showed a pattern similar to that of loggerheads; however, the small number of green turtles used precludes a statistical comparison.

In an additional laboratory experiment, hatchlings were offered a choice between a dark window and a window lighted with monochromatic light of eight wavelengths (360, 400, 500, 540, 560, 580, 600, and 700 nm). Of 30 hatchlings tested individually per wavelength, 30 oriented toward each of the windows transmitting 360 and 400 nm light and 29 oriented toward the 500 nm light. At 540 and 700 nm, window choice was random (binomial 2-population test, $P < 0.05$). At wave lengths of 560, 580 and 600 nm, the numbers of loggerhead hatchlings orienting toward the light window were 2, 1 and 0, respectively, significantly less than would be predicted from randomness ($P < 0.01$), indicating a negative response to these wavelengths. Green turtle hatchlings tested in this arrangement using only 600 or 700 nm light responded randomly to either window ($P < 0.05$).

The study area for the beach experiments was a dark, undeveloped beach in Indian River County, Florida. Loggerhead hatchlings used in these experiments were released individually at night (2200-2300 hrs) in the center of a circular arena surrounded by a trench dug into the berm. The trench was divided into 32 compartments. The compartment into which a hatchling fell at the end of a trial determined its orientation direction. Hatchlings were exposed to five different commercially available light sources mounted similarly in windowed boxes. Light sources used were low (LPS) and high (HPS) pressure sodium vapor and yellow "bug" (BUG), red (RED) and white (WHITE) incandescent lamps. Each light source was presented at azimuth 90° (ocean = 0°) and at two illuminance levels (1.9 and 6.2 lux). Thirty hatchlings from 30 separate clutches were used individually in each of 11 treatments including a control (lights off).

Hatchlings in the control trials dispersed little (mean vector length $r = 0.99$) and oriented in the ocean direction (0°). In comparisons with the control, each light source significantly affected hatchling orientation either in direction or in width of dispersion (nonparametric tests of direction and dispersion for circular data, $P < 0.05$). Only the BUG source at high illuminance did not significantly affect direction ($P = 0.11$) and only the LPS source at low illuminance did not significantly affect dispersion ($P = 0.08$). HPS, RED and WHITE sources attracted hatchlings. In trials with LPS sources, however, hatchlings angled away from the light but in a generally seaward direction. Hatchlings exposed to the BUG source showed no such clear pattern and dispersed widely. The aversion for the yellow (590 nm) light emitted by

the LPS source corroborates what I observed in laboratory trials. In an additional experiment, an LPS source was placed between orienting loggerheads and the ocean. Hatchlings in control trials (light off) oriented seaward (12°) and dispersed little (r = 0.93). With the LPS source on, however, hatchlings dispersed widely (r = 0.18) away from the light and the ocean (141°).

Hatchling loggerheads and green turtles are able to see light outside the range of human spectral sensitivity (near ultraviolet, or 'UV'), are positively phototactic with respect to UV, violet and blue-green light, and apparently use these wave lengths in sea-finding. Loggerheads orient negatively, however, to intermediate wavelengths (yellow-orange). Thus, the human eye (or a photometer) is inappropriate for assessing beach lighting problems relative to sea turtles. Although LPS luminaires placed on beaches may disorient hatchling loggerheads, LPS luminaires set sufficiently behind the dune may affect hatchling sea-finding insignificantly. However, the fact that loggerheads can see LPS light, indicates this light may negatively affect adult nesting behavior. It is also evident that photic behavior and solutions to artificial lighting problems can not be generalized among sea turtle species.

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BOCA RATON SEA TURTLE PROTECTION PROGRAM (1988) IN CONJUNCTION WITH THE NORTH BEACH NOURISHMENT PROJECT

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The City of Boca Raton Sea Turtle Nest Protection and Relocation Program was conducted on five miles of beachfront in 1988. For several years the shoreline in this city has been suffering from severe erosion problems. During the latter part of the sea turtle nesting season, the North Beach Nourishment Project restored 1.45 miles of shoreline by hydraulic dredging of an offshore borrow area. Extensive sea turtle nest relocation and protection activities were initiated because of the erosion problems, as well as the restoration project. Monitoring and nest protection were done in compliance with various permit requirements of the Florida Department of Natural Resources, the Florida Department of Environmental Regulation, the U.S. Army Corps of Engineers, and the U.S. Fish and Wildlife Service.

The purpose of this study was to document the action taken for permit compliance, describe the methodology and procedures used for the 1988 sea turtle protection program, and to assess the impacts of beach nourishment projects on sea turtle nesting.

It was determined that the conservation efforts to protect sea turtles and their nests were successful during the 1988 nesting season in Boca Raton. The nourishment operation in the latter part of the nesting season had only a very minimal impact from the physical dredging operation with the loss of one nest. Relocation efforts for the majority of the nests were necessary even if the restoration had not taken place due to the eroded conditions and threat of tidal inundation. Eggs remaining in the natural state had less chance of hatching success than eggs relocated to the hatchery, verifying egg relocation as an effective conservation method if done properly. Nesting density in 1988 was 178 nests per mile, which was higher that the 135 nests per mile (average) for Boca Raton. The sand source from the borrow area was found to be good in quality and compatible with the existing beach sand. The minimal compaction did not appear to be a problem for nesting sea turtles, however additional cone penetrometer tests shall be done prior to the next nesting season to verify this conclusion.

A three year follow-up of post-nourishment data on the 1985 South Beach Nourishment Project in Boca Raton showed that nesting densities and nesting success have continually improved indicating that the increased dry sand area on South Beach had a positive impact on turtle nesting. Monitoring for several years will be required to determine if this holds true for the North Beach in Boca Raton.

PART II: POSTER PRESENTATIONS

THERE'S MORE TO ORIENTATION THAN MEETS THE EYE

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The offshore migration of hatchling sea turtles represents one of the most amazing examples of orientation seen in vertebrates. Hatchlings lack exposure to obvious potential orientation cues such as the sun, stars, or moon prior to exiting their nests and migrating offshore.

The studies described here address the roles that two orientation cues play in guiding hatchlings offshore during their migration from the surf zone to deep water nursery areas. Specifically, we tested the importance of horizon brightness and waves as guideposts for orientation. Horizon brightness was examined because light cues play a major role in sea finding, the activity just prior the hatchlings' offshore migration. Hence, it is reasonable to hypothesize that light cues (such as differences in horizon brightness) might play some role after hatchlings enter the water.

Waves have been proposed as potential cues that hatchlings could rely upon to guide them offshore (Witham 1980). Similarly, Wibbles (1984) noted that wind generated currents (a form of directional water movement) were important in maintaining oriented swimming by juvenile Kemp's ridley sea turtles (Lepidochelys kempi).

METHODS

All studies used hatchling loggerhead sea turtles (Caretta caretta) from Florida's east coast obtained just prior to emergence and tested the same night (during their swimming frenzy).

Experiments addressing the roles of horizon brightness were conducted in a circular, water-filled orientation tank (see Salmon and Wyneken 1987). The tank was equipped with a 360° projection system and surrounding screen. A light source filtered to give green light (around 520 nm) produced the horizon image. Horizon intensities matched those measured in the field. Four treatments were tested. A 360° horizon, an analog of the offshore horizon hatchlings experience after swimming several km offshore, tested for uniformity of horizon intensity and served to determine if the hatchlings could orient in the presence of an evenly lit horizon. Total darkness controlled for nonvisual orientation cues. An asymmetrical (180°) horizon served to examine the form of hatchling orientation in the "near-shore" environment, simulating a brighter area toward "sea" and darkness near "land." Either the east or west side of the tank was darkened.

The role of waves in hatchling orientation was tested in a wave tank (9.1x0.9x0.6 m). Wave amplitude was 0.03 m, wave length was 2.0 m, and frequency was 1/1.4 s. Hatchlings were tethered to the center of the tank. They could orient in any horizontal direction, as well as dive and surface freely.

Several treatments were presented in random order. Three treatments served as controls: total darkness tested for nonvisual orientation cues; dim light alone served as an assay for the hatchling's ability to orient at all; and exposure to sounds of the motor when mechanically disconnected controlled for orientation relative to the motor's low frequency vibrations. In the experimental treatment, hatchlings were presented with waves in total darkness.

RESULTS

The Role Of Horizon Brightness Differences In Orientation.

Dimly lit, 360° horizon. There was no significant orientation by the 25 hatchlings tested. Thus, the horizon provided no clear orientation cue to the hatchlings. Fourteen turtles circled while 11 picked scattered headings and maintained them.

Total darkness. The group showed no significant orientation. Eight of 15 hatchlings circled continuously and seven held random headings.

Darkened west, 180° horizon. Hatchlings oriented toward each of the margins where the lit and darkened sectors of the two 180° horizons abutted. The group response was significantly bimodal. Eleven of 13 hatchlings held headings. The significance of this pattern of orientation is unclear. Hatchlings in the field do not show this pattern; rather, they head directly out to sea (i.e., toward the center of the brighter seaward horizon).

Darkened east, 180° horizon. Again, hatchlings oriented toward each of the margins. However, this sample showed a more variable response than the "darkened west" group.

The Role of Changing Horizons In Sequence.

As hatchlings swim offshore, they should initially see a brighter seaward (180°) horizon. But when they distance themselves from land, the horizon becomes uniformly bright (360° horizon). If turtles "calibrate" a compass when near-shore, while visual cues are still available (180° horizon), they might be able to continue on oriented headings even away from land. To test for such a calibration, hatchlings were first exposed to a 180° horizon for 20 minutes, then a 360° horizon for 10 minutes. However, the orientations of individuals in the 360° horizon bore little resemblance to their previous orientations with the 180° horizon. Thus it does not appear that hatchlings quickly calibrate a compass when the initial horizon is asymmetrical.

The Role Of Waves In The Orientation of Hatchlings.

Total darkness. No turtles were significantly oriented.

Dim light alone. All but one hatchling oriented relative to a dim light or its reflection on the opposite tank wall. The remaining turtle oscillated between the light and its reflection. Hence, all hatchlings tested were able to orient relative to a visual stimulus prior to being tested with a nonvisual stimulus (waves).

Motor alone in total darkness. This treatment controlled for the potential use of motor vibrations as orientation cues. None of the animals were oriented; all circled.

Waves alone in total darkness. As a group turtles were significantly oriented toward the waves. Ten of 16 individuals held courses at a low angle into the waves. The remaining individuals were more variable in their headings, but tended not to circle.

DISCUSSION

The results of the horizon brightness tests suggest that light cues, such as differences in horizon brightness, can play some role in orientation. However, orientation relative to the borders of the horizon is not consistent with the responses of hatchlings in the field. Hence, at night when hatchlings normally enter the ocean, either visual stimuli are not the primary orientation cues or the responses of hatchlings to visual stimuli are modified by responses to nonvisual stimuli.

The results of wave tank experiments indicate that waves alone provide sufficient information for orientation and can serve as guideposts to lead hatchlings offshore.

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BIOLOGY AND CONSERVATION OF SEA TURTLES NESTING IN QUINTANA ROO, MEXICO, DURING 1988

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The Caribbean beaches of the state of Quintana Roo, Mexico, provide important nesting sites for the green (Chelonia mydas) and loggerhead (Caretta caretta) sea turtles, and associated waters are important foraging habitat for subadult and adult hawskbill turtles (Eretmochelys imbricata). In addition to these three species which occur in large numbers, the leatherback (Dermochelys coriacea) and Kemp's ridley (Lepidochelys kempi) turtles have also been found in the area, although only sporadically and in low numbers. Recent surveys by personnel from the sate para-governmental research agency CIQRO indicate that ten beaches on the Yucatan Peninsula's east coast are utilized by these species.

During the summer nesting season in 1988, 68 people volunteered their efforts during four EARTHWATCH-sponsored expeditions in Quintana Roo. The expeditions were designed to provide intensive studies at two nesting beaches and to boost already existing sea turtle conservation efforts being undertaken by CIQRO. The EARTHWATCH-assisted project spanned the period of most intensive nesting, beginning 20 June and ending 8 August 1988. Concurrent with this work, CIQRO investigators continued their survey work at the eight remaining nesting beaches.

The cumulative data from 1988 suggest that both the number of turtles nesting on X-Cacel and Akumal beaches in Quintana Roo and the fecundity of these nesting females were far greater than previously recorded. Although real population fluctuations and a naturally-induced change in clutch sizes could account for this increase, it is far more likely to be the result of greater research effort and better protection of relocated eggs. In previous years, fishermen had been hired to move and protect eggs in hatcheries, and now it appears that some of these guardians considered clutch-skimming a special "perk" of their jobs. The presence of volunteers prevented similar poaching activities from occurring in the 1988 season.

Poaching, inundation of nests by seawater, and natural predation seem to seriously threaten the sea turtle species of Quintana Roo. Resort development, and with it associated disturbances to sea turtles and their habitat, appear not to have impacted these populations. However, the rate of tourism is growing, and although most construction is taking place in and around Cancun, the plague is unmistakably heading southward. Since the southern beaches of Quintana Roo support viable populations of both loggerheads and green turtles, and since this locale represents a southern extreme of concentrated loggerhead nesting and a northern extreme of mass green turtle nesting, every effort should be expended in trying to conserve these habitats.

EARTHWATCH volunteers obtained information from >270 nesting episodes on X-Cacel and Akumal beaches. Complete data sheets containing information on tag number, size, condition of the animals, and clutch size, were collected for 145 female loggerhead and 40 green turtles. One hundred and ninety clutches of eggs were translocated into four hatcheries on the two beaches (164 loggerhead and 36 green turtle). Mean clutch sizes for translocated nests were 107.6 for loggerheads (sd=17.96, n=144) and 116.0 for green turtles (sd=16.47, n=33). No incidence of poaching or depredation were observed in the hatcheries, and pre-hurricane hatching success in translocated nests was 89%.

Unfortunately, Hurricane Gilbert struck the Quintana Roo coast near the hypothesized time of peak hatching for both species. Based on a conservative estimate of incubation period at 50 days, some 97 (71 loggerhead and 26 green turtle) translocated nests were lost due to hurricane-induced destruction of the hatcheries. This figure represents >9,700 eggs lost to the storm.

Given the catastrophic effects of Gilbert, the conservation work undertaken by EARTHWATCH volunteers and CIQRO researchers is especially important. Had none of the eggs from these beaches been protected, the otherwise high natural and human-induced mortality would have caused very few early clutches to survive to hatching. Although our efforts could not mitigate the enormous impact of Hurricane Gilbert, the intensive conservation effort guaranteed that at least some hatchlings from the 1988 season survived, possibly to be recruited into the future breeding population.

This project will be continued in the coming years. We intend to continue hatchery work, strengthen the Adopt-A-Turtle program, which we helped initiate last year, and derive more information on the loggerheads which curiously seem to prefer rocky nesting habitat in this area. Stock identification work, using analysis of blood proteins, will also continue. We hope not to do a comparative study of hurricane damage, however!

DISTRIBUTION OF RIDLEY, GREEN, AND LEATHERBACK TURTLES IN CHESAPEAKE BAY AND ADJACENT WATERS

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INTRODUCTION

Since the conception of the Virginia Institute of Marine Science (VIMS) Sea Turtle Project, we have found that the Chesapeake Bay is an important foraging area for an estimated 10,000 loggerhead turtles, Caretta caretta, each summer (Bellmund et al. 1987, Byles 1988, Keinath et al. 1987, Lutcavage and Musick 1985). Three other species of sea turtles also inhabit the Bay and adjacent areas during the warmer months (Keinath et al. 1987, Lutcavage and Musick 1985). In order of decreasing abundance they are ridleys (Lepidochelys kempi), leatherbacks (Dermochelys coriacea), and green turtles (Chelonia mydas).

Ridleys were historically found in Chesapeake Bay (Hardy 1962), as were leatherbacks (Hardy 1969) and green turtles (Brady, 1925), although the green turtles may have been misidentified loggerheads. There have been no verifiable records of hawksbill turtles (Eretmochelys imbricata) in the Chesapeake area (Musick 1972). This abstract represents data taken by VIMS personnel and stranding cooperators from 1979 through 1988.

MATERIALS AND METHODS

Data taken from dead and live stranded turtles were collected by VIMS personnel and their cooperating stranding network. Live turtles were captured by cooperating pound net fishermen and turned over to VIMS for examination. When possible, carapace and plastron measurements, weight, and location of the animals were among the parameters recorded. Animals were from the Chesapeake Bay and the Atlantic coast from the Virginia-Maryland border to Corolla, North Carolina.

RESULTS AND DISCUSSION

We have examined nine green turtles (two live, seven dead), 23 leatherbacks (two live, 21 dead), and 108 ridleys (39 live, 69 dead). Not unexpectedly, more dead than live turtles were examined. Although ridleys appear most abundant, many leatherbacks were observed off the mouth of Chesapeake Bay during our aerial surveys (see below).

Most dead ridleys washed up along Virginia's southern seaboard and in the lower Bay. Most live ridleys were captured by fishermen in the York and Potomac Rivers. The number of ridleys observed has been inconsistent between years, while monthly occurrences resemble that of loggerheads (Bellmund et al. 1987). High mortality occurred in June, which coincides with the spring immigration. The cause of the spring mortality is uncertain. In some years, fall ridley (and similar loggerhead) mortality coincides with the flounder fishery off southeast Virginia. Since most fall strandings were off southeast Virginia and northeast North Carolina (some with signs of net entanglement), the turtles may have drowned in trawl nets. The possibility of the bottom trawl fishery drowning turtles needs investigation. Ridley turtles most often encountered were 30-50 cm subadults (range 23-57 cm), larger than the ridleys found in Long Island Sound and Cape Cod Bay. One ridley was a headstarted turtle, but the others were not previously tagged, suggesting they hatched naturally in Mexico or Texas.

Leatherbacks were most common in the lower Bay and along the Atlantic coast. A few dead leatherbacks wash ashore each year, while live captures are rare. A live animal found in the upper Bay near Maryqland was stranded on a shoal; it was pushed off the shoal into deeper water and swam sluggishly into the open

Bay. The other live leatherback, tagged in 1985 in the lower Bay, was reported butchered for food in Cuba in 1986. Most leatherbacks seen on VIMS aerial surveys were observed off the Bay mouth, while relatively few were seen in the lower Bay or farther south along the coast. Leatherbacks may congregate off the Bay mouth (e.g., four leatherbacks were observed within two minutes on an aerial survey) to feed on the abundant jellyfish which breed in the Bay and flush into the Atlantic in great numbers. Most leatherback strandings occur between May and July, but some strand well into winter months (which is not unexpected for an endotherm). Of the leatherbacks we examined, a few showed constriction marks around the flippers, suggesting entanglement in crab pot lines or similar obstructions and subsequent drowning. Leatherback carapace lengths ranged from 124-159 cm.

Few green turtles were observed, although more encounters have occurred recently, and usually later in the season, again coinciding with the fall bottom fishery. Although we have little supportive data, the increased number of green turtles encountered may be coincident with seagrass resurgence in the Bay. The increased number of green turtles may also reflect positive conservation effort on nesting beaches. All the green turtles examined were sub-adults (carapace length range 28-42 cm).

Leatherback turtles appear to utilize food resources from the Bay, although their (as well as green turtle) contribution to the total sea turtle population in and adjacent to the Bay appears small. If green turtles are entering the Bay due to the resurgence of seagrasses, we should encounter more green turtles in the future. It is important to continue monitoring strandings and captures of green turtles and ridleys, since the outcome of conservation efforts at nesting beaches will most likely be observed in these areas where immature turtles occur. It is also important to determine cause for the fall stranding event along the Atlantic coast. If the bottom fishery is the cause of mortality, appropriate conservation efforts may need implementation.

ACKNOWLEDGEMENTS

We would like to thank the sea turtle personnel, past and present: S. Bellmund, J. Brown, R. Byles, W. Jones, R. Klinger, M. Lutcavage, and N. Morse. Parts of the research were funded by the U.S. National Marine Fisheries Service and the Virginia Commission of Game and Inland Fisheries.

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THE EFFECT OF EGG RELOCATION ON DERMOCHELYS CORIACEA HATCHLING SEX DETERMINATION ON SANDY POINT, ST. CROIX

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An intensive study of Dermochelys coriacea has been conducted on Sandy Point, St. Croix (U.S. Virgin Islands) since 1982. The beach is dynamic, with a yearly cycle of severe erosion and accretion. The regularity of this pattern has encouraged an aggressive egg relocation program which has doubled the number of hatchlings entering the water each season. Eggs laid in the erosion zone or near the high water mark are routinely moved to the rookery.

Does egg relocation affect the natural sex ratios of Dermochelys coriacea hatchlings on Sandy Point by changing the incubation temperature? In an attempt to answer this question the following steps were taken:

- 8 transects were run perpendicular to the beach with temperature sensors every 5 m from vegetation line to high water mark, at 60 cm depth.

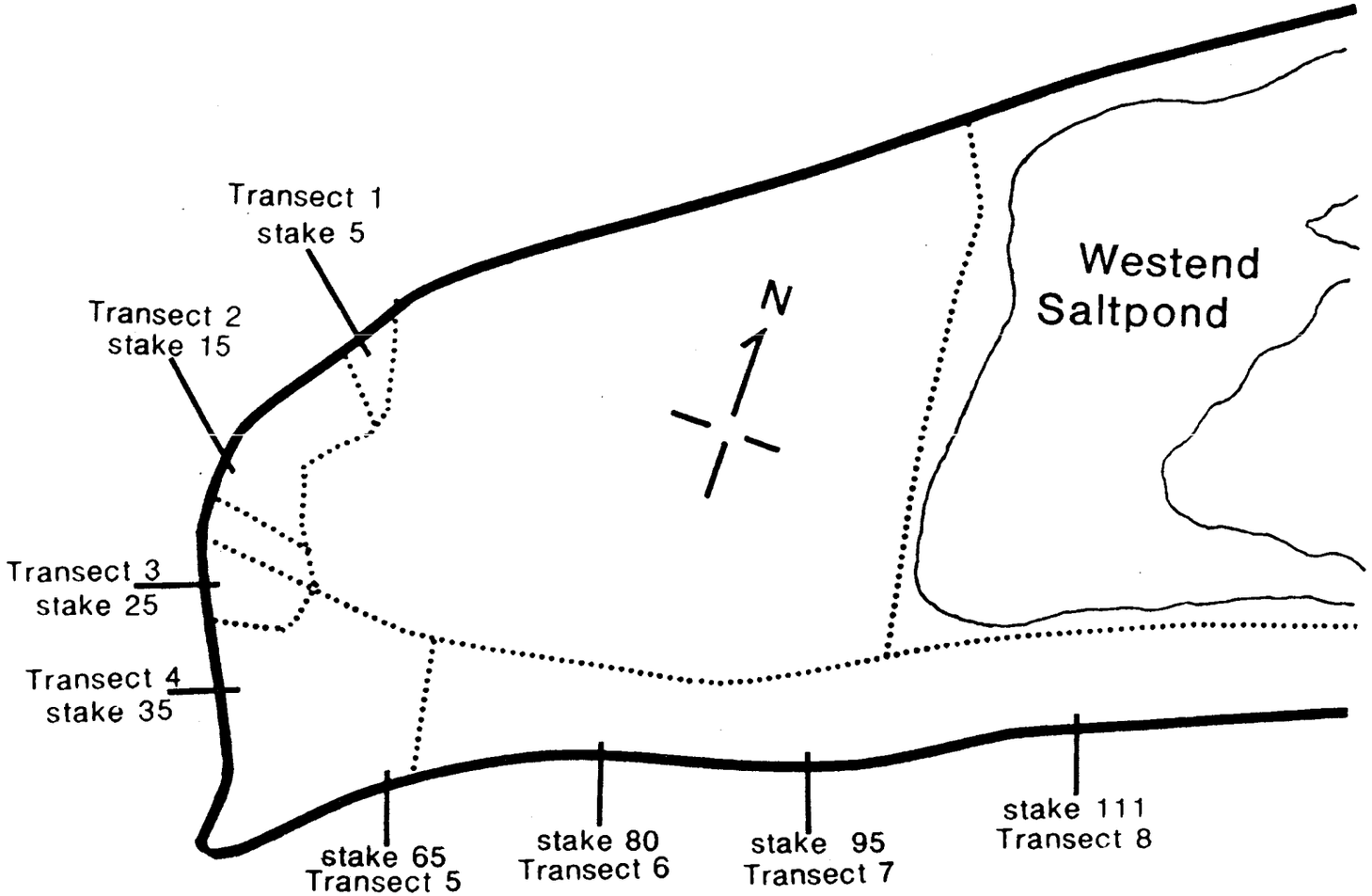
- In situ, relocated, and original locations of relocated nests were monitored with temperature sensors located mid-clutch.

- Temperatures were monitored from April through August, 1987.

No statistically significant temperature differences were recorded spatially.

Seasonal variation in temperature was significant, indicating the percentage of females produced increases as the season progresses.

Early data indicate that egg relocation has no effect on the natural sex ratio of the hatchlings. Predictions of sex ratios were made by estimating the numbers of males and females produced from the duration of incubation, and from nests where temperatures had been monitored. Indications are that the Sandy Point population is heavily weighted towards females.



Placement of transects on Sandy Point, St. Croix, 1987.

VIRGIN ISLAND TURTLE TAG RECOVERIES OUTSIDE OF THE U.S. VIRGIN ISLANDS

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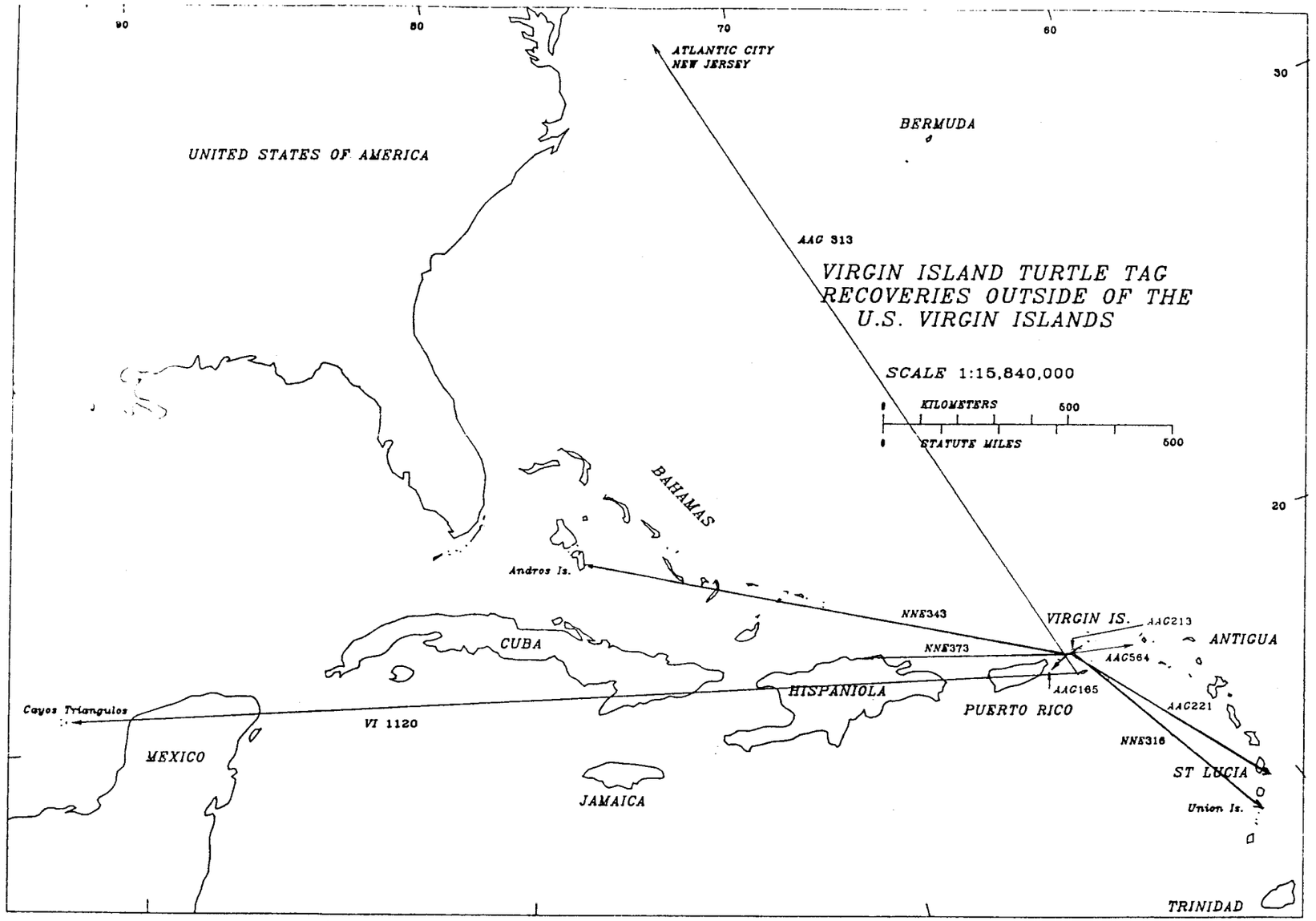
Since 1981 the U. S. Virgin Islands Division of Fish and Wildlife has tagged 164 leatherback (Dermochelys coriacea), 73 hawksbill (Eretmochelys imbricata and 357 green (Chelonia mydas) sea turtles. All leatherbacks were tagged during nesting on Sandy Point, St. Croix. With the exception of 81 green turtles, all green and hawksbill turtles were immatures captured and released in the coastal waters of St. Thomas and St. John. The other 81 green turtles were hatched in Florida, raised at Coral World aquarium on St. Thomas, and then tagged and released nearby. Although released in areas where many wild greens are resident, of which approximately 20% have been recaptured repeatedly, none of the captive-reared turtles have ever been recaptured in Virgin Island waters.

To date, nine turtles tagged in the Virgin Islands have been recovered in locations outside of the Virgin Islands. The majority of these have been recovered by fishermen or divers, who captured the turtles for food. The most distant recoveries (n=2) have been leatherbacks, which is consistent with their pelagic existence. One recovery (tag AAG 313) was a leatherback which stranded in New Jersey 85 days after leaving Sandy Point, St. Croix. This probably represents the migration north after nesting in the Caribbean. The other (tag VI 1120) was captured by a fisherman off Mexico two years after nesting on Sandy Point. As most of these turtles nest on a two year cycle, she may have been in Mexican waters to nest, which could indicate low between season nesting site fidelity for this individual.

The second most distant group of recoveries (n=3) were green turtles, all of which were captive-reared and released at approximately one year of age. This may indicate a lack of developmental habitat fidelity, or a complete lack of geographic orientation due to captive rearing. Two of the three green turtles travelled north along the island chain while one went south, which demonstrates their disorientation.

Based on tag recoveries, it is apparent that hawksbills do not migrate as do the other two common Caribbean species. However, a greater proportion of hawksbills have been recovered outside of the Virgin Islands than of the other two species. Although it has been suggested that hawksbills are more sedentary than green turtles, these data demonstrate that wild hawksbills tagged in the Virgin Islands are much more likely to be found outside of the Virgin Islands than are wild Virgin Island green turtles.

Tag recoveries are invaluable in determining migration and movement patterns in sea turtle species. The recoveries reported here for the U.S. Virgin Islands have provided information on suspected migration/movement patterns in leatherbacks and captive-reared greensm and has revealed greater movement than previously thought for immature hawksbills. Continued tagging and long-range tag recoveries will hopefully provide a more detailed and comprehensive understanding of the migration and movement patterns of sea turtles.


VIRGIN ISLAND TURTLE TAG RECOVERIES OUTSIDE OF THE U.S. VIRGIN ISLANDS
SCALE 1:15,840,000
KILOMETERS
STATUTE MILES
0
500
600
90
80
70
60
30
20
ATLANTIC CITY NEW JERSEY
BERMUDA
UNITED STATES OF AMERICA
AAG 313
BAHAMAS
Andros Is.
NNE343
VIRGIN IS.
AAC213
ANTIGUA
CUBA
NNE373
AAC564
HISPANIOLA
AAC165
PUERTO RICO
AAC221
Cayos Triangulos
VI 1120
NNE316
MEXICO
ST LUCIA
JAMAICA
Union Is.
TRINIDAD

VIRGIN ISLAND TURTLE TAG RECOVERIES OUTSIDE OF THE U.S. VIRGIN ISLANDS

Tag Number	AAG 313	AAG 221	NNE 316	AAG 213	NNE 373	NNE 343	AAG 165	AAG 148	VI 1120
Species	Leatherback	Hawksbill	Green	Hawksbill	Green	Green	Hawksbill	Hawksbill	Leatherback
Location of First Capture/nest	Sandy Point St. Croix	Magens Bay St. Thomas	Headstart St. John	Magens Bay St. Thomas	Headstart	Headstart	Magens Bay St. Thomas	Magens Bay St. Thomas	Sandy Point St. Croix
No. of Times Captured/Nested in V.I.	2	1	0	1	0	0	1	2	3
Date of Last Capture/Nest	8-Jun-81	30-Apr-82	2-Jun-83	28-Jan-82	16-Jun-84	14-Oct-83	29-Oct-81	21-Jun-83	31-May-86
Date of Tag Recovery	1-Sep-81	1-Aug-83	3-Dec-84	15-Jun-85	Aug-85	Nov-85	May-87	June 1987	Summer 1988
Location of Tag Recovery (Straight Line)	Surf City New Jersey	St. Lucia BWI	Union Island Grenadines BWI	Ginger Island BWI	Nagua Dom. Rep.	S. Andros Is. Bahamas	East Coast Puerto Rico	St. Martin W.I.	Triangle Cays Campeche Mex
Distance to Recovery (Kms)	3114	650	750	46	520	1475	95	185	3000
Cause of recovery	Stranding - Intestinal Obstruction by Claylike Mass	N/A	Caught by Fisherman	Caught by Fisherman	Caught by Fisherman	Caught by Fisherman	Caught by Fisherman	Caught by Fisherman	Caught by Fisherman

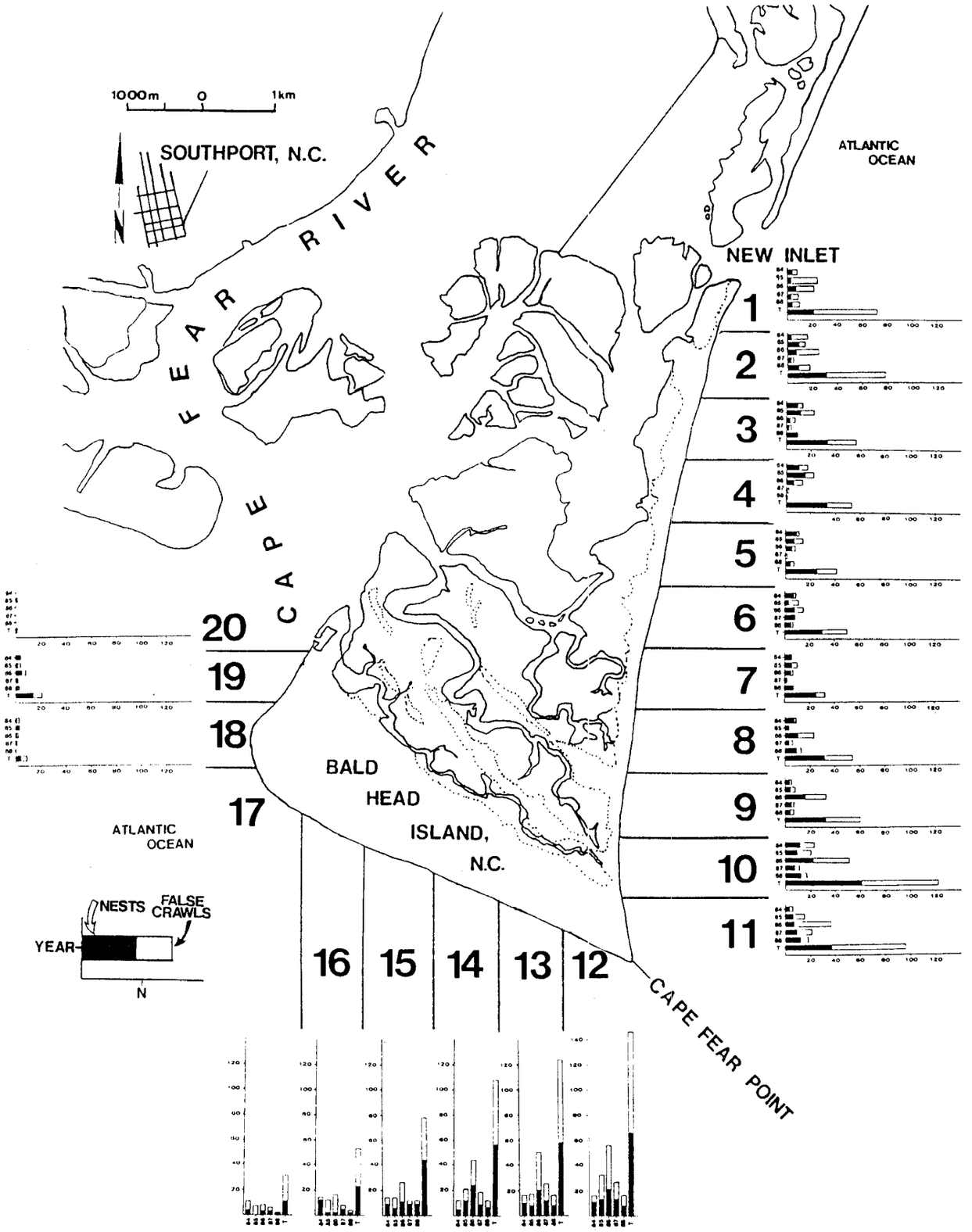


FIGURE 1. Bald Head Island, North Carolina, with twenty 1 km sectors, showing nesting activities, 1984-1988.

NESTING ACTIVITY OF THE LOGGERHEAD SEA TURTLE (CARETTA CARETTA) ON BALD HEAD ISLAND, NORTH CAROLINA

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With future development targeted for the Cape Fear Point area of Bald Head Island, North Carolina (sectors 9-14, Figure 1), and a beach renourishment project being debated for the developed portion of the Island (sectors 15-18), the distribution of nesting activities by the loggerhead sea turtle, Caretta caretta, became a very pertinent question.

The total number of activities (nests and 'false crawls') on Bald Head Island between 1980 and 1988 are shown in Table 1. These numbers were determined by nightly beach patrols at 45-75 minute intervals from late May through August as part of a nest protection project that began in 1980.

A chi-square test was applied to nesting and false crawl data to determine if they were uniformly distributed along the 20 km of beach, 1984-1988 (Table 2). All activities were significantly non-uniform ($P < 0.05$) for all five years. Nest concentrations were most evident during 1985, 1986 and 1987. The area around the Cape Fear Point (sectors 9-13) had values much greater than expected and the sectors that bordered the Cape Fear River (18-20) consistently had lower values than expected. Nesting concentrations around the Cape Fear Point could be associated with several factors: 1) this area is relatively isolated from development, 2) Cape Fear Point is a prograding beach, 3) navigational use of the Frying Pan Shoals (a depositional feature that extends 34 km south-southeast from the Cape Fear Point) by the turtles, and/or 4) a large area of hard bottom and reef structure due east of the Cape Fear Point.

A chi-square contingency table was used to look at uniformity of nesting within each sector over the five year period. Nesting percentages for each year were used to partition out seasonal variation. Only sectors 4 and 16 were significantly non-uniform ($P < 0.05$), with nest percentages decreasing over the time period. This is probably correlated to a large washover area in sector 4 and the rapidly eroding beach (5 m yr^{-1}) in sector 16. The remaining 18 sectors of beach were consistent in the percentage of nests that were laid within that sector.

It is suggested that future development in close proximity of the Cape Fear Point follow the management recommendations established relative to Caretta caretta, especially beach front lighting.

ACKNOWLEDGEMENTS

The author would like to acknowledge the North Carolina Wildlife Resources Commission, The Bald Head Island Conservancy, and all the people who have worked on this project.

Table 1. Nesting Activity on Bald Head Island, North Carolina, 1980-1988.

Year	Total Activity	Nests	False Crawls
1980	172	72	100
1981	293	91	202
1982	188	96	92
1983	284	148	136
1984	213	126	87
1985	281	133	148
1986	456	196	260
1987	175	95	80
1988	182	112	70

Table 2. Chi-square table showing spatial nest distribution on Bald Head Island, North Carolina, 1984-1988. Chi-square values at the bottom of the table indicate whether sectors were significantly different (*). Values with superscripts indicate sectors which had higher (+) or lower (-) nesting activity than expected. Level of significance P = 0.05.

Sector	1984	1985	1986	1987	1988
1	0.84	1.54	0.51	0.64	0.46
2	1.73	1.44	0.51	0.64	2.06
3	1.16	4.05+	4.13-	1.59	1.03
4	2.17	13.24++	1.08	2.56	3.78
5	1.16	0.15	1.88	4.75-	0.46
6	0.08	1.54	0.14	1.07	0.06
7	0.01	0.00	1.88	1.59	0.03
8	0.08	2.71	0.08	0.64	2.06
9	1.73	0.69	5.13+	0.01	0.46
10	3.51	1.44	18.05++	1.07	7.31+
11	1.73	0.00	0.51	3.80	7.31+
12	3.51	7.98++	15.35++	14.33++	1.03
13	2.17	0.63	12.87++	11.07++	1.03
14	0.23	5.85+	24.10++	3.80	0.35
15	1.16	0.00	0.37	3.80	2.06
16	5.16+	2.71	5.59-	0.01	2.31
17	1.73	6.05-	4.13-	0.64	2.31
18	4.46-	2.71	7.26-	4.75-	5.60-
19	1.73	2.71	1.88	1.59	2.31
20	6.30-	4.22-	9.15-	4.75-	5.68-
Chi-sq. value	40.67*	59.66*	114.60*	63.5*	47.93*

SATELLITE BIOTELEMETRY OF A LOGGERHEAD SEA TURTLE (CARETTA CARETTA) FROM THE EAST COAST OF FLORIDA

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INTRODUCTION

One of the major obstacles to understanding and managing sea turtles is the paucity of data on the at-sea activities of the various species. The goal of this study was to examine the movements and behavior of a mature female loggerhead turtle (Caretta caretta) away from the nesting beach. Mark-recapture, aerial survey and biotelemetry can be used to obtain migratory and behavioral information, but have inherent problems for long-term monitoring. Tracking turtles via orbital satellites reduces the need of an extensive outlay of manpower and equipment to follow free-swimming turtles.

MATERIALS AND METHODS

This study used a satellite tracking equipment adapted for sea turtles by the U. S. Fish and Wildlife Service. The program used the Tiros-Argos satellite system. The transmitter used was constructed by Telonics, Inc. of Mesa, Arizona USA. The transmitter was 11.4 x 7.0 x 1.3 cm, powered by three D-cell, 3-volt lithium batteries and required a housing 8.5 cm in diameter and 37.0 cm in length. The satellite tag was attached to a female loggerhead, which was monitored in the western north Atlantic off the east coast of Florida from 26-32°N and 76-81°W during September 1988 to January 1989. The positively buoyant package was attached to the turtle by a stainless steel cable with an eyebolt fastened through holes drilled in the pygal bone.

RESULTS AND DISCUSSION

Three categories of data were obtained from the telemetered turtle: positions, a record of the surface/submergence times, and temperatures. Positions were determined 136 times in 136 days of transmissions. Zero to six data messages (submergence, temperature) were received each day even when the turtle was not at the surface long enough to calculate a position. The map depicts the route taken by the loggerhead upon release after her last nesting south of Cape Canaveral, Florida. The turtle stayed nearshore south of the nesting beach in shallow water for a month before entering deeper waters and the Florida Current on 10 October. The clockwise loop made by the turtle covered more than 1,500 km in 40 days over the Blake Plateau in waters of 800-1,000 m in depth. Re-crossing the Florida current brought the turtle inshore (22 November) where she moved south. The loggerhead spent most of its nearshore time in waters of 60 m or less.

Submergence data are summed over a 12-hour period before being transmitted to the satellite from the turtle. Table 1 lists the means and standard deviations for the number of dives per 12-hour period, the mean dive duration per 12 hours and the product of the two or total submergence per 12-hour period. Overall mean dive durations were usually less than 40 minutes. The number of dives per 12-hour period ranged from zero to over 500, but the predominate pattern was less than 80 dives per 12 hours. The total time spent submerged was skewed towards the upper part of the range (> 600 minutes). During the time the turtle was in deep water, her surface behavior increased markedly; submergence decreased from a mean of 676.2 minutes, with very little variation, to a mean of 426.5 minutes and the data showed greater variation (Table 1). Nearly all of the submergence times per 12-hour periods less than 600 minutes occurred while in deep water. The deep water submergence behavior was significantly different from shallow water behavior (T-test $t=8.74$, $p=0.05$). The number of dives also increased in deeper water and

Table 1. Submergence behavior for the entire study and with the shallow water (< 60 m) and deep water (> 500 m) portions separated. The mean is followed by the standard deviation (SD) and sample size (N) in parentheses.

Group	Number of Dives	Mean Dive per 12 hrs (min)	Mean Submergence per 12 hr (min)
Entire Study	57.8 (80.8,152)	25.7 (25.9,155)	528.4 (212.0,152)
Shallow water	45.5 (77.2,62)	39.6 (31.7,63)	676.2 (37.3,62)
Deep Water	66.2 (82.5,90)	16.1 (15.0,92)	426.5 (222.6,90)

the mean dive duration was less than half that in shallow water. Nearshore submergence behavior after 22 November was similar to the previous shallow water behavior before 10 October.

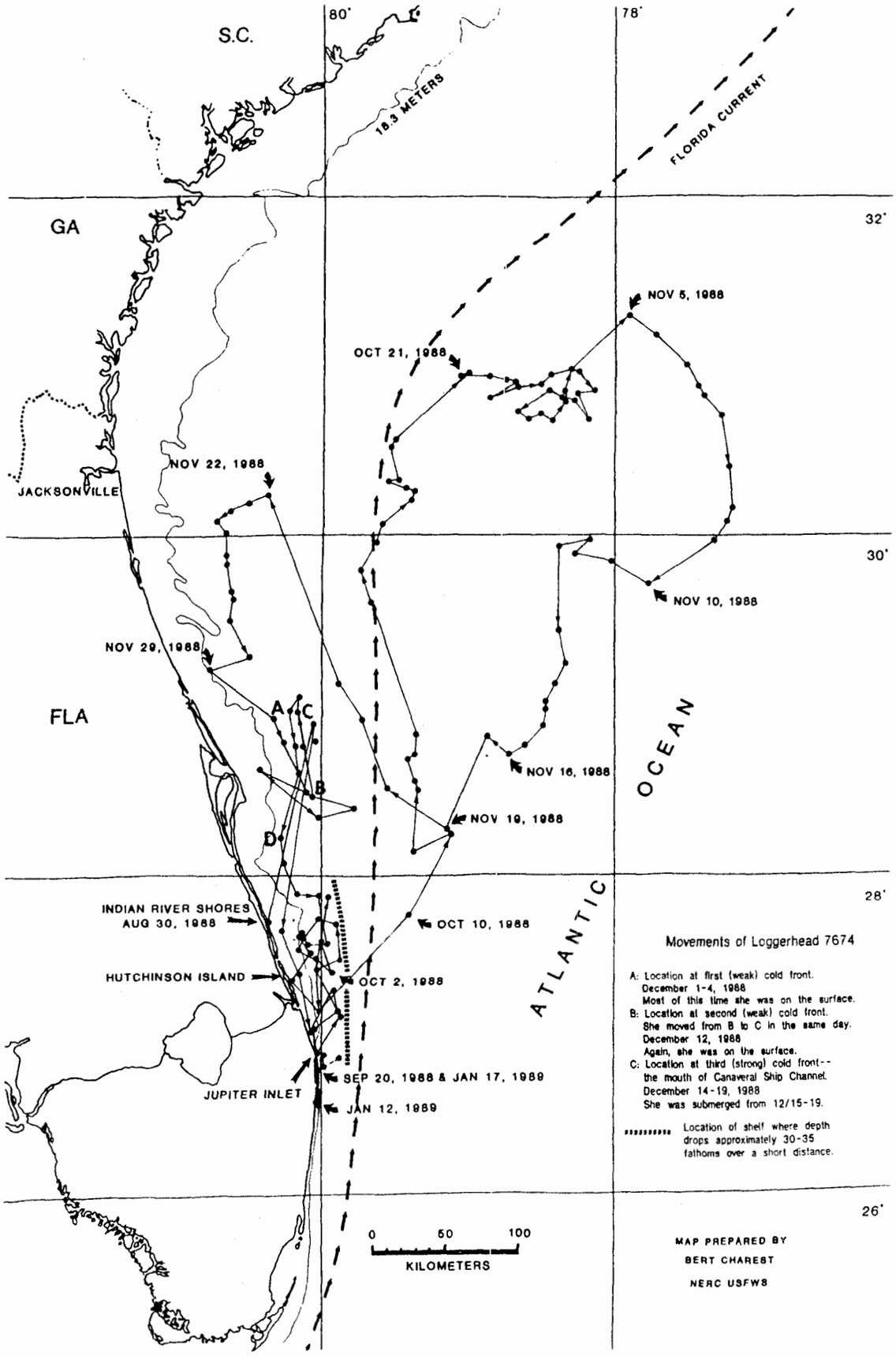
Analysis of the temperatures collected over the study period show that the turtle remained in relatively warm water (19-27°C) throughout the study except for one occasion. Cold air moved through the area on 2 December, again on 13 December, and it remained cold for a week beginning 19 December (map points A, B, C). The only time water temperatures below 18°C were recorded was during the final cold front. Coincident with the drop in water temperature, no transmissions were received for five days. Although brumation was not demonstrated conclusively, neither can it be ruled out. On 2 December (map point A), the turtle was in the vicinity of the Canaveral Channel, Florida, during a cold front passage. When the second cold front moved through 13 December, the turtle had moved away from the area. She moved approximately 50 km between morning and afternoon on the 13th (map points B, C), again to the Canaveral Channel area. Even though the water temperatures did not drop appreciably during these two events, the turtle may have been affected by respiring cold air.

The study was terminated when the transmitter became detached from the turtle 12 January 1989 and began transmitting continuously on land from north of West Palm Beach.

The satellite system has proven successful, and data have been collected that could not have been otherwise obtained without a much greater investment in time and money. The techniques employed are experimental and presently the state of the art in biotelemetry and are readily applicable, if somewhat experimental. More satellite telemetry of east Florida loggerheads is needed before extrapolations can be made to the population.

ACKNOWLEDGEMENTS

Earl Possardt, Jack Woody, Lew Ehrhart and crew, Tim Clabaugh, and Bert Charest helped this project to succeed. Funding was provided by the National Fish and Wildlife Foundation, Washington D.C. and the Endangered Species Office, Fish and Wildlife Service, Albuquerque, New Mexico.


S.C.
GA
FLA
80°
78°
32°
30°
28°
26°
10.3 METERS
FLORIDA CURRENT
JACKSONVILLE
NOV 5, 1988
OCT 21, 1988
NOV 22, 1988
NOV 10, 1988
NOV 29, 1988
A
C
B
D
NOV 16, 1988
NOV 19, 1988
OCEAN
ATLANTIC
INDIAN RIVER SHORES
AUG 30, 1988
OCT 10, 1988
HUTCHINSON ISLAND
OCT 2, 1988
SEP 20, 1988 & JAN 17, 1989
JUPITER INLET
JAN 12, 1989
0
50
100
KILOMETERS
Movements of Loggerhead 7674
A: Location at first (weak) cold front.
December 1-4, 1988
Most of this time she was on the surface.
B: Location at second (weak) cold front.
She moved from B to C in the same day.
December 12, 1988
Again, she was on the surface.
C: Location at third (strong) cold front--
the mouth of Canaveral Ship Channel.
December 14-19, 1988
She was submerged from 12/15-19.
Location of shelf where depth drops approximately 30-35 fathoms over a short distance.
MAP PREPARED BY
BERT CHAREST
NERC USFWS

THE MARINE TURTLE NEWSLETTER

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The decade of the 1970's was a critical time for sea turtles, and an important time for sea turtle research and conservation activities. It was widely recognized that sea turtle populations were declining around the world. Some populations had been extirpated entirely and many others were threatened by commercial exploitation and habitat loss. In 1969, a Sea Turtle Specialist Group had been established under the auspices of the IUCN Species Survival Commission; in July 1975 all species of sea turtle were listed by the Convention on International Trade in Endangered Species (CITES). An increasing amount of attention was focused on the problem as scientists and managers around the world struggled to design and implement research and conservation programs on the basis of very limited knowledge about the biology of these long-lived marine creatures. There was no doubt that the survival prospects for sea turtles would be enhanced by the international and timely sharing of ideas and techniques.

Dr. Nicholas Mrosovsky (University of Toronto, Ontario, Canada) rose to the occasion. In August 1976 he published the first issue of the Marine Turtle Newsletter (MTN). He designed the MTN to be an informal publication which would serve the needs of a growing sea turtle research community by providing a forum to discuss emerging ideas and techniques. The charter issue opened with these editorial remarks:

> "Efforts are going on all over the world to save marine turtles from extinction. Marine turtles are widely distributed and their migrations take them across international boundaries. These facts complicate both arriving at an understanding of their biology and devising the necessary measures for their conservation. Given this situation, the authorities at IUCN and the members of the IUCN Marine Turtle Specialist Group felt that better communication between workers in different parts of the world was needed.
>
> The aim of this Newsletter is:
>
> 1) to provide a forum for exchange of information about all aspects of marine turtle biology and conservation,
>
> 2) to alert interested people to particular threats to marine turtles, as they arise."
> (N. Mrosovsky, Editor)

The Newsletter was a great success, and as the list of recipients grew so did the list of discussion topics. By the end of the decade, sixteen issues later, readers had been alerted to problems confronting sea turtles in Malaysia, the Solomon Islands, Sri Lanka, the USA, India, South Africa, Natal, Oman, Mexico, Suriname, Senegal, Ecuador, Costa Rica, Ascension Island, Réunion Island, and the Cape Verde Islands. Incidental drowning, tagging (including flipper tagging, carapace notching, and tattooing), tag loss, international trade, sonic and radio tracking, artificial incubation of sea turtle eggs, temperature and hatchling sex, growth rate and maturation, diet, captive raising of sea turtles, and the critical status of Lepidochelys kempi had been discussed. By 1980, circulation had risen to include some 700 people in 70 different countries.

In November 1984, Dr. Nat Frazer took over as the Newsletter's second editor. He noted in his opening editorial that, "Under [Dr. Mrosovsky's] editorship, the MTN became a source document of inestimable value to all who study sea turtles -- so much so that it is difficult to believe that anyone could ever hope to maintain a current understanding of sea turtle biology and conservation without regularly reading the MTN." He ended the editorial by quoting S. C. Stearns ("The problem is not to establish who is right,

because no one is, but to identify the portion of truth perceived by each, and to discover how to connect those portions") and predicted that, "If the MTN continues to be a thread connecting the truths perceived by each of us, then my editorship will be a successful one."

His editorship was indeed a successful one. Circulation rose, and authors contributing from around the world assured that the Newsletter remained of "inestimable value". As 1990 approaches and the threats confronting sea turtles are no less alarming than they were 15 years ago, the role of the Newsletter is as important as ever. As the MTN's current editors, we strongly support the founding principles, including the Newsletter's timeliness, international scope, and free distribution. We invite you to share the results of your research on a regular basis! In addition, we welcome general notes of interest to readers (conferences, literature reviews, employment).

We also encourage you to write editorials. There are several crucially important issues that we as a community need to discuss, and eventually to resolve. These include maturation age, natal homing, tag loss, the sex ratio(s) of wild populations, and management issues such as harvest (proportion of eggs, turtle size, seasonality, quotas) and beach lighting. We invite dialogue on conservation options, international initiatives, trade, and research techniques. Should sea turtle conservation "pay its own way"? How? We also welcome notes on successful fund raising, public education, and/or legal campaigns. The MTN is published quarterly (January, April, July, October) and is supported by donations. Your contributions (words or money!) are always welcome.

INCIDENTAL CAPTURE OF SEA TURTLES AT SALEM GENERATING STATION, DELAWARE BAY, NEW JERSEY

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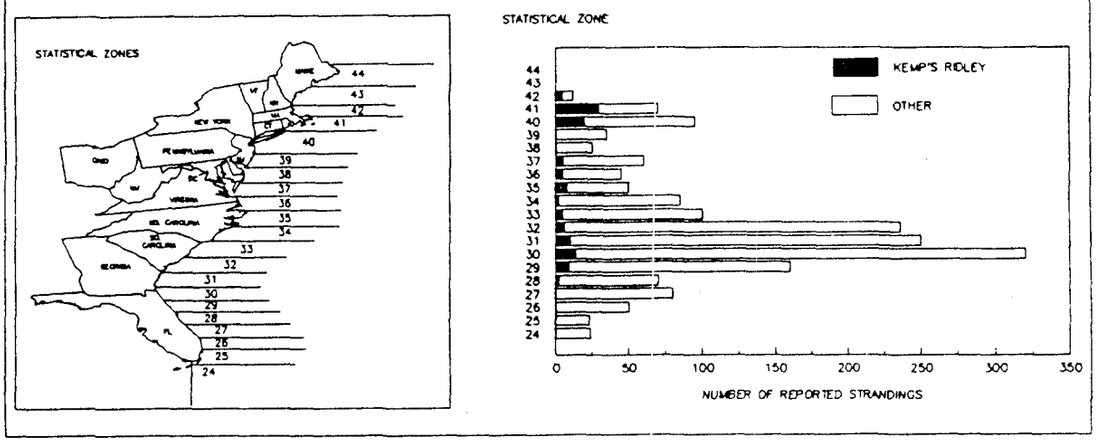
Juvenile loggerhead (Caretta caretta) and Kemp's ridley (Lepidochelys kempi) sea turtles are sporadically captured at the circulating water intake of the Salem Generating Station, Delaware Bay, New Jersey. Both species occur at the station primarily during the month of July when these species are foraging northward along the coast. Later in the summer and early fall these species are still observed in the Bay and coastal New Jersey and Delaware but seem less susceptible to capture at the intake. Administrative controls and daily cleaning of the trash racks at the station's circulating water intake have reduced the mortality of sea turtles incidentally captured on the intake. However, a portion of the turtles have been obviously dead for sometime prior to being captured at the intake. Evidence of propeller damage (deep cuts on carapace) have been noted in several specimens.

CONDITION OF TURTLES CAPTURED
(LIVE/DEAD)

YEAR	C. caretta	L. kempi	TOTAL
1980	0/1	1/0	1/1
1981	1/2	0/1	1/3
1982	0/1	0/0	0/1
1983	0/2	0/1	0/3
1984	0/2	1/0	1/2
1985	2/4	1/1	3/5
1986	0/0	0/1	0/1
1987	3/0	2/1	5/1
1988	2/6	1/1	3/7
TOTALS	8/18	6/6	14/24

SEA TURTLE STRANDINGS, U.S. ATLANTIC COAST 1987
(NMFS, 1988)

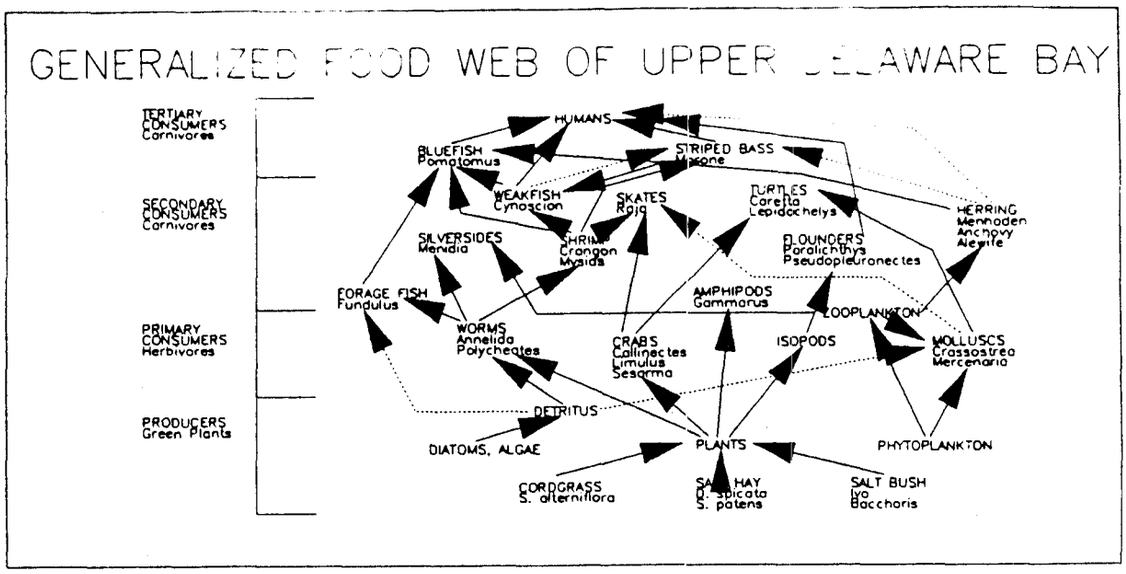


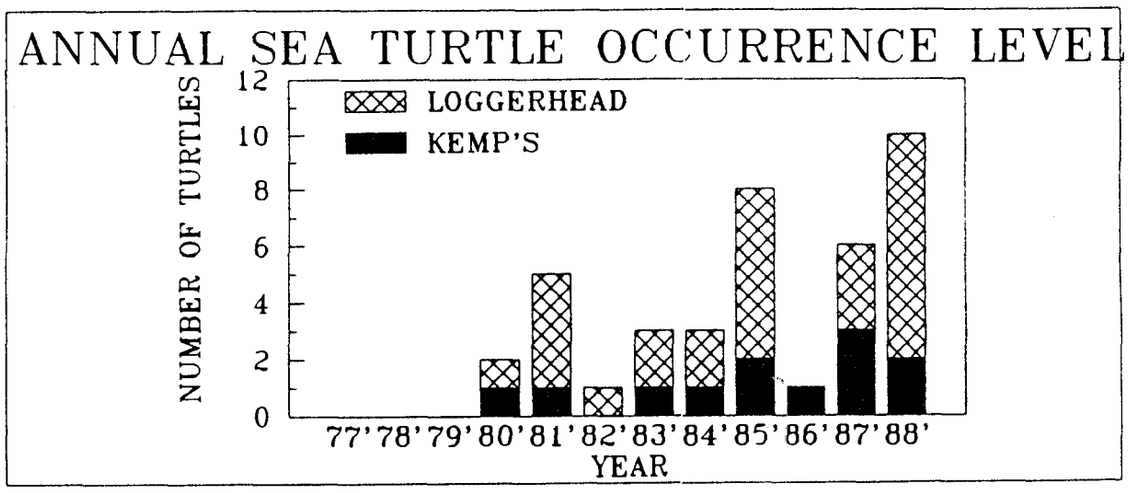
CONDITION OF DEAD TURTLES

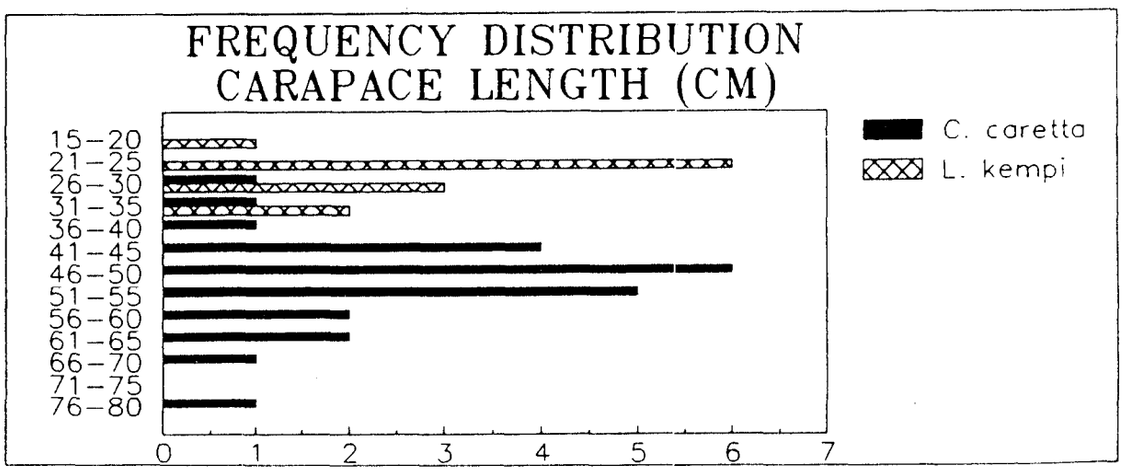
6 – Severely decomposed

8 – Moderately decomposed

10 – Fresh dead


GENERALIZED FOOD WEB OF UPPER DELAWARE BAY
TERTIARY CONSUMERS Carnivores
SECONDARY CONSUMERS Carnivores
PRIMARY CONSUMERS Herbivores
PRODUCERS Green Plants
HUMANS
BLUEFISH Pomatomus
STRIPED BASS Morone
WEAKFISH Cynoscion
SKATES Raja
TURTLES Caretta Lepidochelys
HERRING Menhaden Anchovy Alewife
SILVERSIDES Menidia
SHRIMP Crangon Mysids
FLOUNDERS Paralichthys Pseudopleuronectes
FORAGE FISH Fundulus
AMPHIPODS Gammarus
ZOOPLANKTON
WORMS Annelida Polychaetes
CRABS Callinectes Limulus Sesarma
ISOPODS
MOLLUSCS Crassostrea Mercenaria
DETRITUS
DIATOMS, ALGAE
PLANTS
PHYTOPLANKTON
CORDGRASS S. alterniflora
SALT HAY D. spicata S. patens
SALT BUSH Iva Baccharis


ANNUAL SEA TURTLE OCCURRENCE LEVEL
NUMBER OF TURTLES
0
2
4
6
8
10
12
LOGGERHEAD
KEMP'S
77' 78' 79' 80' 81' 82' 83' 84' 85' 86' 87' 88'
YEAR


FREQUENCY DISTRIBUTION
CARAPACE LENGTH (CM)
15-20
21-25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
61-65
66-70
71-75
76-80
0
1
2
3
4
5
6
7
C. caretta
L. kempi

DEFORMED REJECTS(?) OR AMBASSADORS FOR CONSERVATION
A Sea Turtle Program of Environmental Education and Stewardship for Third Grade Children of the Clarke County Public School District, Georgia

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Pete Schrantz
J. Michael Wharton
James I. Richardson
Northeast Georgia Nature Center, Old Commerce Road, Athens, Georgia 30607 USA

Since 1983, a number of hatchling loggerhead sea turtles, Caretta caretta, from Little Cumberland Island, Georgia, have been bringing a very special message to children in Clarke County, Georgia. These turtles were developmentally deformed at birth and could not survive in the wild. Instead of becoming a meal for gulls on the beach, they (4-6 animals annually) are rescued from their fate and used in a unique multi-media, hands-on, environmental education program developed through the efforts of the Georgia Sea Turtle Cooperative at the Institute of Ecology (University of Georgia) and the Northeast Georgia Nature Center, Athens, Georgia.

This program, "Kids for Turtle Rights," is conducted by naturalists from the Northeast Georgia Nature Center and presented annually to about 700 children in all of the third grade public school classes in Clarke County, Georgia. In a two-hour program the students learn about the needs, habits, and dangers which face sea turtles on the beach and in the ocean. Children are given opportunities to propose solutions to such problems as ocean pollution, drowning in fishing gear, beachfront development, and nighttime lights on beaches which disorient hatchlings. Imaginary journeys, murals, puppets, a video, and a skit are used to view the world through the eyes of a loggerhead sea turtle. The presence of live sea turtles greatly enhances the program. Thus, through this program, turtles which have virtually no chance for survival in the wild are instrumental in bringing awareness of the need for sea turtle conservation to the human community in a dramatic way.

Feedback on the program in the form of letters from children, teacher evaluation reports, contacts with parents, conversations with members of the community, and other personal testimonies indicates that this program has a powerful and long-term impact on the students. In addition, the children take their enthusiasm and new knowledge out of the classroom and into their homes and community. As a result, there are now many more parents and other adults in Clarke County and across Georgia who understand the need for sea turtle conservation.

Loggerhead sea turtles are classified as a threatened species under the U.S. Endangered Species Act of 1973. Thus, the Northeast Georgia Nature Center turtles are accompanied by the proper state and federal permits at all times. They are kept in large saltwater aquaria at 28% salinity and 80°F. They are fed Purina sea turtle "chow" obtained from HEART (Help Endangered Animals - Ridley Turtles) and receive medical attention as needed from the University of Georgia College of Veterinary Medicine. Healthy individuals are usually placed with public educational aquaria at the end of the program. Others have been released off the Georgia coast in sargassum drift lines to the east of the Gulf Stream.

Recently, two of the Nature Center turtles were flown, courtesy of Delta Airlines, to the West Coast to become part of an environmental education program conducted by Michael Rugge, Director of the Sea Turtle Center in Nevada City, California. In their new home these loggerheads will continue their roles as ambassadors of conservation for threatened sea turtles of all species by taking their environmental message to even more school children. Deformed loggerhead rejects from Georgia are now helping California children learn about the pressing needs for sea turtle conservation on Mexican beaches and the courageous efforts of a few individuals to protect nesting leatherbacks, olive ridleys, and Pacific black turtles in that country.

HYDRODYNAMIC FACTORS INVOLVED IN CHOICE OF NESTING SITE AND TIME OF ARRIVALS OF LEATHERBACKS IN FRENCH GUIANA

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In the Atlantic, the favorite beaches of leatherbacks, Dermochelys coriacea (Vandelli, 1761), for nesting are those of French Guiana. The time of arrival of turtles on a beach is mainly influenced by the geographic localization and structure of the beach and the amplitude and time of high tide.

For this study, two beaches were patrolled: Ya:lima:po-Les Hattes (located on the mouths of Mana and Maroni Rivers) and Apo'tïlï-Pointe Isère (not influenced by the fluvial races; cf. map). The Ya:lima:po beach was patrolled from the night of 20 April 1987 to the night of 7 August 1987 (Fretey and Girondot 1988). Volunters worked two hours and were relayed. For the 28,000 turtles seen, the time of observation and the stage of the nesting process were entered in a computer. Then, knowing the length of each nesting stage (Fretey 1981), estimated times of arrival were computed. The Apo'tïlï beach was patrolled from the night of 6 June 1988 to the night of 22 June 1988 and the same procedures were followed.

On Yá:lima:po beach there is a relationship between high tide and the time of leatherback's arrival on the beach. This phenomenon is visualized with the linear regression of the number of turtles per hour as a function of the date. However, for the seven lunar cycles, these regressions have slope values higher than the slope obtained with the times of high tide. The difference between the time of maximun number of animals arriving and the time of high tide is null when the high tide is in the evening, and from 3 (Vigie) to 5 (Bois Tombé 2b, or 'BT2b') hours when the high tide is in the morning (Figure 1).

We explain these observations by two antagonist mechanisms. On one hand, the carrier effect of the rising tide facilitates the arrival of turtles. On the other hand, the fluvial currents prevent the leatherbacks from arriving on Ya:lima:po beach. The Apo'tïlï beach is only subject to tidal currents. The northwest direction of the longshore Guiana current (Prost 1986) carries the fluvial currents far from Apo'tïlï beach. So, the turtles can arrive all the night on this beach with a slight peak at rising tides.

The hourly difference between high tide and the time of arrival can be interpretated by the same mechanisms. The fluvial currents are inversed earlier in the morning for spring-tides than in the evening for neap-tides. As referred to the high tide, the leatherbacks will arrive on the beach sooner in the morning than in the evening.

For morning (AM) high tides, we explain the difference between time of arrival in Vigie and in BT2b by a specific effect of these mechanisms on different parts of Ya:lima:po beach. We propose two explanations for this:

- The fluvial current is higher in Vigie than in BT2b (Girondot, personal observation).
- A sand bank appears in front of Vigie during low tides, and many turbulences are provoked during neap-tides.

Figure 2 presents the percentage of arrivals per night on different parts of Ya:lima:po beach. The maximum of frequentation in Vigie was seen for full and new moons (spring-tides). This arrival in Vigie appears to be facilited when there are spring-tides. This effect is not observed for other parts of this beach. These observations suggest that access on Vigie is submitted to high constraints that prevent the leatherback's arrivals.

The objectives for this study are

- To understand how the different currents in the estuary of Maroni and Mana Rivers interact to influence arrival time of leatherback turtles,

- To study simultaneously the distribution of arrival time on all the estuary's beaches.

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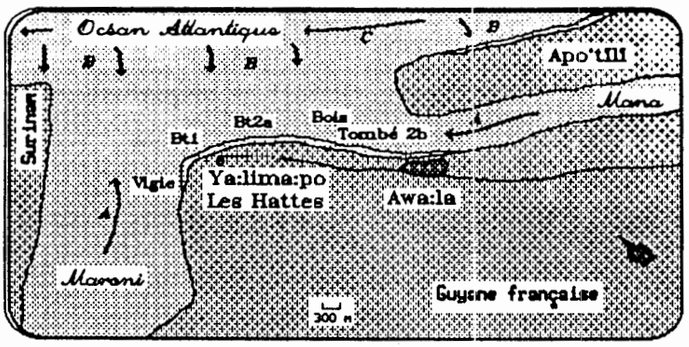
Fretey, J. and M. Girondot.1988. Nidification de la Tortue Luth sur le littoral de Guyane francaise pendant la saison 1987. Ann. Soc. Sci. Nat. Char.-Mar. 7(6):729-737, maps, figs., tabls.

Prost, M.T. 1986. Observations sur l'évolution morpho-sédimentaire du littoral guyanais. Intl. Symp. Sea Level Changes and Quaternary Shorelines, Sao Paulo, Brasil, July 1986. 16p, maps, figs.



Map of the region of Ya:lima:po beach in french Guiana.
A , Fluvial race ; *B* , Direction of tide ; *C* , Stream of Guianas.

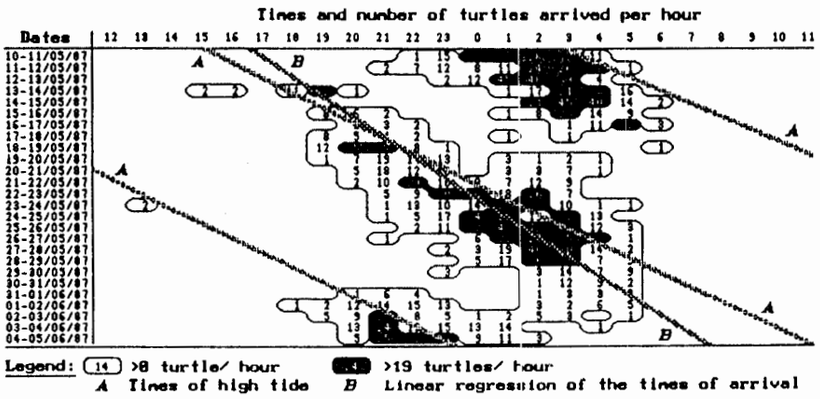


Figure 1: Frequentation of the Ya:lima:po beach in 1987 - 'Vigie'.

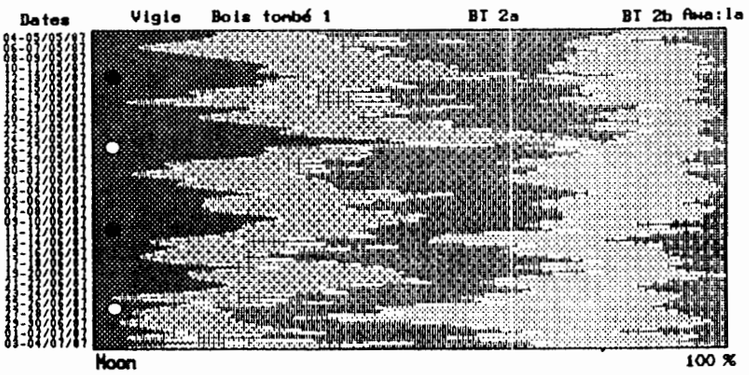


Figure 2: Percentages of arrivals on the different parts of the Ya:lima:po beach in 1987.

A COMPARATIVE ANALYSIS OF MARINE TURTLE REPRODUCTIVE SUCCESS AT PATRICK AIR FORCE BASE, FLORIDA, 1987-88

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Patrick Air Force Base (PAFB), on the central east coast of Florida, is located within the region that supports more marine turtle nesting than any other in the United States. It is only 25 km north of a 21 km area near Melbourne Beach which supports greater loggerhead sea turtle (Caretta caretta) nesting density than any other beach in the Western Hemisphere. While PAFB's proximity to the highly developed resort area of Cocoa Beach may have cast some doubt on its importance as a sea turtle nesting area, preliminary surveys by base personnel suggested otherwise.

The shoreline at PAFB does not look like good sea turtle nesting beach. The profile of the beach is relatively flat between the surf and a steep wall of compact, shelly material that is apparently the legacy of a previous beach restoration project. In 1987 and 1988, however, there was a low terrace of accreted sand at various widths and depths in front of the wall. Even so, it seemed much less than an ideal place for marine turtles to nest and, especially, for clutches of eggs to incubate safely and hatch successfully. For the past two nesting seasons, we have surveyed the beach at PAFB in order to catalog the marine turtle reproductive activity that occurs along this 7 km stretch of beach.

METHODS

The study area was divided into seven 1-km sections, with Section 1 beginning at the southern end of PAFB, opposite State Road 404, and Sections 2 through 7 extending northward. Our assessment of marine turtle nesting activity was done by counting nests and false crawls on walking surveys conducted five days per week, beginning on 15 May and ending on 22 August in 1987 and beginning on 17 May and ending on 31 August in 1988.

To assess the fates of clutches deposited within the study area, we marked 32 loggerhead nests and eight green turtle nests in 1987 and 50 loggerhead nests in 1988 and monitored them throughout incubation. After the last emergence of hatchlings, each nest was excavated and inventoried. Hatching success was defined as the fraction of eggs in which hatchlings survive to term and free themselves from the shell; emerging success is the fraction of eggs which result in hatchlings that emerge from the nest.

RESULTS

Overall, from some standpoint in the future, we may well be able to look back upon 1988 as a fairly "typical year" for sea turtles at PAFB and look back upon 1987 as an "exceptional year". The two years were characterized by the following.

1. High hatching and emerging rates, promoted by the total lack of raccoon predation. In 1987, these high reproductive rates were further promoted by a summer that was climatically benign (Figure 1).

2. A loggerhead density (111 nests/km in 1987; 87 nests/km in 1988) that places it in the "second tier" of loggerhead nesting beaches of the Western Atlantic, a density that is exceeded on only a few of the very best beaches in the region. Figure 2 presents nesting totals by week for both years.

3. The fact that several of the few remaining Florida green turtles also nested here in 1987 adds to the significance that we now perceive for this beach. Ten nests were observed at PAFB in 1987. Although a very low level of green turtle reproductive activity occurred here this past season (resulting in only five false crawls and no nests), 1988 was characterized by a depressed green turtle nesting season throughout the region.

It is reasonable to conclude that the 7 km stretch of beach at PAFB supports more sea turtle nesting than is commensurate with its size. Considering this and the threatened/endangered status of the species involved, it seems equally clear that efforts to protect and enhance sea turtle reproduction at PAFB are justified and worthwhile.

Fig. 1. Hatching and emerging success in 1987 and 1988

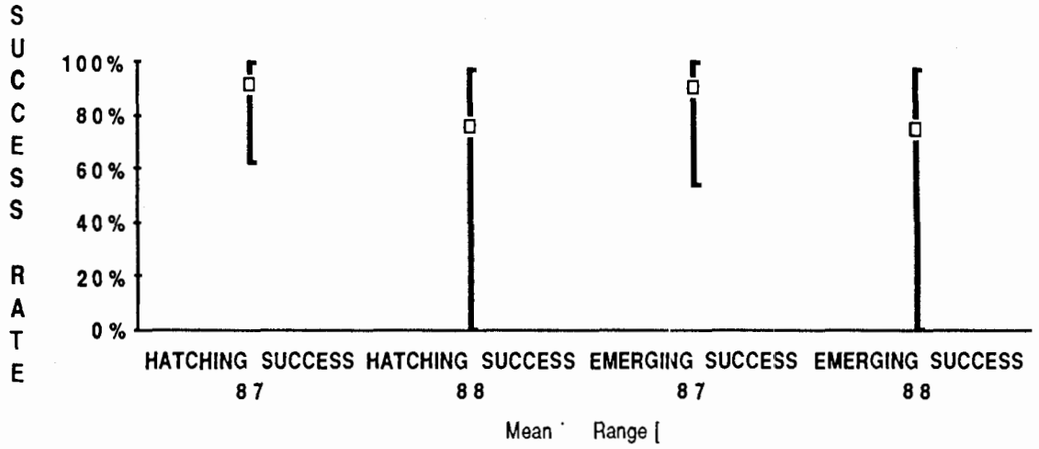
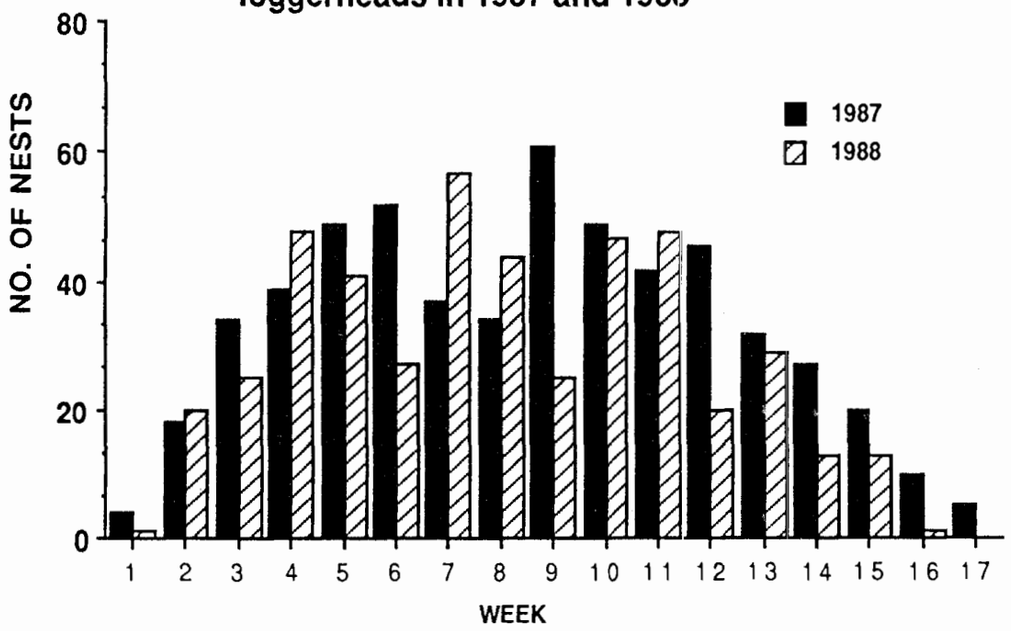


Fig. 2. Nesting totals by week for loggerheads in 1987 and 1988



BUCK ISLAND REEF NATIONAL MONUMENT SEA TURTLE PROGRAM, 1987-1988

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The program objectives were to collect basic biological information on hawksbill sea turtles (Eretmochelys imbricata) nesting on Buck Island Reef National Monument (BUIS), test the feasibility of tagging turtles for a long-term population study, and identify management concerns. BUIS is a park of approximately 800 acres located north of St. Croix (U.S. Virgin Islands) and managed by the National Park Service. There are three principal sea turtle nesting areas; the north shore, West Beach, and the south shore (Fig. 1). The north and south shores are typical hawksbill nesting habitat (beach forest, low berms, cobble or sand beaches, offshore coral reefs), while West Beach has a wide, exposed beach platform and no offshore reefs.

Turtle nesting activities were recorded daily during diurnal and/or nocturnal monitoring patrols. When nesting turtles were encountered, activity, time and location were noted and all subsequent stages of the nesting cycle were timed and logged. Diagnostic markings were recorded during egg deposition; during covering, the turtle was measured and tagged with inconel tags provided by the National Marine Fisheries Service (PPW 800 series). Seventy days after nesting, eggs were excavated to determine hatching success.

Twenty-three hawksbill activities were observed during nocturnal monitoring periods; 18 resulted in the deposition of eggs. An additional 33 activities occurred unobserved. Twelve hawksbills were inconel-tagged and six of these were also painted-tagged. Eight tagged individuals were observed only once, two were observed twice, and two were observed on three occasions (Table 1). The average internesting interval was 15.8 days (sd=0.83, n=4 intervals). Carapace length ranged from 83.5-94.0 cm and carapace width from 76.3-90.0 cm (Table 2). The nesting season peaked between July and September (Figs. 2, 3). In 1988, 88 nests were confirmed, the average clutch size was 140.3 eggs (sd=24.0, n=75), mean hatching success of nests surviving to term was 80.9%, and approximately 6,800 hawksbill hatchlings were released from BUIS. In 1987, 46 nests were confirmed and mean hatching success for nests surviving to term was 83.5%. The number of confirmed nests increased more than four-fold between 1985 and 1988 as a result of intensified diurnal and nocturnal monitoring efforts (Fig. 4).

Several management concerns were identified: (1) beach debris limited access to stable nesting grounds in the beach forest, (2) predation reduced nest success; seven nests were lost to the great land crab (Cardisoma) in 1988, although historically the mongoose (Herpestes) has been the primary predator, (3) poaching, a serious concern in the past, was virtually eliminated in 1987-1988 by program publicity and the presence of research personnel, (4) the effects of recreation were minimized by prohibiting all types of activities using poles, stakes, or digging on nesting beaches during the nesting season, (5) erosion reduced nest success; in 1988 approximately 8% of confirmed nests were lost to erosion; normal rainfall and storm flooding eroded the shoreline vegetation, exposing roots and preventing access to stable nesting areas in the beach forest.

The biological data collected during the 1988 season has established a baseline of information on the hawkbill nesting population at BUIS. The return of tagged animals will now provide information on site tenacity, remigration, fecundity, and tag loss for this endangered and poorly documented species. In light of the continued loss of nesting habitat to development in the wider Caribbean, protected areas such as BUIS play a significant role in the conservation of the hawksbill sea turtle. The 1988 data indicate that a long-term monitoring program is not only feasible, but warranted. The National Park Service will once again support a program of diurnal and nocturnal monitoring of BUIS during the 1989 hawksbill nesting season.

Table 1. Tagging information on hawksbill sea turtles nesting on Buck Island Reef National Monument, U.S. Virgin Islands, 1988. NMFS = U.S. National Marine Fisheries Service.

Painted Number	NMFS Tag*	Date Tagged	Tagging Location	Other Dates Observed
1**	804	6/21/88	South shore	6/5
2	805	6/12/88	South shore	-
3	806	6/13/88	North shore	-
4	807	6/13/88	South shore	7/28
	817	6/28/88	South shore	
5	808	6/13/88	South shore	6/28, 7/28, 7/29
6***	809	6/16/88	South shore	-
-	810	6/17/88	West Beach	-
-	813	8/02/88	South shore	8/18
-	814	8/04/88	South shore	-
-	818	8/04/88	South shore	-
-	820	7/20/88	North shore	-
-	822	7/26/88	North shore	-

* National Marine Fisheries Service inconel tags, series PPW

** Paint tag was applied to carapace during the turtle's first visit (6/5) and the inconel tag was applied later (6/21) when it became apparent that the paint was only temporary; for all other turtles, paint and inconel tags were applied simultaneously

*** Number 6 was the last paint tag applied because the technique was deemed unsuccessful

Table 2. Carapace measurements of hawksbill sea turtles nesting on Buck Island Reef National Monument, U.S. Virgin Islands, 1988. o.c. = over-the-curve.

Dimension	N	mean (cm)	sd	range
o.c. nuchal notch to posterior notch	12	87.7	3.8	83.5 - 94.0
o.c. maximum width	12	81.8	4.0	76.3 - 90.0

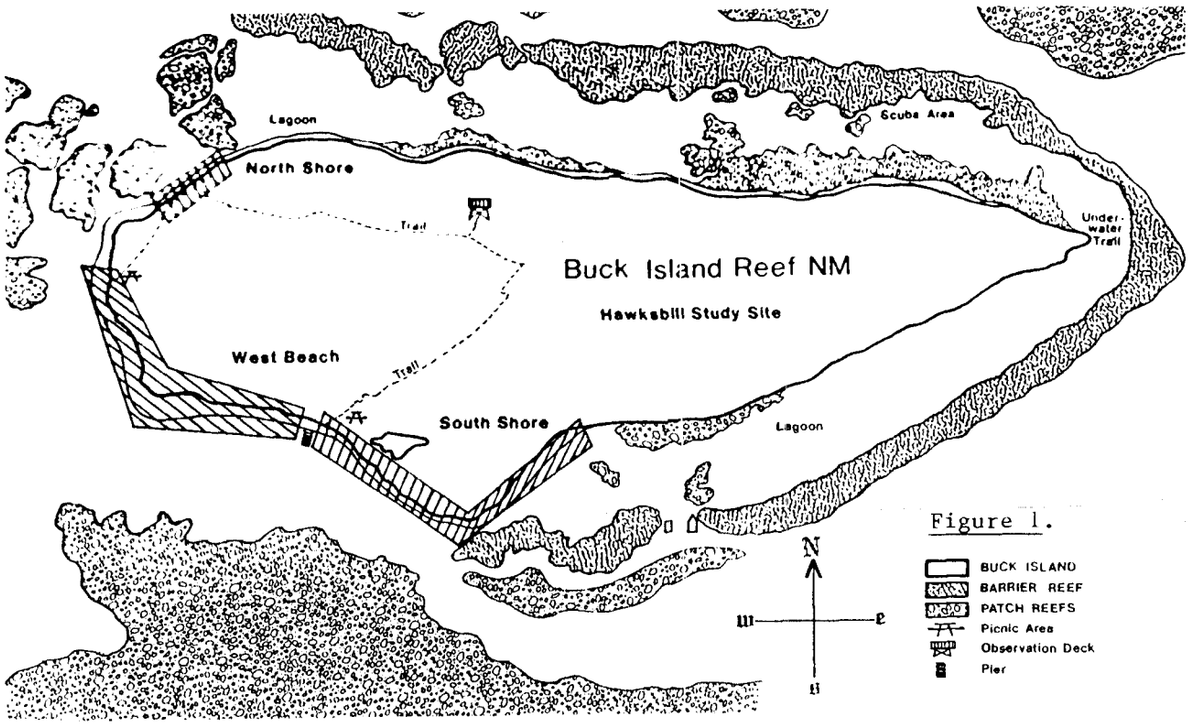


Figure 1.

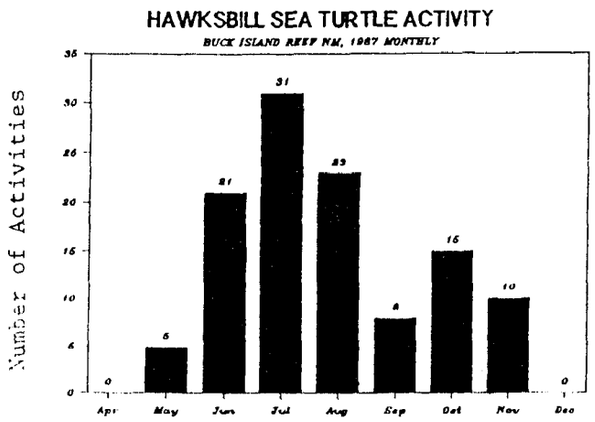


Figure 2. Monthly 1987

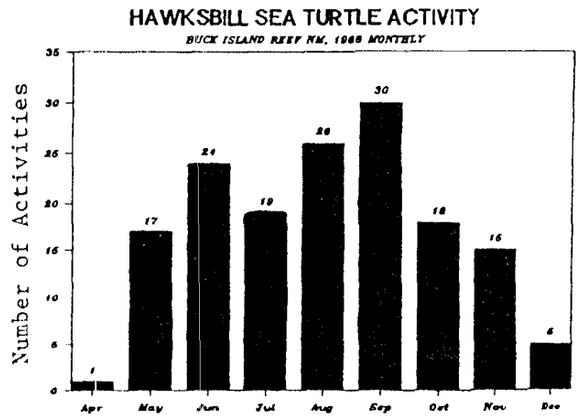
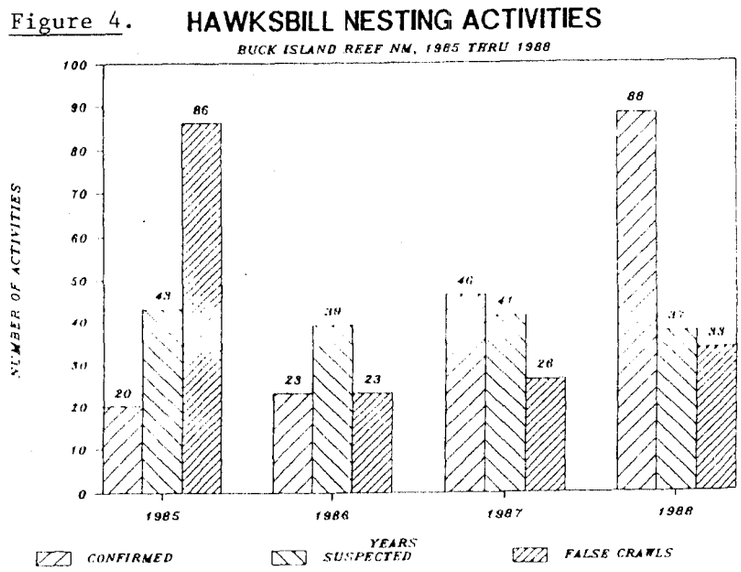


Figure 3. Monthly 1988

Figure 4.



NEST SITE LOCATION AND CLUTCH MORTALITY OF HAWKSBILL TURTLES (ERETMOCHELYS IMBRICATA) IN BARBADOS, WEST INDIES

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S. Willoughby[3]
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BACKGROUND

Moratoria on fishing and stricter enforcement of fisheries legislation are planned by several Caribbean countries and may decrease fishing pressure on hawksbills (Eretmochelys imbricata). However, environmental and habitat characteristics may constrain recovery. In particular, tourism-related development in the Caribbean appears to be decreasing the availability of suitable nesting beaches for sea turtles. The objectives of this study were to estimate abundance of hawksbill turtles in Barbados, to characterize seasonal and spatial variation in nesting activity, to quantify the components of mortality affecting hawksbill clutches, and to comment of the conservation efforts currently underway to rehabilitate hawksbill populations in Barbados.

METHODS

Two approaches were used to estimate spatial and seasonal variation in hawksbill nesting in Barbados. First, the general public were requested through the media to report all nesting and hatching events in 1987 and 1988. Second, once a month for 3 months of the reproductive season (June-August) in both 1987 and 1988, trained volunteers from the Barbados Environmental Association surveyed the entire coastline of Barbados for turtle tracks. Clutch size, incubation time, percent egg and percent hatchling mortality were obtained from 27 nests excavated after hatching, and clutch size was obtained from a further six nests. Unhatched eggs were classified as either undeveloped or as dead embryos. These data were used to calculate emergence success (percent of all eggs that emerged from the nest as hatchlings), which consists of two components: 1) hatching success (percent of all eggs that hatched) and 2) escape success (percent of all hatchlings that escaped from the nest). The data are presented in Table 1, separately for nests made less than and more than 5m above the high tide mark (HTM), and nests on beaches with high human activity (public parks and large hotel beaches) and those on quiet beaches.

RESULTS

Hawksbills prefer to nest on leeward coast beaches (west and south) rather than on windward beaches. Nestings occurred primarily between May and August in both years (Figure 1). The public reported 25.1% (1987) and 33.1% (1988) of the nests estimated from the beach surveys to have been made over the two three-month periods (June-August). These percentages were used to estimate the total number of nests in 1987 and 1988 from the data presented in Figure 1. The estimates obtained are 239 nests in 1987 and 157 in 1988 (mean=198 nests). Allowing for 2-3 nests per female per season, 200 nests per year implies an annual breeding population of 67-100 female hawksbills in Barbados. The breeding female population in any one year is only a sub-set of the total population of females breeding in the country. With a mean interval of 3.5 years between breeding, an annual nesting population of 67-100 implies a total breeding population of 235-350 in Barbados.

Three major mortality factors affect eggs and hatchlings:

1) Flooding mortality: Hatching success in nests < 5m above the HTM (80%) tended to be lower than that in nests > 5m above the HTM (89.1%, Mann Whitney test, T=101, P=0.1). The percent of

undeveloped eggs in nests < 5m above the HTM (16%, Table 1) was significantly higher than in nests > 5m above the HTM (8.6%, T=108, P<0.05, Table 1). By contrast, the percent of eggs that died during development ('dead embryos', Table 1) did not differ in nests < 5m above the HTM (4.3%) and those > 5m above the HTM (5.8%, T=57.5, P>0.05). This suggests that flooding mortality affects eggs only in the early stages of development.

2) Compaction mortality: Emergence success on heavily used beaches (64.9%) was significantly lower than on quiet beaches (83.8%; T=133, P<0.05, Table 1). Emergence success of nests < 5m above the HTM and those > 5m above the HTM did not differ (T=79.5, P>0.05, Table 1).

Hatching success and escape success together determine emergence success. Hatching success on beaches heavily used by the public (83.2%) did not differ from that on quiet beaches (84.7%; T=78, P>0.05), implying that the lower emergence success observed on heavily used beaches results from a lower escape success of hatchlings. Escape success on beaches heavily used by the public (77.9%) was significantly lower than that on quiet beaches (98.8%; T=135, P<0.05). The lower escape success on heavily-used beaches presumably results from increased compaction of sand; death probably occurring through exhaustion and suffocation.

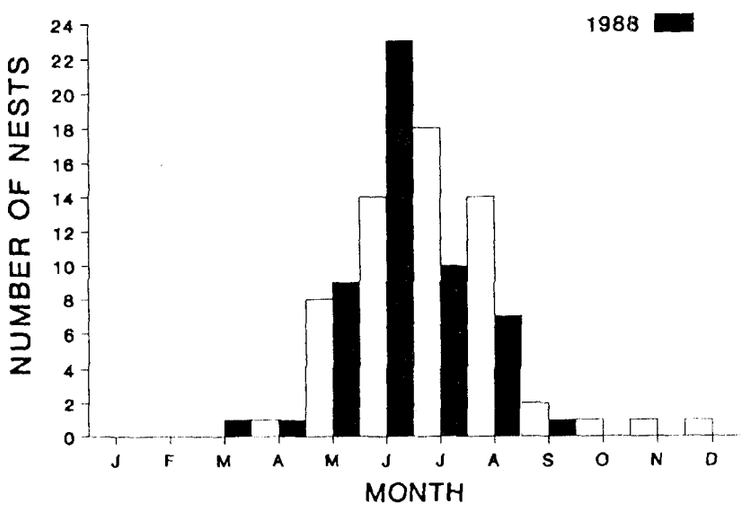
3) Disorientation mortality: Of the 27 nests studied, 14 (55.6%) were affected by beach lighting at hatching, resulting in up to 100% of emerged hatchlings in some nests orienting inland rather than towards the sea.

Conservation activities in Barbados include tagging of nesting females, relocation of nests considered to be in danger from tides, beach erosion, or building construction, and collection of disoriented hatchlings. Hatchlings that appear too exhausted and/or injured to be released are kept and 'head-started' at Bellairs Research Institute until they reach 20cm SCL and are sufficiently large to be tagged. The conservation campaign in Barbados has used the media to explain why attempts to conserve the hawksbill population are necessary. Cooperation by the public in conservation activities for hawksbill turtles has been good. With a rapidly growing tourist industry, it is unlikely that legislation will be passed solely for the protection of turtles at the expense of revenue earning, employment-generating businesses. The future of hawksbill nesting in Barbados will therefore be heavily dependent on the activities of non-governmental organizations, the interest of the public, and the goodwill of owners and managers of beachfront properties.

Table 1. Clutch size, incubation time and survivorship rates of eggs and hatchlings of the hawksbill turtle in Barbados.

	N	Mean	SD	Range
Clutch size	33	127.8	28.9	64-175
Incubation time	13	62	5.3	55-75
Emergence success	27	75.4	26.8	0-94.9
Heavily used	12	64.9	36.0	
Quiet	15	83.8	12.1	
<5m above HTM	7	81.1	14.1	
>5m above HTM	20	73.4	30.0	
Hatchling success	27	84.9	14.7	27.3-96.9
Heavily used	12	83.2	19.3	
Quiet	15	84.7	11.6	
<5m above HTM	7	80.0	14.4	
>5m above HTM	20	89.1	5.9	
% Undeveloped	27	11.1	8.8	1.5-37.2
<5m above HTM	7	16.0	11.8	
>5m above HTM	20	8.6	6.1	
% Dead embryos	27	4.3	8.9	0-46.7
<5m above HTM	7	4.2	6.5	
>5m above HTM	20	5.8	13.7	
Escape success	27	89.5	26.6	0-100
Heavily used	12	77.9	37.4	
Quiet	15	98.8	2.2	
<5m above HTM	7	96.7	4.3	
>5m above HTM	20	86.9	30.6	

FIGURE 1. The number of hawksbill nestings per month reported by the general public in: 1987 ☐ 1988 ■



LOGGERHEAD HATCHLING SUCCESS RATES IN VIRGINIA, 1985-1987

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INTRODUCTION

Virginia waters are a summer foraging ground for up to 10,000 subadult and adult loggerhead sea turtles, Caretta caretta (Bellmund et al. 1987, Keinath et al. 1987, Lutcavage and Musick 1985). However, the abundance of nesting loggerheads on Virginia shores is rare to scarce. With an average of 2 to 3 nests per year (Jones unpublished), Virginia constitutes the northern limit of nesting activity for the Western Atlantic population. One nest was reported from New Jersey in the 1970's. A program to transplant loggerhead eggs from Cape Romain (South Carolina) to Chincoteague (Virginia), Back Bay (Virginia), and Pea Island (North Carolina) was initiated by the Fish and Wildlife Department from 1969-1979. A total of 23,322 eggs from 222 nests were relocated to these areas. A hatch success of 63.4% was reported.

MATERIALS AND METHODS

The nursery site for 1985-1988 was located on the Back Bay National Wildlife Refuge, Virginia Beach, Virginia. Nests were relocated due to beach traffic (44 permitees) and severe beach erosion. The location of the nursery was 3.5 km from the north access ramp and 20 m behind the dune ridge. Beach patrols from Back Wildlife Refuge and False Cape State Park located sea turtle crawls and marked nest sites. The nest was excavated and the eggs were removed and placed in a styrofoam cooler with damp sand and perlite. Each egg was marked to prevent an orientation error and to note its location within the nest. The clutch was then placed in a cylindrical wire cage 35 cm x 75 cm to protect it from predators (ghost crabs, foxes, raccoons). From the surface the top of the egg mass was approximately 15 cm, and the bottom 60 cm. At the time of hatching the hatchlings were counted, weighed and measured. Dead hatchlings were collected and formalized for later sex determination. Live hatchlings were released at night on an outgoing high tide.

RESULTS AND DISCUSSION

Both nature and man affect sea turtle eggs on the nesting beach in Virginia. If the nests aren't located quickly, the evidence disappears under the tires of the permitees or the ocean's tides. The beach should have restricted passage during the critical nesting months.

Eggs are removed from the natural nesting site. Relocated nests may increase hatchling success rates (Wyneken et al. 1988). The first step is to place the eggs in damp perlite and sand to prevent dehydration. The next step is to mark each egg for orientation. The mark is a code as to the location of each egg during the incubation period. If the embryo matures but is still- born, information can be collected as to its sex and depth within the nest.

Eggs are relocated in the nursery area in Back Bay National Wildlife refuge. The isolated area prevents any human contact from summer visitors. This area has been used by the Refuge for many years. As temperature profiles are collected, the impact of the transplant program from 1969 to 1979 and the present relocation of natural nests will be examined.

Hatchling loggerheads emerge healthy and fully developed in this northern range. Their hatch success ranges between 75% and 90% in Virginia; however, their distance to travel to the safety of the Sargassum Sea is 100-200 miles. The trip in the southern range can be as little as 50 miles.

Automatic recording devices will be used to collect the physical parameters at this latitude. The apparatus records temperatures from the surface, various depths, and internal metabolic heat in each nest. Radiation

(watts/m^2), rain moisture in the sand at various depths, wind direction, and wind speed are recorded. This will verify the pivotal temperature for this range of incubating loggerheads.

Table 1 is the data collected during 1985-1987 (no nesting was observed in Virginia in 1988). Figures 1 and 2 show the mean success rates and mean incubation lengths by year for Virginia. The success rates are high. However, the length of incubation is long. This is a result of low incubation temperatures due to the northern latitude. Low incubation temperatures increase the probability of more males. All males from late nests have been recorded from examination of gonads from still-born and dead hatchlings (Jones unpublished).

ACKNOWLEDGEMENTS

We would like to thank the sea turtle personnel, past and present: S. Bellmund, J. Brown, R. Byles, R. Klinger, M. Lutcavage, J. Keinath, D. Barnard, and N. Morse. Funding for part of this research was provided by the Virginia Commission of Game and Inland Fisheries.

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HATCH DATA FOR '85,'86,'87

	# EGGS	% HATCHED	DAYS INCUBATION	(N)	-NOTCH/NOTCH- LENGTH (mm) MEAN	RANGE	CARAPACE WIDTH (mm) MEAN	RANGE	-----WEIGHTS----- (gms) MEAN	RANGE
H185	93	88	63	40	4.97	4.7-5.1	4.03	3.8-4.2	20.71	19.2-23.2
H285	93	39	64	36	4.61	4.3-4.8	3.50	2.8-3.7	18.50	15.4-21.4
H385	114	97	67	50	4.87	4.7-5.1	3.70	2.5-3.9	19.60	17.2-21.8
H485	147	61	67	30	4.38	4.2-4.5	3.34	3.1-3.9	17.64	13.9-21.1
H186	103	91	60	94	4.59	4.4-4.7	3.60	3.4-3.8	18.57	17.3-19.7
H286	117	90	75	105	5.10	4.5-5.3	4.02	3.4-4.2	25.23	20.0-28.1
H187	117	98	61	111	4.52	4.4-4.9	3.60	3.4-3.7	21.80	19.2-23.8
H287	119	75	63		NO DATA COLLECTED					
H387	154	91	62	140	4.59	4.2-4.8	3.55	3.4-3.7	20.70	18.8-23.0
H487	141	98	68	138	4.55	4.3-4.7	3.53	3.3-3.7	19.70	17.6-22.0
H587	94	86	66	80	5.02	4.9-5.2	3.90	3.7-5.0	25.44	23.1-27.2
H687	139	93	72	129	4.49	4.2-4.7	3.50	3.2-3.7	19.36	15.5-22.5

NO NESTING OBSERVED ON VIRGINIA SHORES IN 1988

DEVELOPMENT OF A VIDEO-COLLAR TO STUDY SEA TURTLES IN THE WATER

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Sea turtle behavior in the water is poorly understood because of the difficulty of observing animals at sea. Some of the questions about immersed behavior, as it develops over time and in response to environmental factors, can now be addressed using a newly developed video-collar. Harnessed to the apex of turtle shells, the video-collar obtains a visual record of activity from the animal's approximate perspective. We can thus begin to better understand feeding selectivity, habitat fidelity, social behavior and other motivational states.

The video-collar consists of an 8 mm video camcorder with a charged coupled device (CCD) imaging element. This was reduced to its barest components and reconfigured to fit a hydrodynamic profile. Such streamlined profile is achieved in a custom built epoxy-fiberglass housing having walls capable of withstanding some 1000 psi of hydrostatic pressure and a 1 inch thick, 2 inch diameter, Lexan lens port. Initiation of the recording period is achieved at any specified date and time using a simple electronic timing circuit. Once activated the unit records animal activity for two hours. Work is underway to significantly extend this period by time-delay recording.

The video camcorder is attached to animals using a rapidly deployable harness designed to accommodate turtles of a variety of sizes. Two anterior and two posterior wire straps secure the collar to the apex of the shell. The anterior straps are actively secured by means of small hooks which penetrate approximately 1mm into the outer cuticle of the forward edge of the shell. Connecting these hooks to the anterior wire straps are magnesium elements of known dissolution times in sea water.

The posterior straps are on an adjustable pulley system to accommodate different sized animals. The hooks on these straps are placed over the shell and held securely by tension against the anterior straps. The video-collar is released from animals by dissolution of the anterior magnesium elements, thereby undermining the tensile attachment of the posterior hooks. Following detachment, the buoyant video-collar floats to the water surface where the radio transmitter, housed within its tail section, is activated for retrieval.

ACKNOWLEDGEMENTS

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- OOPS, Greg Marshall

MARINE TURTLE NESTING AND REPRODUCTIVE SUCCESS IN SOUTH BREVARD COUNTY, FLORIDA, 1982-1988

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INTRODUCTION

Since 1982 the University of Central Florida's marine turtle research group has conducted surveys of marine turtle nesting in a 21 km long study area in south Brevard County, Florida, extending from a point 5 km south of the eastern terminus of U.S. 192 in the town of Indiatlantic to a point just north of the Sebastian Inlet State Recreation Area.

In 1985 studies were begun of reproductive success (i.e., the percentage of yolked eggs that yielded hatchlings which emerged from the nest) for loggerhead (Caretta caretta) and green (Chelonia mydas) sea turtle clutches deposited within the south Brevard County study area.

METHODS AND RESULTS

Nesting Survey

Using data gathered by five day per week surveys, the number of loggerhead clutches deposited in the 21 km study area was estimated to be 7,995 in 1982, 9,423 in 1983, and 7,753 in 1984 (Ehrhart and Raymond 1987). In 1985, seven day per week surveys enabled an absolute count of 10,240 clutches (Ehrhart and Witherington 1987). Estimates from the past three years were 10,745 in 1986 (Ehrhart and Witherington 1986), 9,780 in 1987 (Ehrhart et al. 1987), and 8,838 in 1988 (Ehrhart et al. 1988). The mean count of loggerhead clutches for the seven years the south Brevard County study area has been surveyed is 9,253 $\pm$1035 using a confidence interval based on a students' t distribution (P = 0.05).

Because of their very distinctive tracks and nests and their relatively small numbers, an absolute count of green turtle clutches deposited each season was made. Ehrhart and Raymond (1987) reported 47 green turtle clutches deposited in 1982, 43 in 1983, and 32 in 1984. A large increase to 281 clutches was reported in 1985 (Ehrhart and Witherington 1987), a drop to a total of 66 clutches in 1986 (Ehrhart and Witherington 1986), another large increase in 1987 to 206 clutches (Ehrhart et al. 1987), and a drop to 77 clutches in 1988 (Ehrhart et al. 1988). The mean green turtle clutch count for the seven years surveys have been conducted in the study area is 107 $\pm$89 using a confidence interval based on a students' t distribution (P = 0.05).

In addition to the loggerhead and green turtle nesting that occurs in south Brevard County, two leatherback (Dermochelys coriacea) clutches were deposited in the study area and one just beyond the northern boundary of the study area in 1985 (Ehrhart and Witherington 1987). Two more leatherback clutches were deposited in the study area in 1987 (Guseman, personal communication).

Reproductive Success

From 1985 through 1988 the locations of sample nests were marked throughout each season. The eggs in each sample clutch were counted either as they were being deposited by the female or by a careful inventory of the nest within 12 hours of deposition. The contents of each nest were reinventoried 60 days after deposition. The number of infertile or addled eggs, eggs containing partially developed embryos or fetuses, eggs containing hatchlings that died while pipping and hatchlings which had extricated themselves from their egg shells but died while still in the nest were counted. This number was subtracted from the total

number of yolked eggs in the clutch to obtain the number of hatchlings which had successfully emerged from the nest.

The mean emerging success for sample loggerhead clutches in 1985 was 63.6%; 58.8% for sample green turtle clutches (Ehrhart and Witherington 1987). For 1986, Ehrhart and Witherington (1986) reported mean emerging success for sample clutches to be 66.9% and 75.2% for loggerheads and green turtles, respectively. In 1987, the figures were 64.5% for loggerheads and 73.8% for green turtles (Ehrhart et al. 1987). For 1988, the sample loggerhead clutches had a mean emerging success of 56.8%; green turtle sample clutches had a mean emerging success of 54.6% (Ehrhart et al. 1988). Using a confidence level based on a students' t distribution, an overall average emerging success for sample loggerhead clutches is 62.95% ±6.9% (P = 0.05). For green turtles the overall average emerging success for sample clutches is 65.6% ±16.6% (P=0.05).

There are several variables which might affect the hatchling production of any given nesting beach for a given season. With this in mind, a rough estimate of the average seasonal production of hatchlings which successfully emerge from their nests in the south Brevard County study area was calculated by multiplying the overall mean clutch size (1985-1988) by the overall mean emerging success (1985-1988) multiplied by the mean number of clutches deposited (1982-1988). For loggerheads 116 x 63% x 9253 = an estimated 676,209 hatchlings. For green turtles 134 x 66% x 107 = an estimated 9,463 hatchlings.

DISCUSSION

The beaches along the southeastern coast of the United States provide nesting sites for one of Earth's two large aggregations of adult female loggerhead turtles (Ross 1982). Within the southeastern U.S., the greatest loggerhead nesting densities occur from Brevard County, Florida, south to Broward County, Florida (Hopkins and Richardson 1984). The beach included in the 21 km study area in south Brevard County has been shown to have the greatest density of loggerhead nesting in the southeastern U.S. and probably in the entire Western Atlantic. An average of 441 clutches of loggerhead eggs have been deposited on this beach per km during each of the past seven years. During an "average" year, approximately 675,000 loggerhead hatchlings enter the pelagic habitat from this beach. Unquestionably this beach is critically important to the recovery of the Western Atlantic population of this threatened species. Although green turtle nesting activity is much greater on many other beaches in the tropical regions of the world, this beach does provide nesting habitat for a significant number of "Florida green turtles," an endangered species in the United States.

The future of the south Brevard County beach as nesting habitat has to be questioned. Each successive year is marked by the construction of additional single family homes and condominiums within the study area. A proposed causeway linking this relatively isolated stretch of barrier island to the mainland would open to development the resort potential of the area.

It is reasonable to conclude as human population in the south Brevard area continues to increase, so will human activity on the beach at night. What impact will this activity have on marine turtle nesting?

The depredation of marine turtle nests by raccoons is also an increasing problem within the study area. Ehrhart and Witherington (1987) reported that 7% of the nests marked for reproductive success studies were partially or totally depredated by raccoons in 1985. In 1988, almost 19% of the nests marked for reproductive success studies were partially or totally depredated by raccoons (Ehrhart et al. 1988).

Perhaps the most serious long term threat to the nesting beach in south Brevard County is that of sea level rise and beach erosion. Several areas along the 21 km length of the beach have already experienced severe erosion in the past. If 'armoring' of the south Brevard County coast is allowed, it may eventually result in the loss of that stretch of dry sand above the mean high tide line so essential to marine turtle nesting. There is no dry beach at high tide in many other areas where armoring has already taken place. If this beach disappears because of human efforts to control erosion and protect beachfront property, what will be the fate of the loggerheads and green turtles that utilize the critical south Brevard County nesting habitat?

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DEMOGRAPHIC PATTERNS OF CARIBBEAN HAWKSBILLS, JUMBY BAY, ANTIGUA

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Recovery and management of an endangered species requires precise understanding of its population ecology. However, meaningful demographic studies of sea turtles take many years to complete because sea turtles are very long-lived animals. Caribbean hawksbills are particularly difficult to study; their low numbers, dispersed nesting beaches, and elusive nesting behavior account for the lack of population data available in the literature. This poster session presents preliminary (2 yr) results of a demographic study of nesting hawksbills at Jumby Bay (see Corliss et al. in these Proceedings).

METHODS

We use saturation tagging with intensive nighttime patrols to study nesting behavior (see Tucker in these Proceedings). During the 151 days of continuous patrol in 1988 (2 July - 29 November), only six of 156 nests (4%) on Pasture Bay beach (Jumby Bay, Antigua, West Indies) were discovered after the female had departed. This permits us to obtain an accurate measure of seasonal fecundity per turtle, arrival and departure of individual females at the nesting beach, and total stock numbers.

RESULTS

The primary nesting season runs from June through November, although occasional nesting occurs throughout the year. The 1987 season (Figure 1) started very late in June, peaked in September, and ended the middle of November. We gambled on a repeat of this behavior in 1988 and lost(!); there were at least 10 females active in June before the start of the survey on 2 July. This accounts for the abrupt start of nesting activity observed in Figure 2 (1988) which is, of course, an anomaly of our experimental design and not hawksbill behavior. Whereas 1987 nesting activity peaked in September, 1988 nesting activity was distributed rather evenly from July to November (Figure 2). The dramatic weekly modulation of numbers of active females in both 1987 and 1988 is apparently a random phenomenon induced by a precise 2-week internesting interval (Figure 3) and not an indication of group nesting behavior; the choice of a seven day interval of measurement is a human prerogative and not an attribute of turtle biology. The modal shift in the internesting interval from 14 days (1987) to 15 days (1988) has not yet been explained (Figure 3), but may be related to water temperature.

Because each turtle nests an average of five times per season (Figure 4) on two week intervals (Figure 3), the distribution of nesting activity during a 180-day season is determined by the initial arrival dates of individual females (Figure 5). Arrival rates for the 1987 nesting population accelerated in early July and again in early August and then decelerated for the rest of the season. As a result, the overall nesting rate in 1987 (Figure 6) peaked in September when a maximum number of females were active at the same time. In 1988, arrival rates accelerated in late June/early July and then again in September (Figure 5). Thus, it can be seen why the overall nesting rate in 1988 remained fairly steady from July to early November (Figure 6); the two largest groups of arriving turtles were separated by two months and, therefore, did not overlap their nesting activity.

DISCUSSION

We predict that the initial arrival times of nesting hawksbills at Pasture Bay beach may be largely random from June to September and, as a result, that the shape of a June-November nesting activity curve (Figure 6) will probably vary dramatically and unpredictably each season. The fewer the animals in the population, the more unpredictable will be the schedule of a nesting season; potential egg predators . . . take note!

Except for initial arrival time at the nesting beach, Jumby Bay hawksbills are highly regular and predictable. Individuals lay more clutches per season (±5) than we expected. Similarly, a lot of activity (156 nests during the 1988 survey) proved to be the effort of a relatively few animals (39 turtles). We estimate 40 actively nesting turtles and 190-200 nests for the 1988 calendar year at Pasture Bay beach. Stock assessment formulae that use less than 5 clutches per turtle are in danger of grossly overestimating total numbers of nesting females, the price to be paid for an inadequate sampling plan. We have much still to learn; additional studies of hatchling sex ratios and adult remigration intervals will begin in 1989. Estimates of recruitment and loss of adults to the Jumby Bay population will require 10 years of continuous surveys.

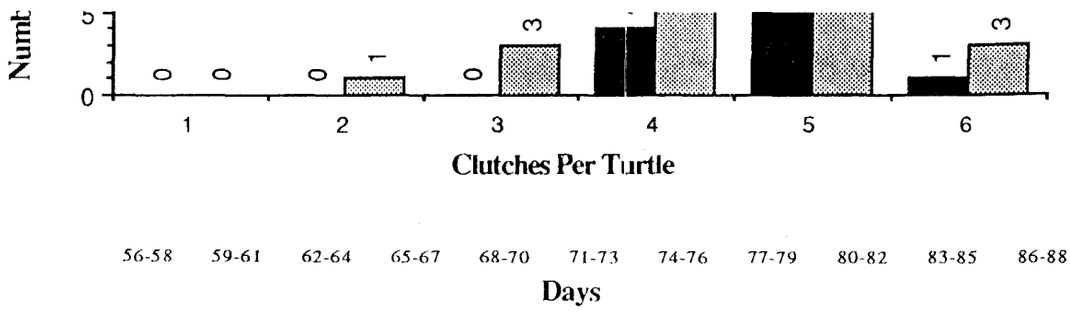


Fig. 1: Active Adult Females at Pasture Bay During Peak Nesting Season (1987)

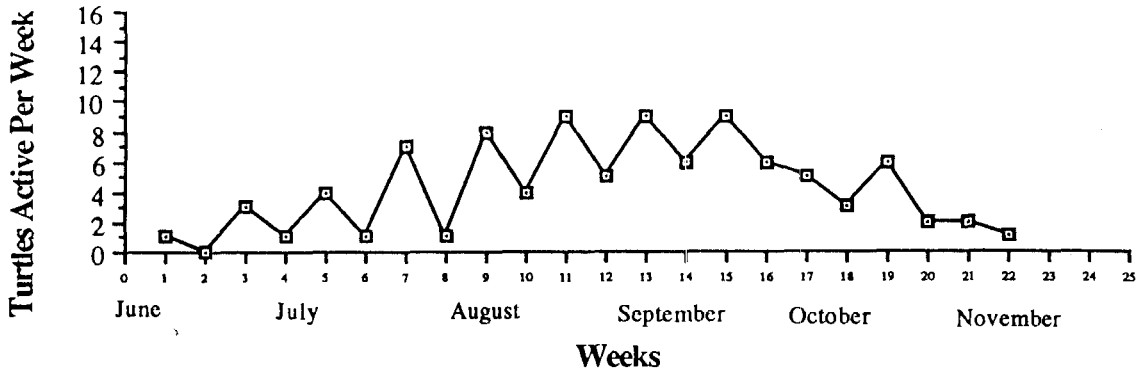


Fig. 2: Active Adult Females at Pasture Bay During Peak Nesting Season (1988)

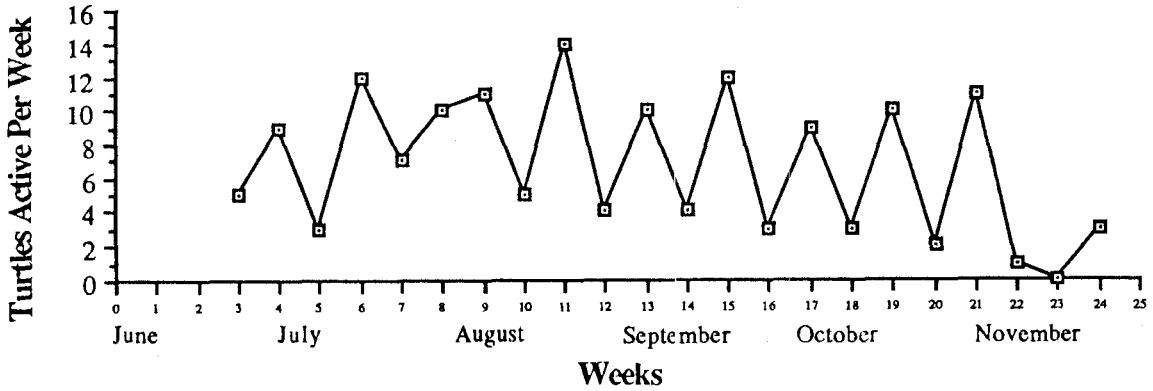


Fig. 3: Duration in Days Between Nesting Events

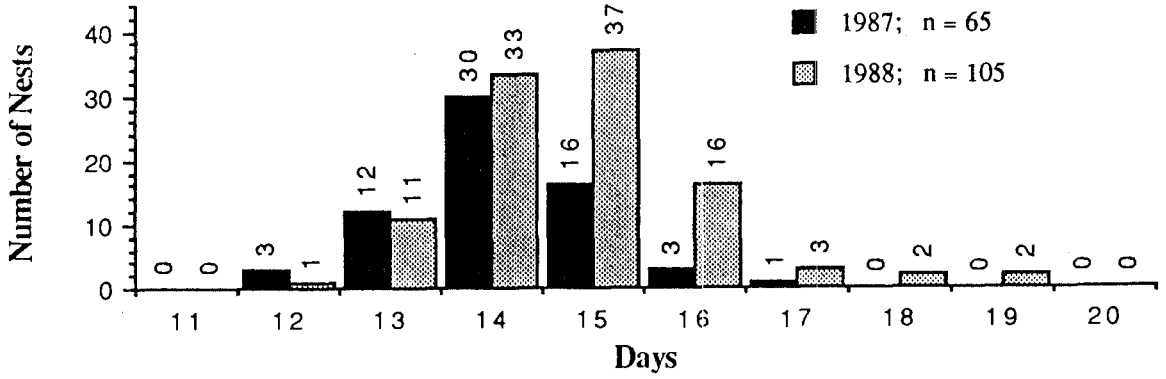


Fig. 4: Midseason Nests Per Turtle (Missing Intervals Filled) at Pasture Bay

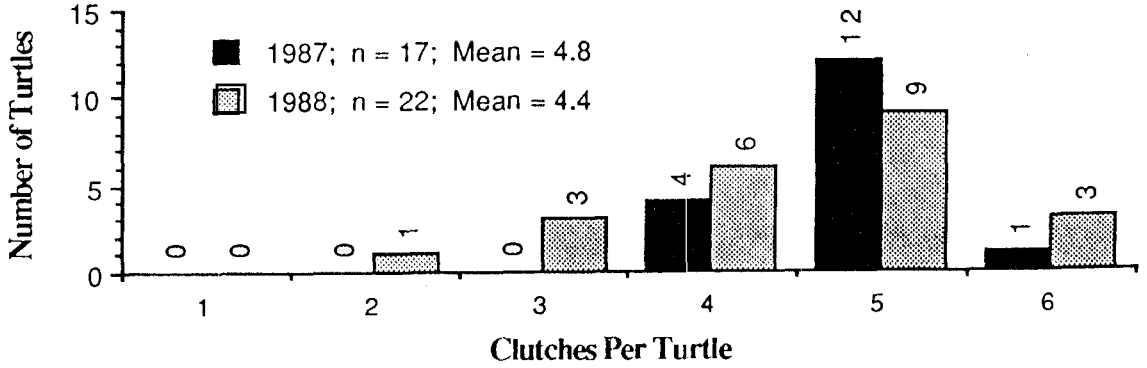


Fig. 5: Cumulative Adult Female Turtles in Pasture Bay Population During Peak Nesting Season

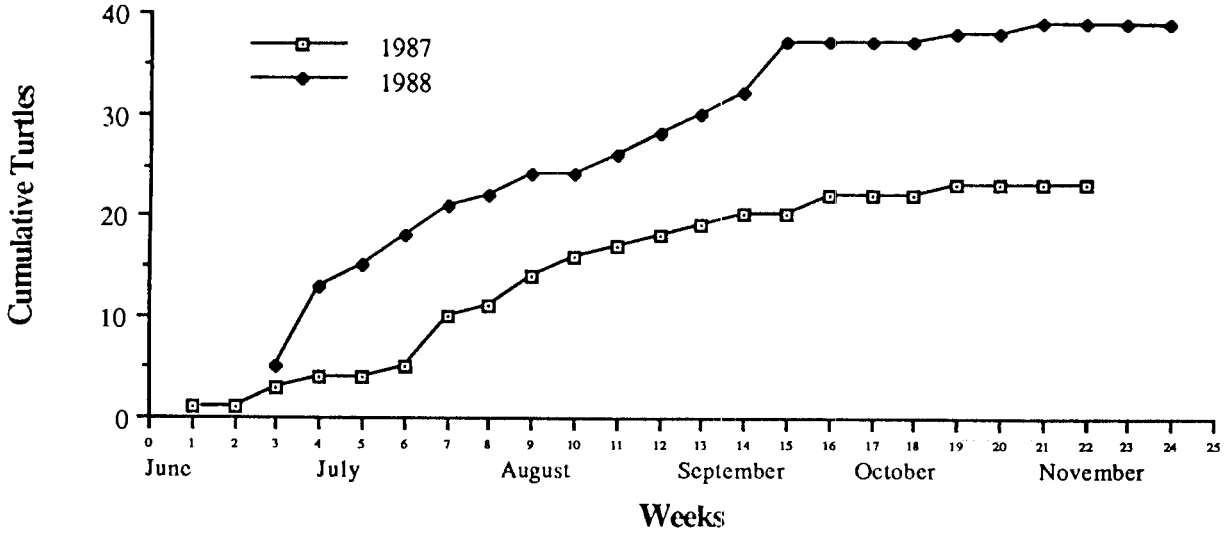


Fig. 6: Cumulative Nests at Pasture Bay During Peak Nesting Season

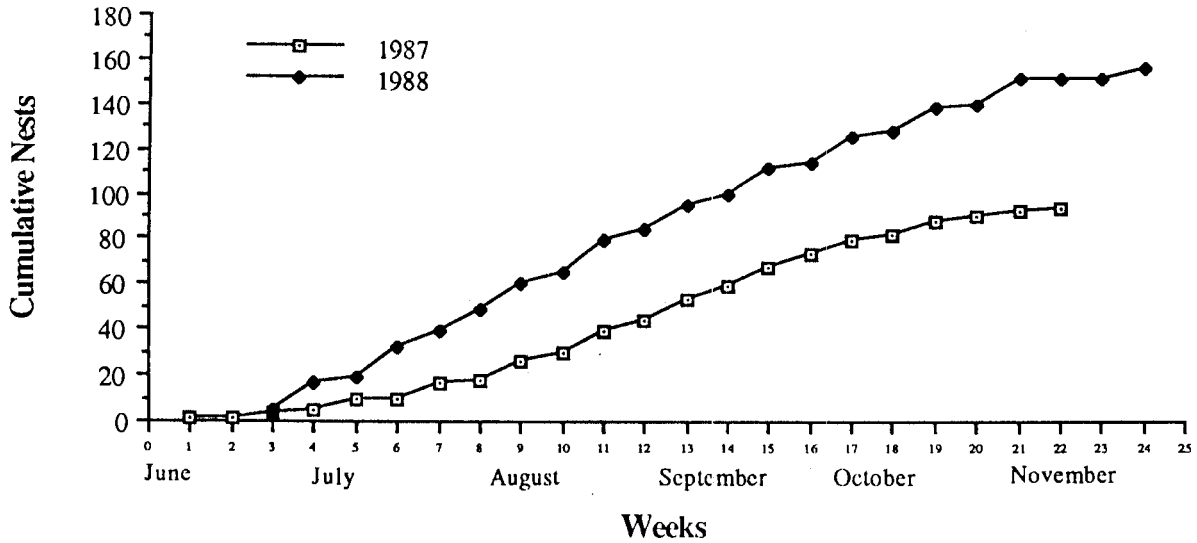
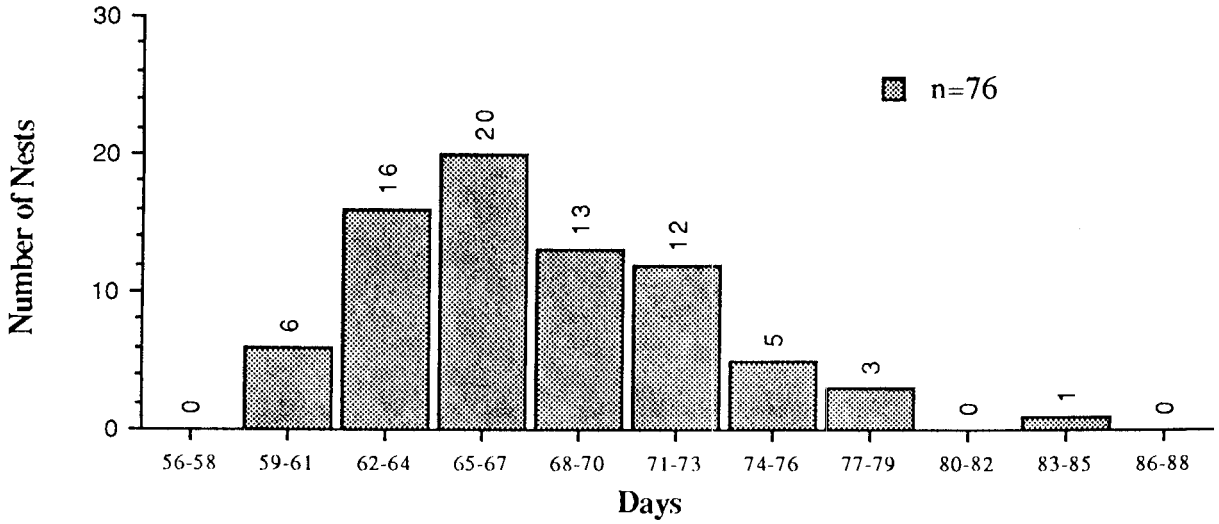


Fig. 7: Clutch Development Time (1988)



ULTRASONIC IMAGING OF OVARIES AND EGGS IN SEA TURTLES

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INTRODUCTION

The development of non-invasive and low risk techniques for studying the reproductive biology of sea turtles as well as other endangered species is a high priority. Radioimmunoassay techniques for measuring circulating hormone levels provide only part of the overall picture required to properly understand the reproductive systems of marine turtles. X-ray has long been available to detect the presence of eggs in turtles but it is cumbersome and ineffective for studying ovarian structures. The most effective technique to date for studying ovarian morphology has been laparoscopy. Laparoscopy, although very useful, does involve risk of injury or death to the animal and is considered an invasive technique. We have been developing the use of ultrasound techniques to improve our ability to monitor follicular development more accurately and at more frequent intervals, as well as for the detection of oviducal eggs. Ultrasound also reduces risk of injury to the turtles and has application towards monitoring general health of both captive and wild populations.

METHODOLOGY

Ultrasound units vary in their specific modifications but overall function is similar. The most important factors involved are the type of transducer and magnification capabilities of the unit itself. Transducers are available in varying wavelengths (2.5 to 7.5 MHz) and types (i.e., sector scanner). Depth of penetration is inversely related to the quality of resolution (i.e., 7.5 MHz probes have higher resolution quality but less penetration depth than a 2.5 MHz which has significantly greater penetration depth but less resolution). Lower wavelengths (2.5-3.5 MHz) are more suitable for larger species, such as green turtles and loggerheads, while higher wavelengths (5 MHz) are very effective for smaller species, such as Kemp's ridleys and hawksbills. The procedure involves turning the turtle over on its back and placing the probe tip against the inquinal region anterior to the hindlimb and scanning the available region. The ultrasound waves are unable to penetrate heavily keratinized shell or bone.

RESULTS AND DISCUSSION

We have so far been able to detect follicles in the three sea turtle species tested (Kemp's ridleys, hawksbills, and green turtles). In female Kemp's ridleys, we have been able to observe not only varying diameters of follicles (10-30 mm), but also eggs in the oviduct (Figures 1, 2). These observations have been validated through the use of laparoscopy and water bath comparison of fresh tissues.

The advantages of ultrasound over other techniques (i.e., laparoscopy) are numerous.

1) It is totally non-invasive and significantly lowers the risk to the turtles.

2) It allows accurate measurement of structures observed (i.e., follicles and eggs) and makes possible monitoring the turtles' condition at more frequent intervals without increasing the stress factor.

3) The procedure also is relatively quick (5-10 minutes per turtle, including handling) and requires no anesthesia of any sort.

ACKNOWLEDGEMENTS

We would like to thank Fred Chavez of Equisonic Inc. for his assistance. Our thanks are also extended to the Cayman Turtle Farm Ltd., Grand Cayman, Cayman Islands. Support was provided by Sea Grant College Program NA85AA-D-SG128 and Sea Turtles Inc.

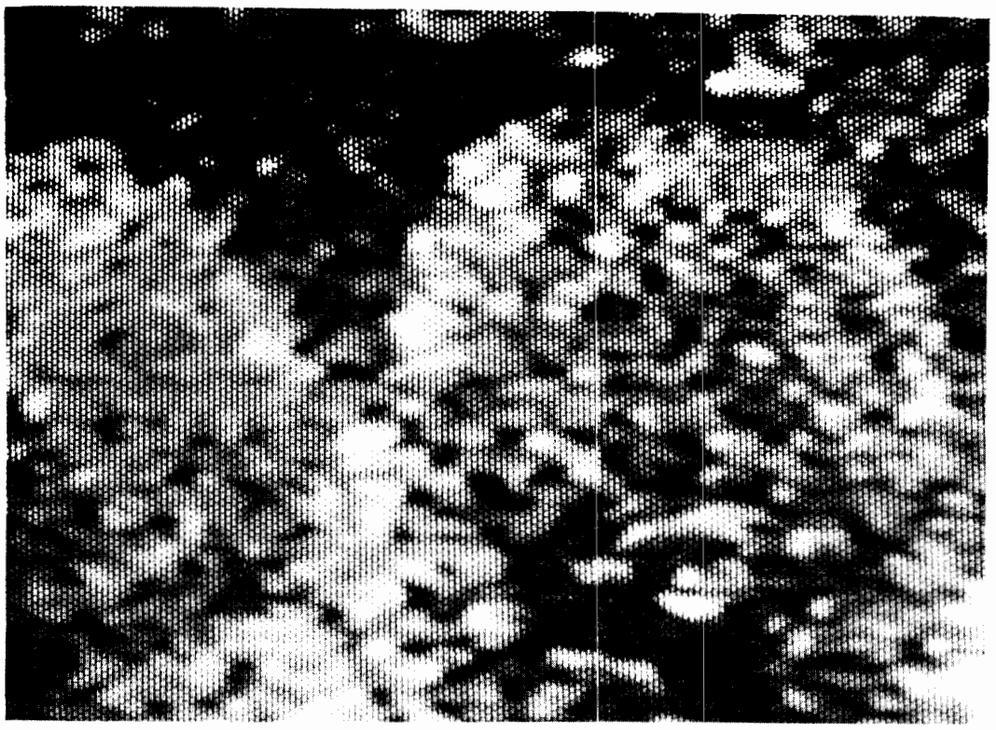


Figure 1. Ultrasonic image of a vitellogenic follicle (21 mm dia.) in situ from a Kemp's ridley.

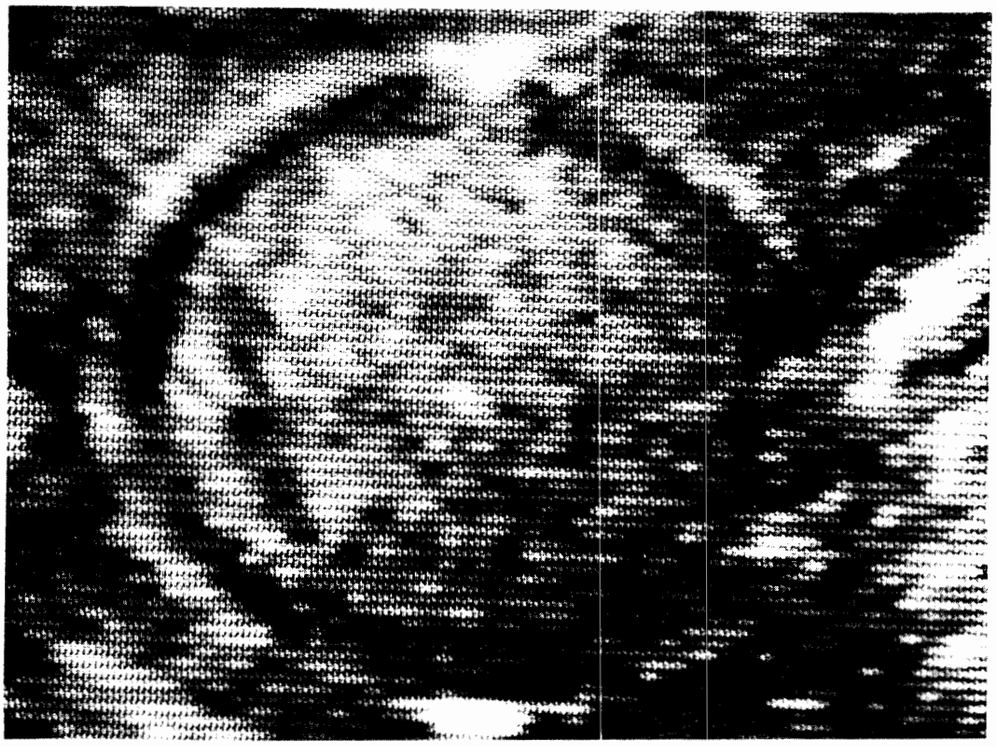


Figure 2. Ultrasonic image of an egg (38 mm dia.) in situ from a Kemp's ridley.

THE SEA TURTLE CENTER: AN EDUCATIONAL AND RESOURCE TOOL

Michael Rugge
Director, Sea Turtle Center, P.O. Box 634, Nevada City, California 95959 USA

The Sea Turtle Center is a non-profit organization created to support educational, conservation and research programs in the field. The principal Center concern is the protection of sea turtles and other endangered species around the world.

The Center was established as a resource tool for scientists who are unable to acquire current research publications in their fields of interest, and especially to support those operating on low budgets or no money at all for essentials such as postage, duplicating copies, or computer time. We are glad to support these activities, and to assist scientists (especially in Mexico) in their efforts to keep abreast of new information as it becomes available.

Our Newsletter is free to all interested persons who feel a need to be in communication with the world. The Center has acknowledged those scientists who have responded to our requests for up-to-date information to share with other researchers in the field and with our members.

This year the Director of the Center was not only able to attend the 9th Annual Sea Turtle Workshop himself, but was also able to sponsor Laura Sarti, Director of the conservation program in Mexiquillo, Michoacan, working with Dermochelys and Lepidochelys. This was a tremendous opportunity for Laura to present her data and inform the scientific community of her efforts in Mexico (see Sarti et al., this volume).

The Center places strong emphasis on education here in the United States and also in Mexico. Our slide show programs on Sea Turtles and Endangered Species have been well received by all ages and societies. Our broader goals are to contribute to the study of sea turtles in Mexico and throughout the world. We will accomplish these goals with direct action, support and volunteer programs. We are also planning to publish data as it becomes available about the programs the Center supports. If you would like to become a member of the Center (and receive our Newsletter), please write to the Director at the address above. Thank you!

HABITAT PREFERENCE AND BEACH MANAGEMENT FOR NESTING HAWKSBILLS, JUMBY BAY, ANTIGUA, WEST INDIES

Cheryl Ryder
James I. Richardson,
Lynn A. Corliss
Rebecca Bell
Georgia Sea Turtle Cooperative, University of Georgia, Athens, Georgia 30602 USA

Protection and management of nesting beaches is crucial to the recovery of the endangered Caribbean hawksbill. The needs of man and turtle are too often mutually exclusive, and the turtle is coming up the loser. This poster session reports on an exciting research and management program to integrate critical beach habitat needs for hawksbills with man's economic development needs on a resort island near Antigua. The Jumby Bay hawksbills (see Corliss et al. and Richardson et al. in these Proceedings) represent an extremely important nesting population of Caribbean sea turtles whose welfare has now become a top management priority for the resort.

Pasture Bay beach has approximately 1700 feet (=510 m) of utilizable nesting habitat and an additional 450 feet (=135 m) of pasture-fronted beach degraded many years ago by previous owners and now unusable for nesting. Within recent memory, the majority of Pasture Bay beach was a complex thicket of open sand patches, seagrape (Cocoloba uvifera), salt shrub (Suriana maritima), and a variety of other native woody shrubs and trees. Intensive raking for aesthetic purposes has now opened much of the beach in various ways, such that there are five beach types (Table 1) that offer a combination of nesting habitat types for the hawksbills. The differing response of the turtles to the five habitat types is the essence of our research design.

Nesting is distributed discontinuously along the beach (Figure 1), such that various habitat types have very different importance values (Table 1). Mixed shrub thicket with a narrow berm (Section 1) and scattered "islands" of mature seagrape leading to the water's edge (Section 4) are preferred habitats. As the shrubbery setback increases (Sections 2, 3), the importance value drops off (Table 1), even though these sections are backed by excellent nesting habitat. Since the frequency of false crawls (0.53 per successful nesting crawl) is low and distributed evenly among beach types (Sections 1-4), the management challenge is to entice the turtle onto the beach. Once on the beach, a hawksbill will search persistently for an adequate nest site and will usually locate some vegetative cover into which she will crawl several meters to place the nest (Figure 2). Occasionally a turtle will nest in the open (Figure 2). Hatching success is high (>80%) across all beach types at Pasture Bay.

In shrub thicket (Section 1), where the distribution of plants does not affect turtle movement, the preferred distance from mean high water for nests was 4-6 m (Figure 3). Thus, a 10 m band of persistent vegetation would provide adequate nesting habitat if its proximity to the water made it accessible. The discontinuous array of seagrape "island" clumps in Section 4 induces a more even nest distribution which does not reflect a normal behavioral preference by the turtle (Figure 4). Within this section, turtles most often choose to emerge where vegetation is closest to the water's edge (Figure 5) and follow a chain of shrub "islands" to an acceptable nesting site. Since the decision to emerge is the most important factor in nesting success, a study is underway of ambient darkness and horizon height at the water's edge and offshore, as these parameters affect nesting behavior.

Pasture Bay beach is degrading slowly because of raking and beach cleaning. The finite supply of sand is being wind blown to a shrub line too far away from the water for acceptable nesting habitat. A steep, vegetated berm is being replaced by a low, flat beach without vegetation. Where the sand has been eroded at the water's edge, patches of flint cobbles and limestone reef-rock are being exposed. Remaining trees are becoming isolated on pedestals of sand, as the surrounding sand is being removed by wind. A single tree in sector 15 close to the water's edge is all that is left in the area of wide beach habitat (Section 3) to

attract turtles out of the water; its loss will render Section 3 almost unusable for nesting. Remaining patches of vegetation are beginning to receive too much nesting use, as nests are disturbed by other nesting turtles. Luckily, the problems have been identified, and Jumby Bay intends to rebuild and protect the beach for their hawksbills. Replanting will stop wind erosion, and sand can be replenished from other sources. Properly placed seagrape clusters can lead hawksbills to preferred nesting habitat in a stepwise fashion. A steep, vegetated berm will provide a magnificent private swimming beach for guests and a quality nesting beach for turtles. Homes are being placed back from the beach, with lights screened by vegetation. There are plans to convert the additional 450 feet of unusable cobble beach into usable nesting habitat. Jumby Bay is on the road to becoming a prototype of recreation, industry, and endangered species management working in harmony. The time is none too soon for Caribbean hawksbills!

Table 1: Beach characterization, nesting frequency (1987 + 1988), and habitat importance values for various sections of Pasture Bay beach, Jumby Bay, Antigua.

Section	Beach Type	Sector	Approx. Length	Total Nests	Nests per 10'	Importance value	Shrubbery setback
1	Mixed shrub	23-31	460'	86	1.87	4.7	0-4m
2	Narrow beach	17-22	320'	37	1.16	2.9	10-20m
3	Wide beach	10-16	400'	32	.80	2.0	30-40m
4	Sea-grape	4-9	360'	96	2.67	6.7	variable
5	Lawn	1-3	150'	6	.40	1.0	>100m

Fig. 1: Nest Concentration by Beach Sector (1987 + 1988)

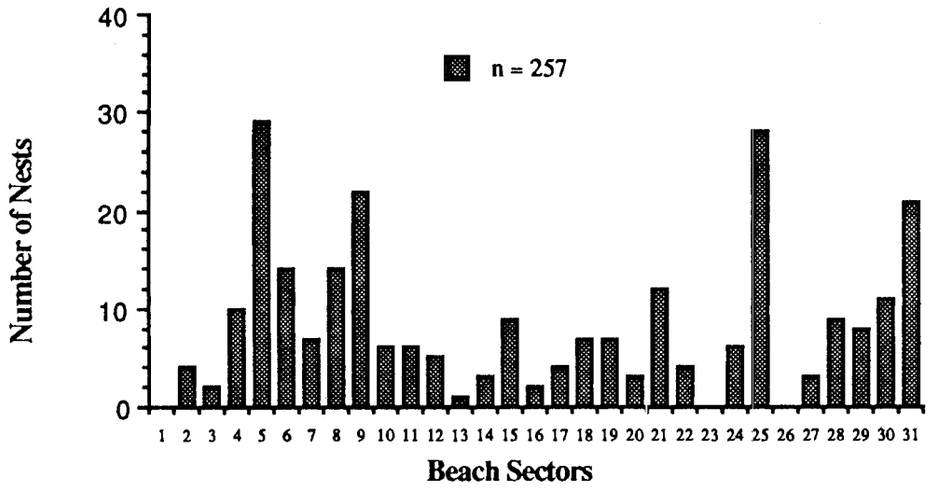


Fig. 2: Distance of Nests from Edge of Vegetative Cover

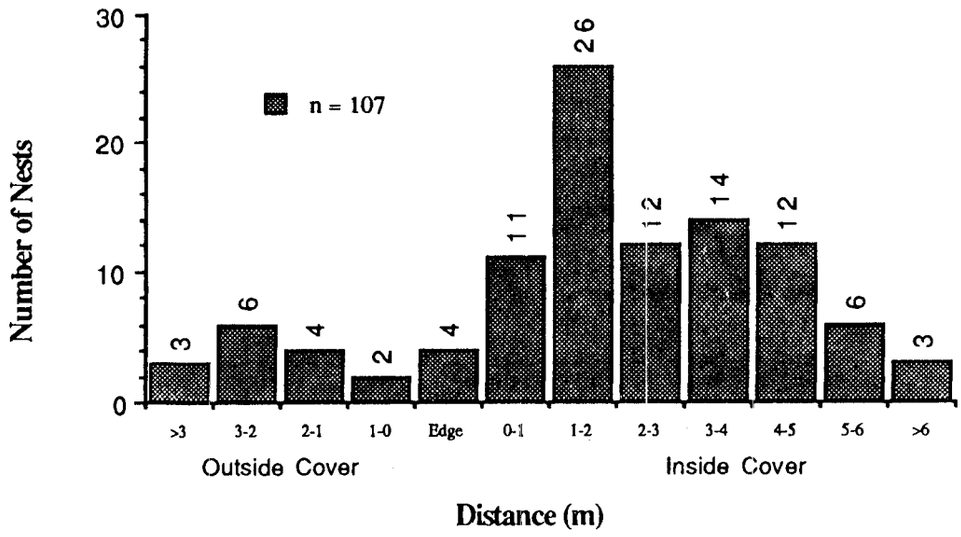


Fig. 3: Nest Distance Above High Water Line: Mixed Shrub Habitat

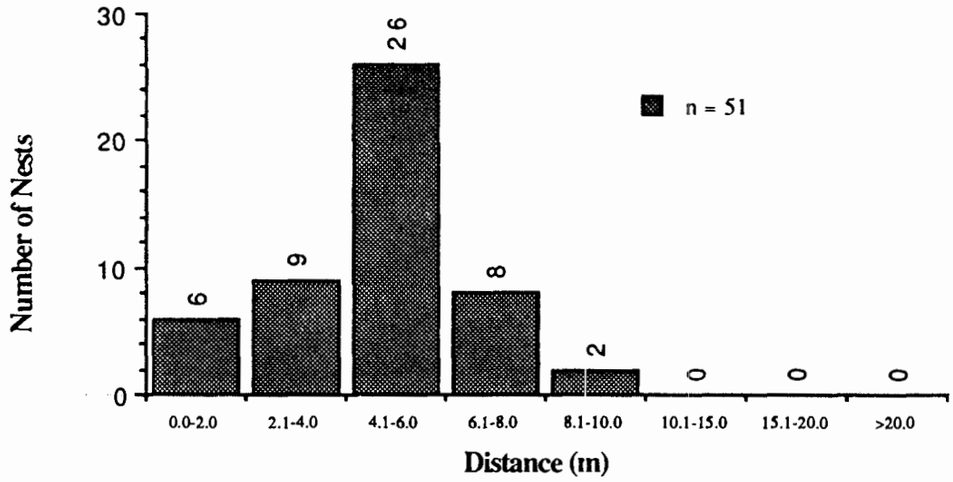


Fig. 4: Nest Distance Above High Water Line: Seagrape Clump Habitat

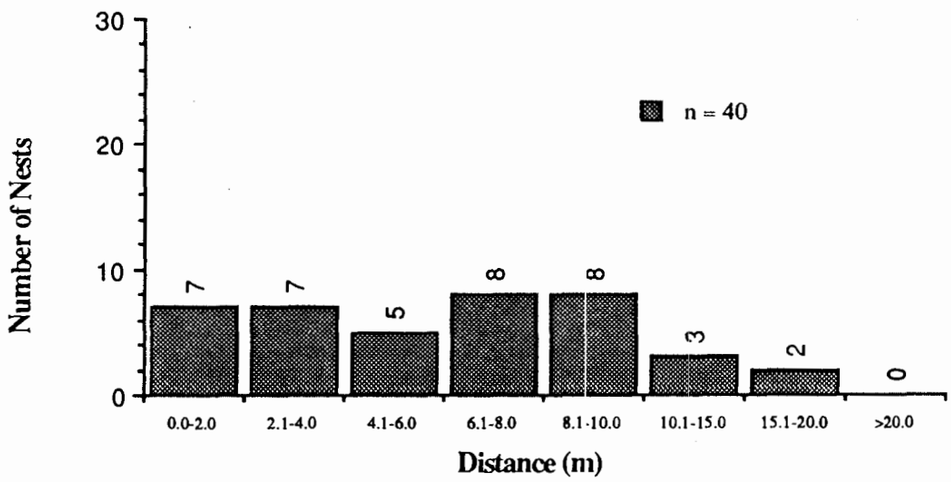
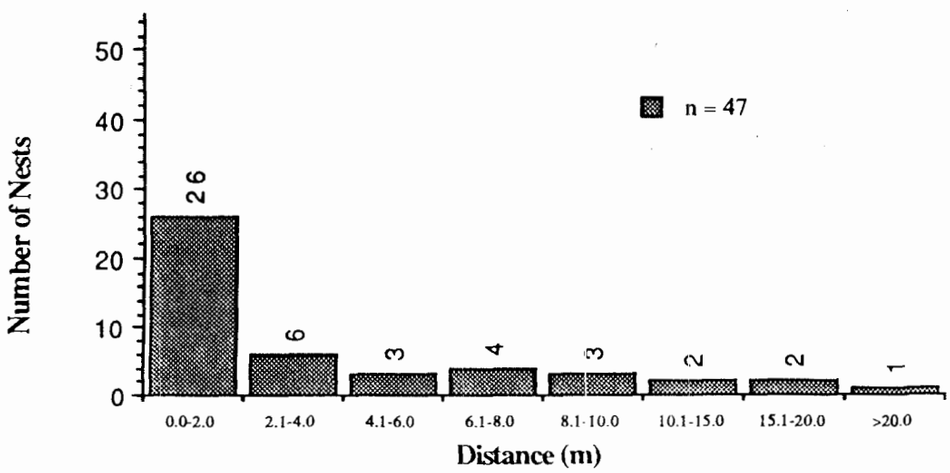


Fig. 5: Open Terrain: High Water Line to Cover: Seagrape Clump Habitat



TAGGING OF ADULT FEMALE LOGGERHEADS ALONG THE SOUTHWEST COAST OF FLORIDA

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In the past, extensive tagging studies have been conducted on sea turtles nesting on the east coast of Florida; however, few comprehensive tagging studies have been conducted on sea turtles nesting on the southwest coast of Florida. In 1986, the Sarasota County Department of Natural Resources initiated a tagging study on Manasota Key, Florida, and in 1987 Mote Marine Laboratory began tagging sea turtles nesting on Casey Key, Florida. Both Keys are in Sarasota County. Through this tagging effort we are attempting to 1) determine sight tenacity among nesting females; 2) define seasonal nesting cycles; and 3) estimate nesting population size.

Over a three year period (1986-1988) on the two keys, a total of 304 turtles were tagged, 23% of which were resighted. Eighty-five percent (85%) of the turtles that were resighted returned to the same key on which they were tagged. There were seven turtles observed that had either been tagged in a previous year or had been tagged in another Florida county. Three females that were tagged in the Sanibel-Captiva area were observed on Manasota Key in 1986 (a distance of approximately 90 km). There were also 71 turtles sighted more than once; 60% of those were sighted twice (Figure 1).

Straight-line carapace length and width ranged from 72.0 cm-104.0 cm and from 60.0 cm-87.0 cm, respectively. Size ranges of turtles tagged on the two keys did not differ significantly, except in 1988 when turtles tagged on Casey Key were significantly larger than those tagged on Manasota Key (Figure 2). No relationship was observed between size of carapace and clutch size, or between size of carapace and percent hatchability.

Nesting intervals ranged between 10 and 13 days, with a median of 11 days (Figure 3). Nesting activity increased slightly during the last week in June and in mid-July (Figure 4).

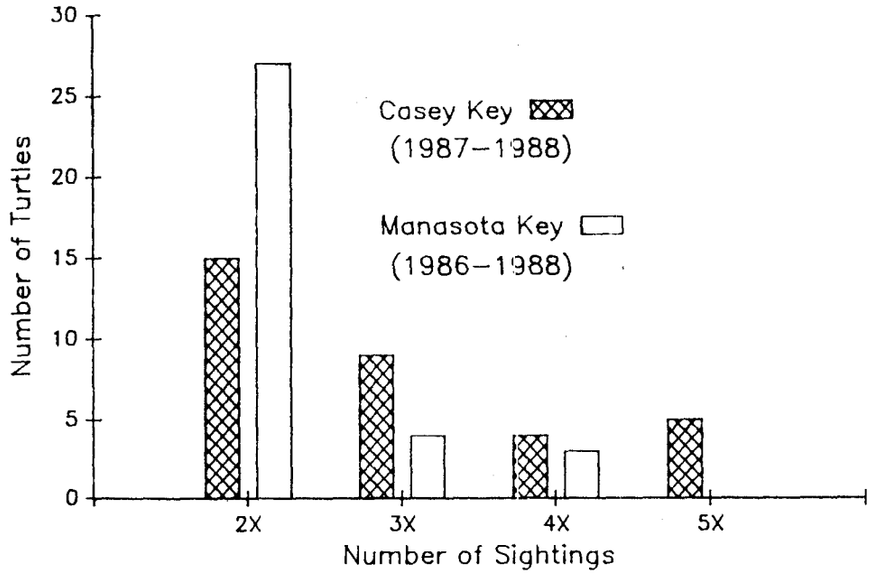

Figure 1. Number of turtles sighted more than one time for Casey and Manasota Keys, FL (1986–1988).

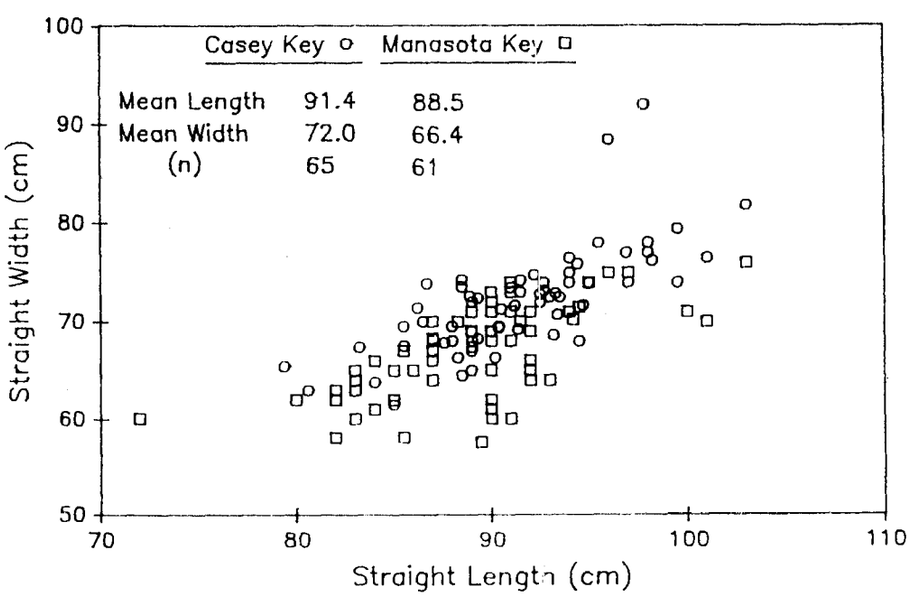

Figure 2. Straight line carapace lengths and widths for turtles tagged on Manasota and Casey Keys, FL (1988).

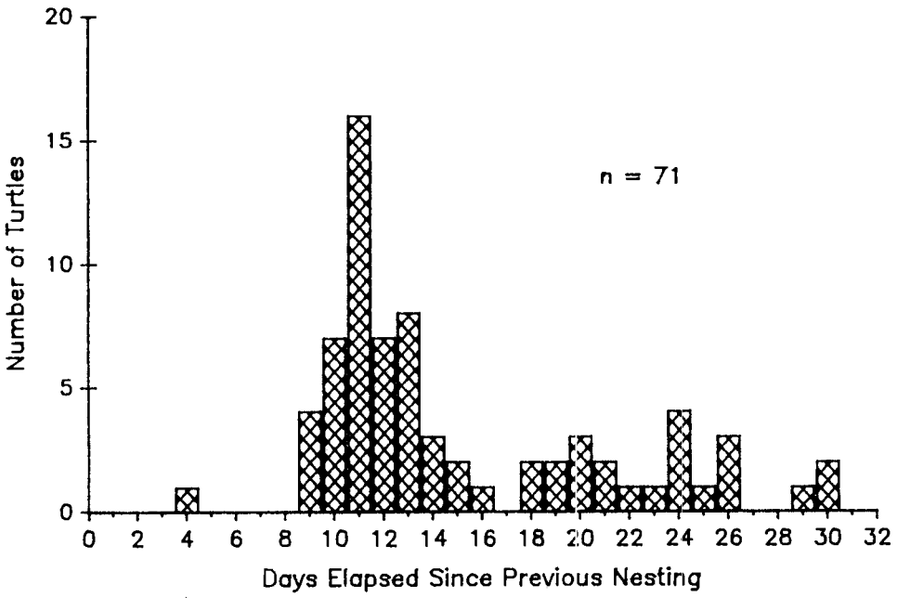

Figure 3. Number of days between nestings for turtles tagged on Casey and Manasota Keys, FL (1986–1988).

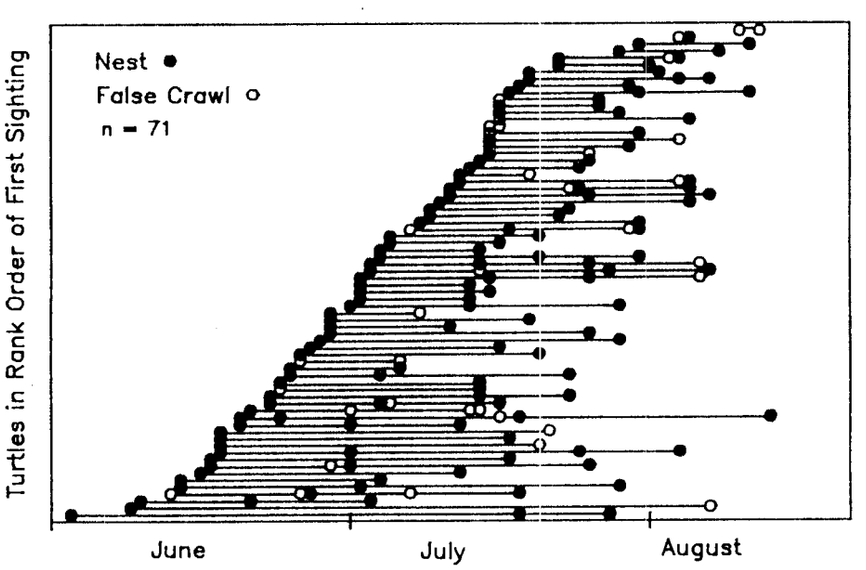

Figure 4. Nest and false crawls for each turtle tagged on Casey and Manasota Keys, FL (1986–1988).

SKELETOCHRONOLOGICAL AGE ESTIMATES FOR JUVENILE LEPIDOCHELYS KEMPII FROM ATLANTIC COAST OF NORTH AMERICA

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Heather J. Kalb
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Kemp's ridleys are the smallest living sea turtles; adults average 646 mm in carapace length (range 595-750 mm). This small adult size suggests that these turtles attain sexual maturity at a younger age than any of the other living sea turtles. Data on growth rates of recaptured nesting females and of captive-raised hatchlings provide variable estimates of age at sexual maturity: 5.5 years (Márquez 1973), ≈6 years (Pritchard and Marquez 1973), and 8-9 years (Márquez et al. 1981). The salvage of juvenile ridleys from the eastern seaboard of the United States (Long Island, Chesapeake Bay, Cumberland Island) provided an opportunity to use the skeletochronological technique to estimate the ages and to develop growth curves for free-living Lepidochelys kempii.

MATERIALS AND METHODS

Bone sections were removed from the middle of the humeral shaft and prepared both as thin (0.5 mm) and histological (8 um, hematoxylin stained) sections. The diameters of the periosteal layers and the resorption core were measured on the short- and long-axis of each section (n=30), independently by the two investigators. Age estimates were made by assigning the smallest remaining periosteal diameter of a section to an appropriate growth-layer class (Table 1), thus subsequent diameters of that section fell sequentially into adjacent and ascending classes. The age estimate derives from the class in which the outside diameter of the section falls. We make the usual skeletochronological assumption that one growth layer equals one year of growth. Statistical tests and growth curve equations derive from SYSTAT programs.

RESULTS AND DISCUSSION

Although the two data sets were obtained independently (short-axis by Kalb; long-axis by Zug), the bone sections examined and measured for each set derived from adjacent areas of the humeri. The age estimates for both sets were made following the same protocol (Table 1). The two data sets have different ranges (short, 1-6 years; long, 2-7 years) but similar means (3.3 ±1.38 years and 3.6 ±1.34 years, respectively). The means are not significantly different, and a comparison of the two sets (Wilcoxon matched-pairs sign-ranked test; T=53.5, df 17) also demonstrates that the two sets are not significantly different.

The juvenile turtles (253-433 mm sCL) range in estimated age from 1-6 years (short-axis; Figure 1A) and 2-7 years (long-axis; Figure 1B). The long-axis ages show greater variation relative to carapace length, but neither of the age sets show any distant outliers. Both sets also demonstrate that a 100 mm range of carapace length is common for most year classes, suggesting a wide variation in annual growth rates of individual turtles.

Both logistic and von Bertalanffy curves calculated from the skeletochronological age estimates possess asymptotic values (Table 2) that are not representative of carapace lengths at sexual maturity, hence these growth equations cannot be used to predict age of sexual maturity for free-living Kemp's ridleys. The inadequacy of the skeletochronological age-growth equations results from the limited age and size range of the sample. Older and larger individuals are required to produce asymptotes that realistically portray the average carapace length at sexual maturity. Although we are not yet able to predict accurately the age for sexual maturity, the data do indicate that Kemp's ridleys likely require more than ten years, perhaps more than 15 years, to attain sexual maturity.

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Márquez, R.M., A. Villanueva O., and M. Sanchez Perez. 1981. The population of the Kemp's ridley sea turtle in the Gulf of Mexico--Lepidochelys kempii, p.159-164. In: Karen A. Bjorndal (ed.), Biology and Conservation of Sea Turtles. Smithsonian Inst. Press, Washington D.C.

Pritchard, P.C.H. and R. Marquez. 1973. Kemp's ridley turtle or Atlantic ridley, Lepidochelys kempi. IUCN Monogr. 2:1-30.

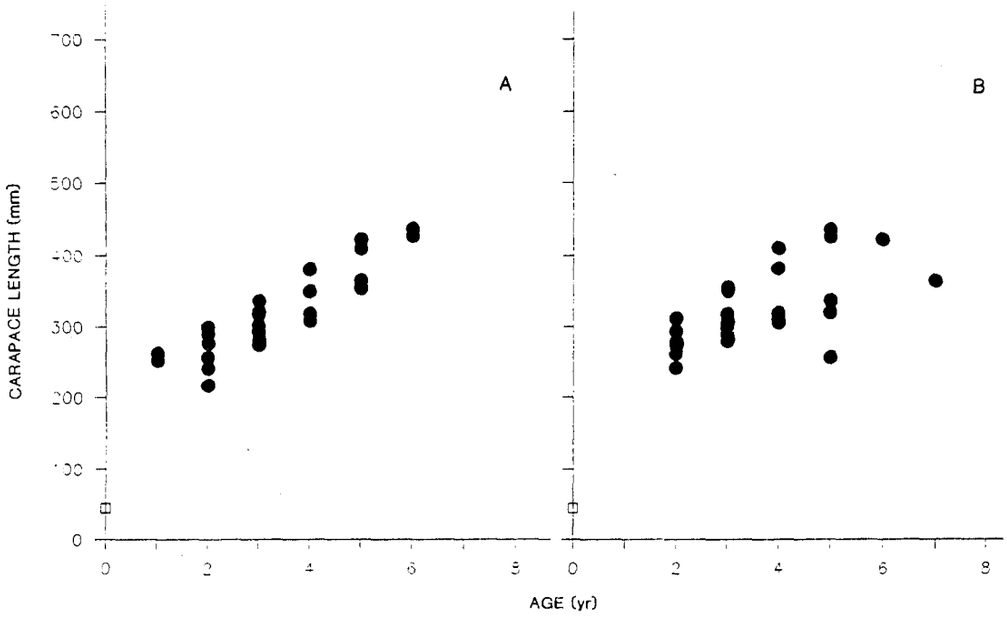

Figure 1. The relationship of estimated ages (yr) to carapace lengths (mm, sCL) in the short-axis (A) and long-axis (B) data sets.

Table 1. *Selected examples of the growth-layer class ranking chart (long-axis diameters) and the ranking protocol.*

ID	Diameters (mm) Bone Resorptn Core	Periosteal Layers or Rings 1	2	3	4	5	6	7	Age (yr)
221767	00.8	hatchling							0
117049	03.5	.	10.9	.	.	.	.	.	2
285151	03.6	7.1	08.1	10.6	.	.	.	.	3
227690	03.9	.	12.3	12.7	.	.	.	.	3
235604	03.9	6.6	11.7	.	.	.	.	.	2
285153	04.4	.	08.7	09.5	09.9	10.6	.	.	5
285142	04.5	.	08.2	09.7	13.7	.	.	.	4
285144	04.5	5.2	08.3	.	.	.	.	.	2
285143	05.4	.	11.6	.	.	.	.	.	2
285147	06.1	.	08.2	08.3	08.7	09.0	.	.	5
227689	06.2	.	08.4	10.7	.	.	.	.	3
285146	06.2	7.6	08.8	09.1	10.1	11.0	.	.	5
117047	06.7	.	12.8	15.1	.	.	.	.	3
235598	08.0	.	08.4	09.7	09.9	12.3	.	.	5
227696	08.5	.	.	11.2	17.0	.	.	.	4
235605	09.3	.	.	10.6	14.9	18.3	.	.	5
235404	10.9	.	.	12.7	14.1	16.9	19.7	.	6
285140	12.5	.	12.9	14.2	15.4	15.9	16.1	16.3	7

RANKING PROTOCOL

1. By resorption core diameter.
2. Assign innermost periosteal layer to lowest class; diameters of resorption core and innermost periosteal layer are used to determine class assignment of specimen. Core diameter of specimen suggests the number of periosteal layers resorbed and innermost layer diameter determines the lowest class through its diameter lying within this class's range as determined by preceding assigments. Hypothesized range of first periosteal layer diameter is 3.0-7.6 mm.

Table 2. *Comparison of growth curve parameters for four Kemp ridley age and data sets.* Age (yr, X) and size (mm sCL, Y). Data sets are: Marquez, 1972: table 2; Marquez, 1972:table 2 & fig. 3 combined; Kalb's short-axis age estimates; Zug's long-axis age estimates.

	A	B	k
Logistic			
Marquez	414.8 (45.99)	6.510 (0.818)	1.156 (0.158)
Marquez combined	700.0 (16.46)	7.047 (0.598)	0.623 (0.036)
Short-axis	3.0×10^{12}	1.41×10^{10}	0.188
Long-axis	408.8 (103.56)	1.166 (0.679)	0.438 (0.542)
von Bertalanffy			
Marquez	699.3 (396.7)	-	0.266 (0.166)
Marquez combined	1010.2 (86.08)	0.975 (0.012)	0.135 (0.020)
Short-axis	403.4 (27.88)	-	0.533 (0.101)
Long-axis	377.4 (22.56)	-	0.613 (0.120)

APPENDIX I: AGENDA DOCUMENT

Host

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Sandy Green
Ruth Ellen Klinger
Lloyd Logan
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Steve Owens
Jim Richardson
Thelma Richardson
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Fred Smith
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Special Thanks To:
Institute of Ecology, University of Georgia
Marineland of Florida
Jekyll Island Authority
Georgia Department of Natural Resources
(Coastal Resources Division)
University of Georgia's Marine Extension Service

Art for Agenda cover and Workshop T-shirt
provided by Lloyd Logan

Agenda booklet design and layout by Saundra G. Green

Ninth Annual Sea Turtle Workshop

Agenda

Tuesday, 7 February 1989

4:00-9:00 p.m.	Registration, Conference Center, Villas by the Sea, Jekyll Island, Georgia.
6:00-11:00 p.m.	Informal social. Light fare and beverages available. Oglethorpe Condo, Villas by the Sea.

Wednesday, 8 February 1989

7:30 a.m.-11:00 p.m.	*Poster Sessions Open, Conference Center.*
8:00 a.m.-12:00 Noon	*Registration, Conference Center.*
8:10 a.m.-6:00 p.m.	*Technical Sessions, Conference Center.*
1:00-6:00 p.m.	*Late Registration, Oglethorpe Condo. Villa number to be announced.*
6:00-8:00 p.m.	*Dinner Break*
6:00 p.m.-1:00 a.m.	*Informal Social, Oglethorpe Condo. Additional activities to be announced.*
9:00-11:00 p.m.	*Audio-visual Presentations, Conference Center.*

8:10 a.m. ***Welcome*, James I. Richardson** (Georgia Sea Turtle Cooperative), Host.

Technical Session I: Your Tax Dollars at Work

8:25 a.m.	Session Introduction - **Blair Witherington**, Chair.
8:30 a.m.	**Richardson, G.E.** (Minerals Management Service). Sea Turtles and Structure Removals in the Gulf of Mexico.
8:45 a.m.	**Lohoefener, R., W. Hoggard, K. Mullin, C. Roden, and C. Rogers** (NOAA/NMFS). Do Sea Turtles Associate with Oil Platforms in the Northern Gulf of Mexico?
9:00 a.m.	**Gitschlag, G.R., E.F. Klima**, and **M.L. Renaud** (NOAA/NMFS). Sea Turtles and the Explosive Removal of Offshore Oil Platforms.
9:15 a.m.	**Kendall, D.** (Univ. of Georgia Marine Extension Service). TED Testing in the Southeast.
9:30 a.m.	**Klima, E.F., M.L. Renaud**, and **G.R. Gitschlag** (NOAA/NMFS). Evaluation of Commercial Use of TEDs.
9:45 a.m.	**Mitchell, J.F., R. Lohoefener**, and **J.W. Watson** (NOAA/NMFS). A Method for Evaluating the Exclusion of Juvenile Sea Turtles from Turtle Excluder Devices.

10:00 a.m. **Wolf, R.E.** (City of Boca Raton, Environmental Div.). Boca Raton Sea Turtle Protection Program - 1988 in Conjunction with the North Beach Nourishment Project.

10:15 a.m. **Nelson, D.A., and D.D. Dickerson** (Waterways Experiment Station). Effects of Beach Nourishment on Sea Turtles.

10:30 a.m. ***Break***

Technical Session II: International Initiatives

10:55 a.m. Session Introduction - **Rod Mast**, Chair.

11:00 a.m. **Canin, J.** (Greenpeace). International Trade in Sea Turtle Products.

11:15 a.m. **Donnelly, M.** (Center for Marine Conservation). International Trade in Hawksbill Shell in the Wider Caribbean.

11:30 a.m. **Blanco-Castillo, Y.** (Greenpeace). The Importance of CITES for the Protection of Sea Turtles.

11:45 p.m. **Pinto-Rodríguez, B.** (CHELONIA, *Puerto Rico Herpetological Society*). Sea Turtle Recovery Action Plan for Puerto Rico-WIDECAST.

12:00 Noon **Richardson, J.I., and K.L. Eckert** (WIDECAST). WIDECAST: Implementation of a Caribbean Initiative.

12:15 p.m. **Berry, F.** (Heliconiaceae). WATS III, STAO III: Where Do We Go From Here?

12:30 p.m. <u>**Panel: International Initiatives**</u>
Georgita Ruiz, Chair.

1:00 p.m. ***Lunch Break***

Technical Session III: Kemp's Ridley Update

2:25 p.m. Session Introduction - **Rafe Boulon**, Chair.

2:30 p.m. **Ruiz, G.** (PRONATURA - Asoc. Mexicana Proconservación de la Naturaleza, A.C. and WIDECAST). The Kemp's Ridley Conservation Project in Tecolutla, Veracruz.

2:45 p.m. **Márquez M., R.** (Proyecto Tortugas Marinas, CRIP). Facts about Reproduction of the Kemp's Ridley Sea Turtle.

3:00 p.m. Cancellation

3:15 p.m. **Shaver, D.J.** (Padre Island National Seashore). Results from 11 Years of Incubating Kemp's Ridley Sea Turtle Eggs at Padre Island National Seashore.

3:30 p.m. **Rudloe, A., J. Rudloe, and L. Ogren** (Gulf Specimens Marine Laboratory Inc.). Populations of Atlantic Ridley Sea Turtles (*Lepidochelys kempi*) in Apalachee Bay, Florida Coastal Waters.

3:45 p.m. **Byles, R.** (U.S. Fish and Wildlife Service, Endangered Species). Satellite Telemetry of Kemp's Ridley Sea Turtles.

4:00 p.m. ***Break***

Technical Session IV: Turtles at Sea (1)

4:25 p.m. Session Introduction - **Charles Tamblah**, Chair.

4:45 p.m. **Margaritoulis, D.** (Admin. Council, Sea Turtle Protection Society of Greece) Conservation, Research, and Management of *Caretta caretta* on the Greek Islands of the Mediterranean.

4:30 p.m. **Wershoven, B.W.**, and **J.L. Wershoven** (Broward County Audubon Society) Assessment of Juvenile Green Turtles and Their Habitat in Broward County, Florida Waters.

5:00 p.m. **Limpus, C.J.** (Queensland Turtle Research Project, IUCN, SSC Marine Turtle Specialist Group). Forage Ground Fidelity Following Breeding Migrations in *Caretta*.

5:15 p.m. **Morgan, P.J.** (National Museum of Wales). *Dermochelys coriacea* in British Waters 1988.

5:30 p.m. **Schoelkopf, R.J., J.R. Spotila**, and **F.V. Paladino** (Marine Mammal Stranding Center, Brigantine, N.J.). Sea Turtles of New Jersey: Where are the Ridleys?

5:45 p.m. **Keinath, J.A., R.A. Byles**, and **J.A. Musick**, (VIMS, College of William and Mary). Satellite Telemetry of Loggerhead Turtles in the Western North Atlantic.

6:00 p.m. ***Dinner Break***

8:00 p.m. Auction, Oglethorpe Condo. **Rod Mast**, Auctioneer.

9:00-11:00 p.m. Audio-visual Presentations, Conference Center.

Thursday, 9 February 1989

7:30 a.m.-11:00 p.m. — *Poster Sessions, Conference Center.*

8:10 a.m.-6:00 p.m. — *Technical Sessions, Conference Center.*

7:00 p.m.-10:00 p.m. — *Dinner Extravaganza, South Dunes Picnic Area, Jekyll Island. Tickets available at registration desk.*
Transportation to be arranged.

6:00 p.m.-1:00 a.m. — *Informal Social, Oglethorpe Condo.*

Technical Session V: Population Ecology

8:10 a.m. Session Introduction - **Karen Eckert**, Chair.

8:15 a.m. **Ernest, R.G., R.E. Martin, N. Williams-Walls**, and **J.R. Wilcox** (Applied Biology, Inc.). Population Dynamics of Sea Turtles Utilizing Shallow Coastal Habitats Off Hutchinson Island, Florida.

8:30 a.m. **Tucker, T.** (Georgia Sea Turtle Cooperative, Dept. of Zoology, Univ. of Georgia). So Many Sea Turtles, So Little Time: Underestimating Fecundity and Overestimating Populations?

8:45 a.m. **Bowen, B.W., A.B. Meylan**, and **J.C. Avise** (Dept. of Genetics, Univ. of Georgia). Population Structure and Evolutionary History of the Green Turtle, *Chelonia mydas*.

9:00 a.m. **Congdon, J.** (Savannah River Ecology Laboratory, Univ. of Georgia). Life History of Blanding's Turtle: A Model for Sea Turtles.

9:15 a.m. **Frazer, N.B.** (Biology Dept., Mercer Univ.). Nesting Cycles of Sea Turtles: Typical, But Not Cycles.

9:30 a.m. ***Break***

Technical Session VI: Physiology

9:55 a.m.	Session Introduction - **Scott Eckert**, Chair.
10:00 a.m.	**Witham, R., P. Lutz, G. Bossart**, and **S. Shaw** (RSMAS, Univ. of Miami). Effects of Artificial Food on the Health of Sea Turtles.
10:15 a.m.	**Kochinsky, L.** (Aqua-Med, Inc.). Sea Turtle Diseases Affecting Captive-raised Turtles.
10:30 a.m.	**George, R.** (VIMS, Dept. of Fisheries). Alphaxalone/Alphadolone and Ketamine HCL as Anesthetic Agents in the Loggerhead Sea Turtle (*Caretta caretta.*).
10:45 a.m.	**Neville, A., W.D. Webster**, and **W.B. Brooks** (Univ. of North Carolina - Wilmington). The Effects of Nest Temperature on the Duration between Pipping and Emergence in Hatchling Loggerhead Sea Turtles.
11:00 a.m.	**Limpus, C.** (Queensland Turtle Research Project, IUCN, SSC Marine Turtle Specialist Group). Environmental Regulation of Green Turtle Breeding in Eastern Australia.
11:15 a.m.	**Gouveia, J.F.**, and **W.D. Webster** (Univ. of North Carolina - Wilmington). The Timing of Sexual Differentiation in the Loggerhead Sea Turtle.
11:30 a.m.	**Wachtel, S.**, and **S. Demas** (OB-GYN/Univ. of Tennessee, Memphis). Sex-Specific DNA in the Sea Turtle.
11:45 a.m.	**Owens, D., T. Wibbels, C. Limpus**, and **D. Rostal** (Biology Dept., Texas A&M Univ.). Sea Turtle Reproductive Chronology: The Model and the Questions.
12:00 Noon	***Stretch Break***
12:10 p.m.	<u>Panel: Sex Determination</u> **Colin Limpus**, Chair.
1:00 p.m.	***Lunch Break***

Technical Session VII: Turtles on the Beach (1)

2:25 p.m.	Session Introduction - **Deborah Crouse**, Chair.
2:30 p.m.	**Martin, R.E., R.G. Ernest, N. Williams-Walls**, and **J.R. Wilcox** (Applied Biology, Inc.). Long-term Trends in Sea Turtle Nesting on Hutchinson Island, Florida.
2:45 p.m.	**Alvarado, J.**, and **A. Figueroa** (Universidad Michoacana). Breeding Dynamics of the Black Turtle (*Chelonia agassizi*) on the Coast of Michoacan, Mexico.
3:00 p.m.	**Chaves Quirós, A.** (Organization for Tropical Studies, Univ. Costa Rica). Study of Marine Turtle Populations on the Pacific Coast of Costa Rica.
3:15 p.m.	**Hall, K.V.** (Univ. of Puerto Rico - Marine Sciences). Intraseasonal Variation of *Dermochelys coriacea* Reproductive Characteristics at Culebra, Puerto Rico.
3:30 p.m.	**Sarti M., L.**, and **M. Rugge**. (Universidad Nacional Autónomo de México, Sea Turtle Center). Sea Turtle Nesting at Coleta de Campos, Michoacan, Mexico.
3:45 p.m.	**Cancellation**
4:00 p.m.	***Break***

Technical Session VIII: Turtles on the Beach (2)

4:25 p.m.	Session Introduction - **Jeanette Wyneken**, Chair.
4:30 p.m.	**Horikoshi, K.** (Archie Carr Center for Sea Turtle Research). Egg Survivorship of Tortuguero Green Turtles (*Chelonia mydas*) During the 1988 Season.
4:45 p.m.	**Lara, X.** (Escuela de Biologia, Universidad de Costa Rica). Nesting Season of *Chelonia agassizi*.
5:00 p.m.	**Corliss, L.A.**, and **J.I. Richardson** (Georgia Sea Turtle Cooperative, Institute of Ecology, University of Georgia). Biology and Management of the Hawksbill Turtle (*Eretmochelys imbricata*), Jumby Bay, Antigua.
5:15 p.m.	**Kontos, A.R., M.A. Nieves**, and **W. Cardona** (Dept. of Zoology and Institute of Ecology, Univ. of Georgia). Nest Site Parameters of the Hawksbill Turtle (*Eretmochelys imbricata*) on Mona Island, Puerto Rico.
5:30 p.m.	**Possardt, E.E.**, and **D. Jackson** (U.S. Fish and Wildlife Service). Status of Proposed East-Central Florida Sea Turtle Refuge.
5:45 p.m.	**Agardy, T.** (Woods Hole Oceanographic Institute). What Information Is Really Critical to the Management of Sea Turtles and Why?
7:00-10:00 p.m.	***Dinner Extravaganza, South Dunes Picnic Area, Jekyll Island.***

Friday, 10 February 1989

7:30 a.m.-11:00 p.m.	*Poster Sessions, Conference Center*
8:10 a.m.-6:30 p.m.	*Technical Sessions, Conference Center.*
8:00-10:00 p.m.	*Audio-visual Presentations, Conference Center.*
6:30 p.m.-1:00 a.m.	*Informal social, Oglethorpe Condo.*

Technical Session IX: Turtles at Sea

8:10 a.m.	Session Introduction - **Robert Schoelkopf**, Chair.
8:15 a.m.	**Amos, A.A.** (University of Texas at Austin, Marine Science Inst.) The Occurrence of Hawksbills (*Eretmochelys imbricata*) on the Texas Coast.
8:30 a.m.	**Epperly, S.P.**, and **A. Veishlow** (NMFS/NOAA, Beaufort Laboratory). Description of Sea Turtle Distribution Research in North Carolina.
8:45 a.m.	**Knowlton, A.**, and **B. Weigle** (New England Aquarium). A Note on the Occurrence of Leatherback Turtles (*Dermochelys coriacea*) along the Florida Coast in February 1988.
9:00 a.m.	**Morreale, S.J., A. Meylan**, and **B. Baumann** (Oceanos Ocean Research Foundation). Sea Turtles in Long Island, New York: An Historical Perspective.
9:15 a.m.	**Standora, E., S. Morreale, R. Estes, R. Thompson**, and **M. Hilburger** (Biology Dept., State Univ. College, Buffalo, NY). Growth Rates of Juvenile Kemp's Ridleys and Their Movement in New York Waters.

9:30 a.m. **Burke, V.J., E.A. Standora, and S.J. Morreale** (Okeanos Ocean Research Foundation). Environmental Factors and Seasonal Occurrence of Sea Turtles in Long Island, New York.

9:45 a.m. **Plotkin, P.** (Univ of Texas at Austin-Marine Science Institute). Feeding Ecology of the Loggerhead Sea Turtle in the Northwestern Gulf of Mexico.

10:00 a.m. **Lutz, P.** (RSMAS, Univ. of Miami). Pollution: The Strange Story of Balloons and Sea Turtles.

10:15 a.m. ***Break***

Technical Session X: Orientation

10:40 a.m. Introduction to Session - **Joe Ferris**, Chair.

10:45 a.m. **Dickerson, D.D., and D.A. Nelson** (Waterways Experiment Station). Recent Results on Hatchling Orientation Responses to Light Wavelengths and Intensities.

11:00 a.m. **Nelson, D.A., and D.D. Dickerson** (Waterways Experiment Station). Management Implications of Recent Hatchling Orientation Research.

11:15 a.m. **Witherington, B.** (Archie Carr Center for Sea Turtle Research). Artificial Beach Lighting and the Seaward Orientation of Hatchling Loggerhead Turtles.

11:30 a.m. **Wyneken, J., and M. Salmon** (Dept. Ecology, Ethology, and Evolution, Univ. of Illinois). There is More to Orientation than Meets the Eye.

11:45 a.m. **Salmon, M., and K.J. Lohmann** (Dept. Ecology, Ethology, and Evolution, Univ. of Illinois). Loggerhead Hatchlings Use Surface Waves for Offshore Orientation.

12:00 Noon **Musick, J.A., J.A. Keinath, D.E. Barnard, V. Hutchinson, and R. DuBois** (Virgina Institute of Marine Science). The Effects of Electromagnetic Radiation on Biomagnetism in Diamondback Terrapin Hatchlings as Related to Sea Turtle Migration.

12:15 p.m. **Lohmann, K.J.** (Neural and Behavioral Biology Program, Univ. of Illinois). Magnetic Orientation by Hatchling Loggerhead Sea Turtles.

12:30 p.m. **Plenary Session: J.I. Richardson, R. Shoop, and F. Berry.**

1:00 p.m. ***Lunch Break***

Technical Session XI: Around the World

2:25 p.m. Session Introduction - **Tony Tucker**, Chair.

2:30 p.m. **Eley, T.J.** (Dept. of Geography, Univ. of West Florida). Sea Turtles and the Kiwai, Papua New Guinea.

2:45 p.m. **Tamblah, C.R.** (Center for Special Studies, Davidson College). Conservation of Sea Turtles in Sri Lanka.

3:00 p.m. **Rodriguez M., Stanley** (Costa Rica). Playa Grande Leatherback Conservation.

3:15 p.m. **Ross, J.P., and D. Carr** (Caribbean Conservation Corp.). Comprehensive Management Plan for Tortugero, Costa Rica.

3:30 p.m. **Solé, G., and G. Medina.** (FUDENA - Fundación para la Defensa de la Naturaleza, Venezuela). Ten Years of Monitoring Green Turtles (*Chelonia mydas*) at Aves Island, Venezuela.

3:45 p.m. **Pritchard, P.C.H.** (Florida Audubon Society). "Let the Fox Guard the Chickens." Sea Turtle Conservation in Guyana, 1988.

4:00 p.m.	**Lagueux, C.J.** (Archie Carr Center for Sea Turtle Research). Economic Analysis of Sea Turtle Eggs in a Coastal Community on the Pacific Coast of Honduras.
4:15 p.m.	**Cruz, G.** (Universidad de Tegucigalpa). The Impact of the Lobster Fleet in the Capture of Hawksbill Turtle in the Atlantic Coast of Honduras.
4:30 p.m.	***Break***

Technical Session XII: Stranding

4:55 p.m.	Introduction to Session - **Charles Maley**, Chair.
5:00 p.m.	**Wells, P.** (Florida Park Service-DNR, Save-A-Turtle, Inc.). Summary of nesting and stranding activity in the Florida Keys and Associated Waters--1980 to Present.
5:15 p.m.	**Booker, W.C.**, and **L.M. Ehrhart** (Univ. of Central Florida). Systematic Aerial Surveys of Marine Turtle Carcass Strandings in NMFS Zones 28 and 29; 11 August 1987 to 31 December 1988.
5:30 p.m.	**Heinly, R.W.** (Texas A&M Univ.). Size Distribution of Sea Turtles Along the Texas and Louisiana Coasts.
5:45 p.m.	**Schroeder, B.A.**, and **C.L. Maley** (Florida Department of Natural Resources). 1988 Fall/Winter Strandings Along the Northeast Florida-Georgia Coast.
6:00 p.m.	**Shoop, C.R.**, and **C. Ruckdeschel** (Dept. of Zoology, Univ. of Rhode Island, Cumberland Island Museum). Trauma to Sea Turtles Stranded on Cumberland Island, Georgia in 1986 and 1987.
6:15 p.m.	***Closing Remarks*** - **James I. Richardson.**
6:30 p.m.	***Dinner Break***
8:00-10:00 p.m.	Audio-visual Presentations, Conference Center.

Saturday, 11 February 1989

Early a.m.- 12:00 Noon	TED Demonstration aboard the *R.V. Georgia Bulldog*. Participation limited, sign-up at registration desk.
8:30 a.m.- 12:00 Noon	Necropsy Workshops.
8:30 a.m.- 12:00 Noon	Anatomy Workshops.
10:00-11:00 a.m.	Laparoscope demonstration, **Colin Limpus.**

Poster Sessions

Barnard, D.E., J.A. Keinath, and J.A. Musick (Virgina Institute of Marine Science). Distribution of Ridley, Green and Leatherback Turtles in Chesapeake Bay and Adjacent Waters.

Basford, S., and R.L. Brandner (N.Y. Zoological Society and V.I. Division of Fish and Wildlife). The Effect of Egg Relocation on Sex Ratios of Leatherback Hatchlings on Sandy Point, St. Croix.

Boulon, Jr., R.H. (Dept. of Planning and Natural Resources, V.I. Division of Fish and Wildlife). Virgin Island Turtle Tag Recoveries Outside of the U.S.V.I.

Brooks, W.B. (The Bald Head Island Conservancy). Nesting Activity of the Loggerhead Sea Turtle (*Caretta caretta*) on Bald Head Island, North Carolina.

Byles, R., and C.K. Dodd (U.S. Fish and Wildlife Service - Endangered Species). Satellite Telemetry of East Florida Loggerhead Turtles.

Chaves Q., A. (Organization for Tropical Studies, Univ. of Costa Rica). Sea Turtles and Nesting Beaches of the Pacific Coast of Costa Rica.

Corliss, L.A., J. I. Richardson, C. Ryder, and R. Bell (Georgia Sea Turtle Cooperative, Institute of Ecology, Univ. of Georgia). Jumby Bay Hawksbills: An Integrated Approach.

Eckert, K.L., and S.A. Eckert (Georgia Sea Turtle Cooperative, Dept. of Zoology, Univ. of Georgia). Marine Turtle Newsletter.

Eggers, J.M. (Public Service Electric and Gas Co., Environmental Affairs, ITT). Incidental Capture of Sea Turtles at Salem Generating Station, Delaware Bay, New Jersey.

Fitch, L., and P. Schrantz (Sandy Creek Nature Center, Athens, Georgia). Kids for Sea Turtle Rights!

Girondot, M. (Centre de Etude é Protection de Tortue, Yalimapo, Guyane Francais). Nest Site Selection as It Relates to Arrival Time of *Dermochelys coriacea*.

Guseman, J.L., and L.M. Ehrhart (Univ. of Central Florida). A Comparative Analysis of Marine Turtle Reproductive Success at Patrick AFB, Florida, 1987-88.

Hernandez, R.G. (Centro de Invest. de Quintana Roo, *CIQRO*). Turtle Protection in the Mexican Caribbean Area.

Hillis, Z.M., and A. Mackay (USDI/National Park Service, Christianstad, St. Croix). Hawksbill Sea Turtles at Buck Island Reef NM.

Horrocks, J.A., H.A. Oxenford, and S. Willoughby (Bellairs Research Institute, Dept. Biology, Univ. of the West Indies). Abundance, Mortality, and Conservation of the Nesting Population of Hawksbill Turtles (*Eretmochelys imbricata*) in Barbados.

Jones, B., and J.A. Musick (Virginia Institute of Marine Science). Loggerhead Hatchling Success Rates in Virginia - 1985, '86, '87.

Margaritoulis, D. (Admin. Council, Sea Turtle Protection Society of Greece). Conservation, Research, and Management of *Caretta caretta* on the Greek Islands of the Mediterranean.

Marshall, G. (SUNY at Stony Brook). Development of a video-collar to study sea turtles in the water.

Mast, R.A. and F. Berry (WWF). Manual of Sea Turtle Research and Conservation Techniques, III Edition.

Mattison, C.A. (Nova University). Results from the Broward County Sea Turtle Program.

Medina, G. (FUDENA - Fundación para la Defensa de la Naturaleza, Venezuela). Nesting Beaches and Breeding Sites of Five Species of Sea Turtles Along the Venezuela Coast.

Pinto-Rodríguez, B. (Puerto Rico Dept. of Natural Resources and CHELONIA, *Puerto Rico Herpetological Society*). CHELONIA Efforts to Save Sea Turtles in the Puerto Rico DNR Project.

Redfoot, W.E., and **L.M. Ehrhart** (Seminole Community College). Marine Turtle Nesting and Reproductive Success in South Brevard County, Florida.

Rivera Lugo, P.J. (Puerto Rico Dept. of Natural Resources). Management of Leatherback Turtles along the Eastern Coast of Puerto Rico.

Rostal, D., T. Robeck, D. Owens, E. Louis, and **D. Kraemer** (Dept. of Biology, Texas A&M University). Ultrasonic Imaging of Ovaries and Eggs in Sea Turtles.

Rugge, M. (Sea Turtle Center). The Sea Turtle Center.

Ryder, C., J.I. Richardson, L.A. Corliss, and **R. Bell** (Georgia Sea Turtle Cooperative, Institute of Ecology, Univ. of Georgia). Utilization of Nesting Habitat by Hawksbill Sea Turtles, Jumby Bay, Antigua, W.I.

Smith, F.G. (Dept. of Anatomy and Radiology, Vet. Med., Univ. of Georgia). International Sea Turtle Videodisc Program.

Tallevast, T. (Florida Cooperative Fish and Wildlife Research Unit). Assessment of Juvenile Marine Turtle Stocks in the Culebra Archipelago, Culebra, P.R.

Wiese, V., T. East, and **B. Perry** (Mote Marine Laboratory). Tagging of Adult Female Loggerheads along the Southeastern Coast of Florida.

Zug, G.R., and **H.J. Kalb** (Dept. of Vertebrate Zoology, Natl. Museum of Natural History). Skeletochronological age estimates for juvenile *Lepidochely kempi* from the Atlantic Coast of North America.

Audio-visual Sessions

Byles, R. (U.S. Fish and Wildlife Service, Albuquerque). Alternative Conservation Methods: Sea Turtles in Michoacan, Mexico *(slides)*.

Cottingham, D. (NOAA/NMFS - Office of Ecology and Conservation). Marine Debris *(video)*.

Hillis, Z.M., and **A. Mackay** (USDI/National Park Service, Christiansted, St. Croix). Buck Island Reef NM: Hawksbill Sea Turtles *(slides)*.

Margaritoulis, D. (Admin. Council, Sea Turtle Protection Society of Greece). The Loggerhead Sea Turtles of Greece *(video)*.

Morgan, P., and **C. Luginbuhl** (David Luginbuhl Research Institute). A Record Leatherback in Wales *(video)*.

Pritchard, P.C.H. (Florida Audubon Society). Flatback Turtle Nesting and Emergence in Australia *(16mm film)*.

Rivera Lugo, P.J. (Puerto Rico Dept. of Natural Resources). Management of Leatherback Turtles Along the Eastern Coast of Puerto Rico *(video)*.

Rouse, N. Swimming with Turtles *(video)*.

Ruiz, G. (PRONATURA - Asoc. Mexicana Proconservación de la Naturaleza, A.C. and WIDECAST). The Kemp's Ridley Conservation Project in Tecolutla, Veracruz *(video)*.

Sarti, L. (Universidad Nacional Autónomo de México, Sea Turtle Center). The Life History of Leatherbacks *(16mm film)*.

APPENDIX II: REGISTERED PARTICIPANTS AND RESPONDENTS

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