NOAA's National Marine Fisheries Service
Endangered Species Act Section 7 Consultation

Biological Opinion

Agency: Permits, Conservation and Education Division of the Office of Protected Resources, NOAA's National Marine Fisheries Service

Activity Considered: Biological Opinion on the Permits, Conservation and Education Division's proposal to issue a Permit (Number 15135) to Blake Price of the North Carolina Division of Marine Fisheries, for research on multiple sea turtle species in North Carolina pursuant to section 10(a)(1)(A) of the Endangered Species Act of 1973.

Consultation Conducted by: Endangered Species Division of the Office of Protected Resources, NOAA's National Marine Fisheries Service

Approved by: _____

Date: MAY 23 2011 _____

Section 7(a)(2) of the Endangered Species Act (ESA) (16 U.S.C. 1531 *et seq.*) requires that each federal agency shall ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When the action of a federal agency "may affect" a listed species or critical habitat that has been designated for them, that agency is required to consult with either NOAA's National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS), depending upon the listed resources that may be affected. For the action described in this document, the action agency is NMFS' Office of Protected Resources – Permits, Conservation and Education Division. The consulting agency is NMFS' Office of Protected Resources – Endangered Species Division.

This document represents NMFS' biological opinion (Opinion) on the effects of the proposed studies on endangered and threatened species and designated critical habitat, and has been prepared in accordance with section 7 of the ESA. This Opinion is based on our review of the Permits, Conservation and Education Division's draft Environmental Assessment, draft amendment for Permit Number 15135, the recovery plans for listed sea turtle species, scientific and technical reports from government agencies, peer-reviewed literature, and other sources of information.

A complete administrative record for this consultation is on file at NMFS' Office of Protected Resources.

CONSULTATION HISTORY

The history of this consultation is best described by reviewing the history of gillnet fisheries and corresponding sea turtle interactions in North Carolina. This is due to the fact that the research proposed under Permit 15135 would test gillnet modifications which could be applied in relevant North Carolina fisheries to aid fisheries managers in successfully reducing sea turtle mortality and continued strandings.

The Pamlico Sound gillnet fishery for southern flounder is entirely the management responsibility of the North Carolina Division of Marine Fisheries (NCDMF). On June 21, 2000, NMFS received an application from the NCDMF for an incidental take permit (ITP) to authorize the incidental takings of listed sea turtles, incidental to the operation of the large-mesh gillnet fishery in southeastern Pamlico Sound during the fall 2000 fishing season. NMFS consulted on the issuance of the ITP for NCDMF's application and issued an Opinion on October 5, 2000. NMFS determined that issuance of the ITP and the operation of the southern flounder gillnet fishery, under NCDMF management, was not likely to jeopardize the continued existence of loggerhead, green, and Kemp's ridley sea turtles. NMFS approved the ITP on October 5, 2000, NCDMF validated it by signing on October 24, 2000, and the ITP expired December 16, 2000.

On August 8, 2001, NCDMF submitted a second application, including a conservation plan, for an ITP for the shallow water (generally ≤3 feet) gillnet fishery in southeastern Pamlico Sound to be effective from September 15 through September 15, 2001. The application also included a research component to test different gillnet configurations for sea turtle and finfish bycatch. NMFS consulted on the issuance of the ITP for NCDMF's application and issued an Opinion on September 26, 2001. NMFS determined that issuance of the ITP and the operation of the southern flounder gillnet fishery and the related research activities, under NCDMF management, was not likely to jeopardize the continued existence of loggerhead, green, and Kemp's ridley sea turtles. NMFS approved the ITP 1348 on September 28, 2001, and it expired December 16, 2001.

On July 18, 2002, NCDMF submitted an application, including a conservation plan, for a third ITP for the shallow water (generally ≤3 feet) gillnet fishery in southeastern Pamlico Sound and the mainland along the shoreline of Hyde and Pamlico counties. The management measures were effective from September 1 through December 15 each year for 2002 through 2004. NMFS consulted on the issuance of ITP 1398 for NCDMF's application and issued an Opinion on August 30, 2002. NMFS determined that the issuance of ITP 1398 and the operation of the southern flounder gillnet fishery, under NCDMF management, was not likely to jeopardize the continued existence of loggerhead, green, and Kemp's ridley sea turtles. NMFS approved the ITP 1398 on August 30, 2002, and it expired on December 15, 2004.

On June 15, 2003, NCDMF submitted an application for a directed scientific research permit pursuant to section 10(a)(1)(A) of the ESA. The research was meant to build on the research specified in ITP 1348. That directed scientific research permit (Number 1446) was issued to the NCDMF to allow testing of two types of large mesh gillnets in areas currently closed to large mesh gillnets in southeastern Pamlico Sound, NC. The primary directive of the study was to identify gillnet types (i.e., low profile gillnet) that would reduce sea turtle interactions, while

maintaining targeted catch. NMFS determined that after reviewing the current status of leatherback, loggerhead, green, hawksbill, and Kemp's ridley turtles, the environmental baseline for these species, the effects of the take authorized in the permit, and probable cumulative effects, that issuance of the permit was not likely to jeopardize the continued existence of leatherback, loggerhead, green, hawksbill, and Kemp's ridley sea turtles.

On February 15, 2006, NCDMF submitted another application to conduct additional gillnet research testing a low profile gillnet under Permit 1563. This was to continue building on their similar previous research. NMFS determined after reviewing the current status of leatherback, loggerhead, green, hawksbill, and Kemp's ridley turtles, the environmental baseline for these species, the effects of the take authorized in the permit, and probable cumulative effects, that issuance of the permit was not likely to jeopardize the continued existence of any of these listed species.

On February 23, 2010, the Karen Beasley Sea Turtle Rescue and Rehabilitation Center filed suit against the NCDMF in the U.S. District Court for the Eastern District of North Carolina, Southern Division. In the complaint, the plaintiff contended that NCDMF was in violation of the ESA by authorizing gillnets to operate and take sea turtles in state waters not covered by the NMFS ITP and not complying with the ITP requirements for observer coverage and enforcement. On May 13, 2010, a settlement agreement was reached in the case. The settlement agreement includes many terms and conditions, including restrictions to large mesh gillnet such as when they can be set and removed, the maximum net height, maximum yardage of nets, and distance between nets.

Also part of the settlement agreement was the contingency that all North Carolina gillnet fisheries be consolidated together and one ITP be done for all the gillnet fisheries in North Carolina. This new North Carolina gillnet fisheries ITP is currently being analyzed by the National Marine Fisheries Service.

In January, 2011, the NMFS Office of Protected Resources – Permits, Conservation and Education Division (PR1) submitted this initation package to the NMFS Office of Protected Resources – Endangered Species Division (PR3) for NCDMF to conduct gillnet research that would test shallow water gillnets with LED light configurations (Permit 15135). The research that would be conducted under Permit 15135 is separate from the North Carolina gillnet fisheries ITP that is currently being analyzed by NMFS. On January 13, 2011, PR3 initiated consultation on Permit 15135.

BIOLOGICAL OPINION

I. DESCRIPTION OF THE PROPOSED ACTION

The proposed action addressed in this Opinion is PR1's authorization of Permit 15135 for NCDMF to conduct research on gillnet configurations to reduce sea turtle bycatch in Core Sound, North Carolina (NC). The authority for PR1's permit issuance is pursuant to section 10(a)(1)(A) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 *et seq.*).

The proposed action (Permit 15135) would authorize the NCDMF to test shallow water gillnet configurations with LED lights against identical shallow water control gillnets without lights in Core Sound, NC. The study would be modeled after a successful study by Wang *et al.* (2009), which found that LED lights significantly reduced mean sea turtle catch rates by 40% in Baja California Sur, Mexico. The purpose of this action (Permit 15135) would be to uncover whether LED lights are a significant deterrent to sea turtles in NC gillnet fisheries which could significantly reduce their bycatch while maintaining fishery yield.

Table 1 outlines takes that could occur by species and activity under the proposed action. The proposed amendment would authorize 68 sea turtle takes for the entire study (broken down by species and procedure in Table 1 below). Calculations and justifications used to produce these take numbers for each species are discussed in detail in the *Exposure Analysis* section.

Table 1. Proposed issuance of annual takes of sea turtles in NCDMF gillnet study.

Species	Life Stage	Take	Take Action	Procedures
Green sea turtle	Adult/Subadult/ Juvenile	16	Capture, Handle, Release	Bycatch reduction gillnet experiment; mark, flipper tag; mark, PIT tag; measure; photo/video
Green sea turtle	Adult/Subadult/ Juvenile	15	Unintentional mortality	Bycatch reduction gillnet experiment; measure; unintentional mortality
Kemp's ridley sea turtle	Adult/Subadult/ Juvenile	13	Capture, Handle, Release	Bycatch reduction gillnet experiment; mark, flipper tag; mark, PIT tag; measure; photo/video
Kemp's ridley sea turtle	Adult/Subadult/ Juvenile	5	Unintentional mortality	Bycatch reduction gillnet experiment; measure; unintentional mortality
Loggerhead sea turtle	Adult/Subadult/ Juvenile	10	Capture, Handle, Release	Bycatch reduction gillnet experiment; mark, flipper tag; mark, PIT tag; measure; photo/video
Loggerhead sea turtle	Adult/Subadult/ Juvenile	5	Unintentional mortality	Bycatch reduction gillnet experiment; measure; unintentional mortality
Hawksbill sea turtle	Adult/Subadult/ Juvenile	2	Capture, Handle, Release	Bycatch reduction gillnet experiment; mark, flipper tag; mark, PIT tag; measure; photo/video; including unintentional mortality
Leatherback sea turtle	Adult/Subadult/ Juvenile	2	Capture, Handle, Release	Bycatch reduction gillnet experiment; mark, flipper tag; mark, PIT tag; measure; photo/video; including unintentional mortality

Capture. Turtles would be captured using a large mesh gillnet. Both control and experimental gillnets would be constructed identically (5 3/4 inch stretch mesh; 15 meshes deep; # 177 twine; 20 lb lead core lead line, and 5/16 inch float line). Green (Lindgen-Pitman Elactralume) LED fishing lights would be placed along the floatline at 10 m intervals along the nets. The floatline would have floating buoy lines (~5 ft in length) attached to each end. Reduced line length is made feasible because the nets would be deployed in shallow water. Anchors would be used on each end of gillnet sets, which would create only minimal bottom disturbance along the sandy bottom. See Figure 1 for the proposed net designs.

The only difference between the experimental and control nets would be the illumination of the green LED fishing lights on the experimental net. Lights would also be hung on the control nets, but would not be illuminated.

On each fishing day, two fishermen would each deploy 1,000 yards of alternating control and experimental gillnet in an approximate continuous line. Refer to Figure 2 for the net set configurations. Nets would be deployed in relatively shallow water (1 – 3 ft') throughout Core Sound, and set almost exclusively on sandy bottom. Each 1,000 yards would consist of five pairs of 200 yard net shots comprised of 100 yards of control net and 100 yards of experimental net. There would be approximately 25 feet of space between the control and experimental nets in each 200 yard pair. Each 200 yards of gillnet would be separated by approximately 75 ft so that each matched pairs (control and experimental) fishes independently. Each fisherman would deploy nets within the study region in the same general area based upon their experience and knowledge of target species distribution on a given day, but the fishermen would remain sufficiently apart (1/4 - 1/2 mile) from one another to eliminate potentially confounding factors between the two fishermen.

In order to mimic the commercial fishery, nets would be set at dusk and retrieved at daylight for approximate 8 - 12 hour sets. Nets would not be monitored over night. Nets would be removed from the water during daylight hours. The days of the week when sets would occur would be limited, in accordance with the settlement agreement for the recent litigation.

Each fishing operation would consist of the fisherman and an observer. Observers would be hired and trained to collect all data. Upon retrieval of the nets, the scientific observer would sample and record all finfish catch and bycatch information including: identifying, counting and weighing all catch by species and net origin of catch (control or experimental net). Finfish catch and bycatch would be sorted, sampled and coded. Observers would record the location in the net of all sea turtle captures with relation to where the animal was captured in the length of the net. Captures would also be recorded by proximity to the control or test nets.

The matched-pair sampling design would allow for a total of ten matched paired samples each fishing day. This study would be conducted for 30 days (60 fishing trips) for a total of 300 matched pairs. A power analysis was conducted, which indicated that this design would provide statistical power to detect bycatch reduction potential.

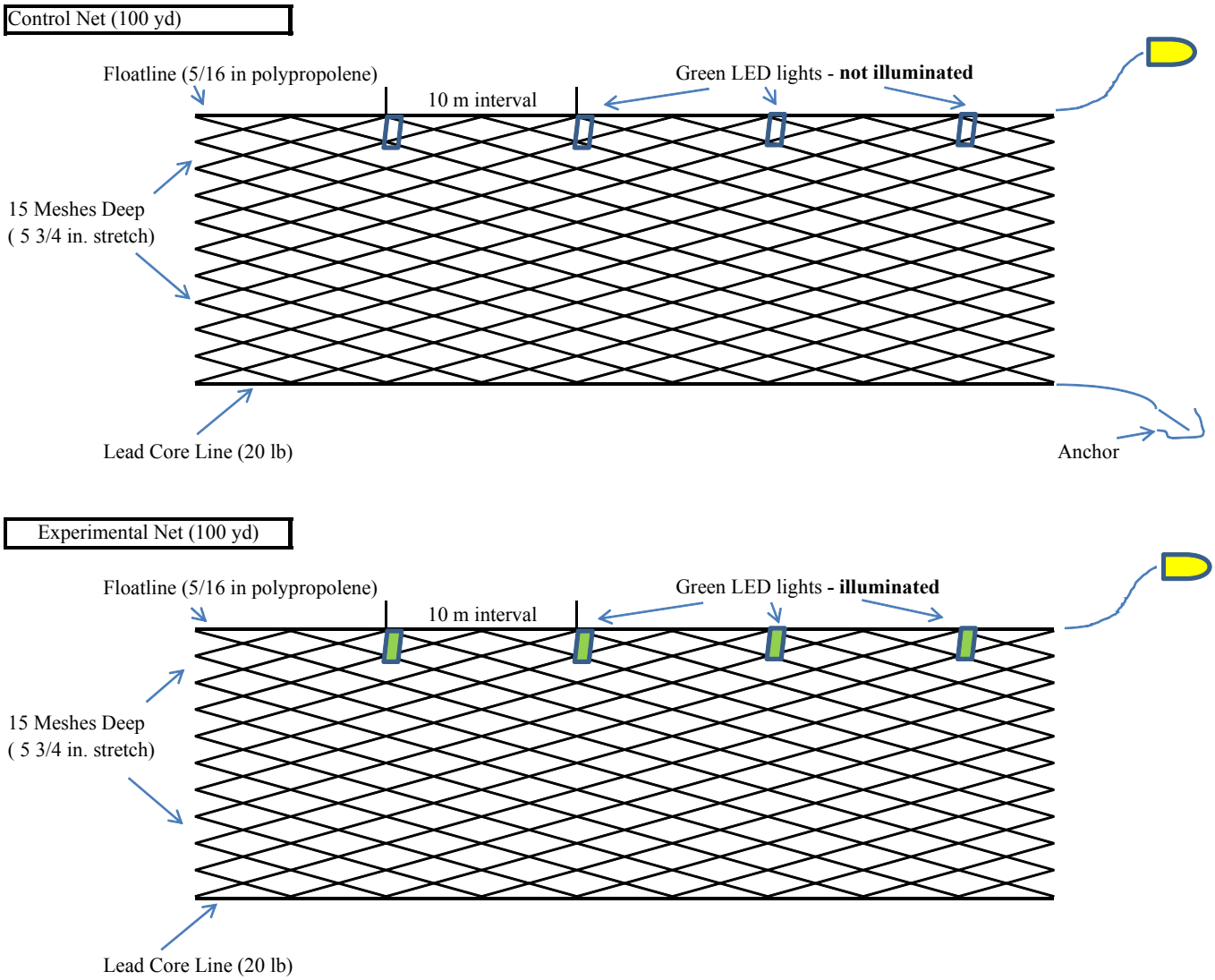
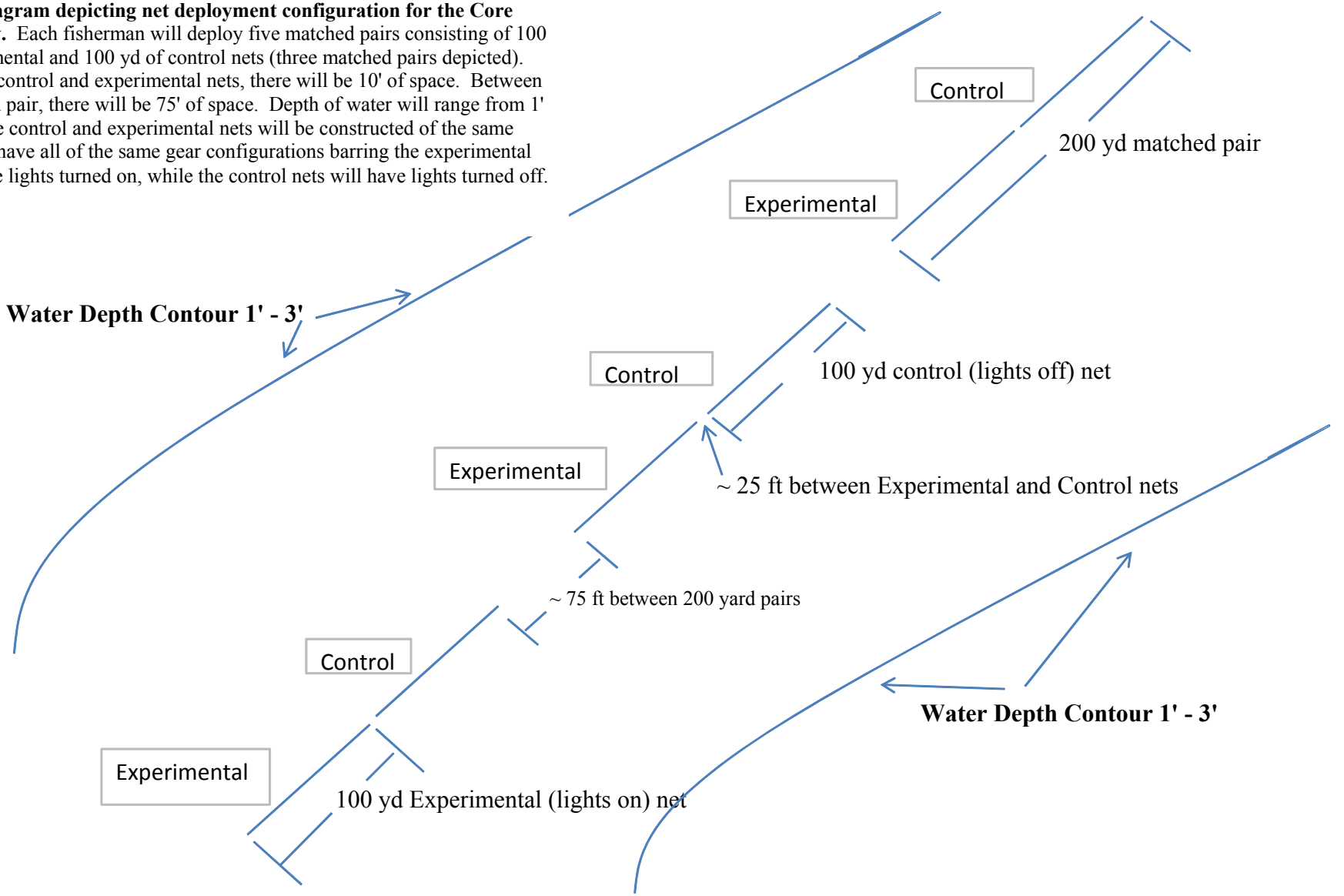


Figure 1. Control and Experimental Net Designs. All net materials and construction will be identical for both the Control and Experimental nets. Both net types will have LED lights affixed to the floatline at 10 m intervals, but only the experimental net will have these lights illuminated. The nets will be paired together (with ~ 10' between the control and test net), with an anchor on each end of the pair. A pair consists of 100 yd of Control and 100 yd of Experimental net bridled together. Between each matched pair, there will be 75' of space. Each fisherman will deploy 5 matched pairs per fishing day.

Figure 2. Diagram depicting net deployment configuration for the Core Sound Study. Each fisherman will deploy five matched pairs consisting of 100 yd of experimental and 100 yd of control nets (three matched pairs depicted). Between the control and experimental nets, there will be 10' of space. Between each matched pair, there will be 75' of space. Depth of water will range from 1' – 3'. Both the control and experimental nets will be constructed of the same material and have all of the same gear configurations barring the experimental nets will have lights turned on, while the control nets will have lights turned off.



Before deployment of the net, a careful visual inspection of the area would be made to ensure there are no marine mammals present near the study site. In the case where marine mammals are sighted near the netting sight, nets would either not be deployed or would be pulled in and netting activity would cease until the area is clear.

With the exception of the LED lights, all gear and fishing methods used during the study would conform to the restrictions of the summer flounder gillnet fishery. This includes unmonitored sets at night.

Handling, measuring, photographing. Observers would monitor the retrieval of the net and sample all catch. All sea turtles would be counted, measured, and identified by species. A curved carapace length and curved carapace width would be measured and recorded for each animal. Every attempt would be made to take photographs of all captured sea turtles before release and recorded by date, location, study and net type. Additional information on the capture would also be recorded such as the location in the net where the turtle was captured and how the animal was entangled.

Upon capture, turtles would also be thoroughly examined for any possible injuries. Observers would be trained to identify, handle, tag, and resuscitate sea turtles under NMFS protocols (NMFS-Beaufort Lab).

In order to compare the catch per soak hour between the experimental and control nets, the species composition and weight of all animals captured in each set would be recorded. Flounder, other finfish, and bycatch would be sorted, sampled, and recorded.

Flipper and PIT tagging. All live turtles captured in good condition would be tagged with two Inconel tags in the rear flippers and one pit tag in the left front flipper. All tagging equipment including the PIT tag applicator and Inconel tag pliers would be washed and disinfected following each application and prior to use on another animal.

Before insertion of any tags, all flippers would be scanned for the presence of pre-existing PIT or flipper tags. Identification numbers from any pre-existing tags would be recorded and included in the annual report. Turtles with fibropapillomas would be kept separate from other turtles and separate sets of towels, pads, and measuring and tagging gear would be used.

Holding, Transport, and Release. While onboard, all turtles would be restricted to a small area to prevent injury and either kept warm or cool depending on the air temperature. Temperature would be regulated either by shading or exposing to the sun. If temperatures allow, turtles would also be kept moist by periodically drenching with water.

Healthy turtles would be returned to the water following identification, measurement and tagging. Turtles would be released after the removal of all nets and away from the research area, to eliminate the possibility of immediate recapture. However turtles would be released in the same general habitat as the capture site.

Resuscitation attempts would be made on all sea turtles that are lethargic or comatose for a minimum of two hours. This would consist of placing the turtle on its breastplate, and securing the hindquarters upward using a small flat board (e.g. measuring board). Every effort would be made to ensure removal of any potential water in the turtle's lungs by opening the mouth (use of pencil), elevation and gently rocking the turtle back and forth raising the turtle up to 3 inches on each side.

All comatose or debilitated turtles will be brought to shore and transferred to the North Carolina Sea Turtle Stranding and Salvage Network (NCSTSSN) staff for examination, data collection, and treatment. The Principal Investigator is in the process of contacting the NC Wildlife Resource Commission (NCWRC) sea turtle biologist to confirm acceptance of any comatose, debilitated or dead sea turtles, and would ensure this coordination is established prior to initiation of the project. All sea turtle mortalities will be turned over to the NC WRC Sea Turtle Stranding Network for postmortem examinations. Once on shore, observers would remain with all turtles until NCSTSSN personnel arrive to complete the transfer. While on shore, all live turtles would be restricted to a small area to prevent injury to themselves or other turtles. Holding times would not exceed 6 hours including transport time to shore. The final disposition (e.g., released alive, died) of all turtles taken to a rehabilitation facility would be included in the annual report.

II. PERMIT CONDITIONS

Number and Kind(s) of Protected Species, Location(s) and Manner of Taking

The table below outlines the number of protected species, by species, authorized to be taken, and the locations, manner, and time period in which they may be taken. The table shows maximum authorized takes (i.e., over the life of the permit) during gear research in Core Sound, North Carolina.

SPECIES	LIFE STAGE	AUTHORIZED TAKE	TAKE ACTION	PROCEDURES	DETAILS
Green sea turtle	Adult/ Subadult/ Juvenile	16	Capture/ Handle/ Release	Bycatch reduction experiments; Mark, flipper tag; Mark, PIT tag; Measure; Photograph/Video	
Green sea turtle	Adult/ Subadult/ Juvenile	15	Unintentional mortality	Bycatch reduction experiments; Measure; Unintentional mortality	
Kemp's ridley sea turtle	Adult/ Subadult/ Juvenile	13	Capture/ Handle/ Release	Bycatch reduction experiments; Mark, flipper tag; Mark, PIT tag; Measure; Photograph/ Video	

SPECIES	LIFE STAGE	AUTHORIZED TAKE	TAKE ACTION	PROCEDURES	DETAILS
Kemp's ridley sea turtle	Adult/ Subadult/ Juvenile	5	Unintentional mortality	Bycatch reduction experiments; Measure; Unintentional mortality	
Loggerhead sea turtle	Adult/ Subadult/ Juvenile	10	Capture/ Handle/ Release	Bycatch reduction experiments; Mark, flipper tag; Mark, PIT tag; Measure; Photograph/ Video	
Loggerhead sea turtle	Adult/ Subadult/ Juvenile	5	Unintentional mortality	Bycatch reduction experiments; Measure; Unintentional mortality	
Hawksbill sea turtle	Adult/ Subadult/ Juvenile	2	Capture/ Handle/ Release	Bycatch reduction experiments; Mark, flipper tag; Mark, PIT tag; Measure; Photograph/Video; Unintentional mortality	alive or dead
Leatherback sea turtle	Adult/ Subadult/ Juvenile	2	Capture/ Handle/ Release	Bycatch reduction experiments; Mark, flipper tag; Mark, PIT tag; Measure; Photograph/ Video; Unintentional mortality	alive or dead

Tracking take. The PI or other Researcher shall notify the Permits, Conservation and Education Division (Permits Division) of sea turtle takes in the following manner:

a. At a minimum, updates of research takes by species shall be submitted at intervals of every 3 turtles (3, 6, 9, etc.) caught; and

b. If 4 or more turtles are caught in any one set, research must stop and the Permits Division must be notified via phone (301-713-2289). After a discussion of the circumstances, changes to sampling may be required before the Permits Division allows research to resume.

Researchers working under this permit may collect visual images (*e.g.*, still photographs, motion pictures) as needed to document the permitted activities, provided the collection of such images does not result in takes of protected species.

The Permit Holder may use visual images and audio recordings collected under this permit, including those authorized, in printed materials (including commercial or scientific publications)

and presentations provided the images and recordings are accompanied by a statement indicating that the activity was conducted pursuant to Permit No. 15135. This statement must accompany the images and recordings in all subsequent uses or sales.

Upon written request from the Permit Holder, approval for photography, filming, or audio recording activities not essential to achieving the objectives of the permitted activities, including allowing personnel not essential to the research (*e.g.* a documentary film crew) to be present, may be granted by the Chief, Permits Division.

a. Where such non-essential photography, filming, or recording activities are authorized they must not influence the conduct of permitted activities or result in takes of protected species.

b. Personnel authorized to accompany the Researchers during permitted activities for the purpose of non-essential photography, filming, or recording activities are not allowed to participate in the permitted activities.

c. The Permit Holder and Researchers cannot require compensation in return for allowing non-essential personnel to accompany Researchers to conduct non-essential photography, filming, or recording activities.

Researchers must comply with the following conditions related to the manner of taking:

<u>Handing, Measuring, Weighing, PIT and Flipper Tagging</u>

a. When handling, measuring, and/or tagging turtles, researchers must use the following procedures:

i. All equipment (tagging equipment, tape measures, etc.) that comes in contact with sea turtles must be cleaned and disinfected between the processing of each turtle; and

ii. Maintain a separate set of sampling equipment for handling animals displaying fibropapillomas tumors/or lesions (all equipment that comes in contact with the turtle must be cleaned with a disinfectant between the processing of each turtle).

iii. All turtles must be examined for existing tags, including PIT tags, before attaching or inserting new ones. If existing tags are found, the tag identification numbers must be recorded and included in the annual report. Researchers must have PIT tag readers capable of reading 125, 128, 134.2, and 400 kHz tags.

iv. Flipper Tagging with Metal Tags- All tags must be cleaned (e.g., to remove oil residue) and disinfected before being used. Applicators

must be cleaned (and disinfected when appropriate, e.g., contaminated with fluids) between animals. The application site must be cleaned and then scrubbed with a disinfectant (e.g. Betadine) before the tag pierces the animal's skin.

v. PIT Tagging- New, sterile tag applicators (needles) must be used. The application site must be cleaned and then scrubbed with a disinfectant (e.g. Betadine) before the applicator pierces the animal's skin. The injector handle shall be disinfected if it has been exposed to fluids from other animals.

b. General Handling and Releasing of Turtles:

The Permit Holder, Principal Investigator, Co-investigator(s), or Research Assistant(s) acting on the Permit Holder's behalf must use care when handling live animals to minimize any possible injury, and appropriate resuscitation techniques must be used on any comatose turtle prior to returning it to the water. Whenever possible, injured animals should be transferred to rehabilitation facilities and allowed an appropriate period of recovery before return to the wild. An experienced veterinarian, veterinary technician, or rehabilitation facility must be named for emergencies. If an animal becomes highly stressed, injured, or comatose during the course of the research activities the researchers must contact a veterinarian immediately. Based on the instructions of the veterinarian, if necessary, the animal must be immediately transferred to the veterinarian or to a rehabilitation facility to receive veterinary care. All turtles must be handled according to procedures specified in 50 CFR 223.206(d)(1)(i).

Turtles are to be protected from temperature extremes of heat and cold, provided adequate air flow, and kept moist (if appropriate) during sampling. Turtles must be placed on pads for cushioning and this surface must be cleaned and disinfected between turtles. The area surrounding the turtle must not contain any materials that could be accidentally ingested.

During release, turtles must be lowered as close to the water's surface as possible to prevent potential injuries.

The Permit Holder, Principal Investigator, Co-investigator(s), or Research Assistant(s) acting on the Permit Holder's behalf must carefully observe newly released turtles and record observations on the turtle's apparent ability to swim and dive in a normal manner. If a turtle is not behaving normally within one hour of release, the turtle must be recaptured and taken to a rehabilitation facility.

Leatherbacks must only be boarded if they can be safely brought on board the vessel. Leatherback turtles must be handled by at least two people, one on either side of the turtle, and precautions must be taken to ensure that animals are supported from underneath. Leatherback turtles must not be turned on their back. Field and laboratory observations indicate that leatherbacks have more friable skin and softer bones than hardshell turtles which tend to be hardier and less susceptible to trauma. Extra care must be exercised when handling, sampling and releasing leatherbacks.

Netting Special Conditions

Nets must not be put in the water when marine mammals are observed within the vicinity of the research, and the marine mammals must be allowed to either leave or pass through the area safely before net setting is initiated. Should any marine mammals enter the research area after the nets have been set, the lead line must be raised and dropped in an attempt to make marine mammals in the vicinity aware of the net. If marine mammals remain within the vicinity of the research area, nets must be removed.

Transport and Holding

Turtles must be transported via a climate-controlled environment, protected from temperature extremes and kept moist (if appropriate). The turtles must be placed on pads for cushioning. The area surrounding the turtle must not contain any materials that could be accidentally ingested.

Turtles transported to a facility and held (e.g., for rehabilitation) must be maintained and cared for under the "Care and Maintenance Guidelines for Sea Turtles Held in Captivity" issued by the U.S. Fish and Wildlife Service.

Reports

1. The Permit Holder must submit annual, final, and incident reports, and papers or publications resulting from the research authorized herein to the Permits Division. Reports may be submitted
   - through the online system at https://apps.nmfs.noaa.gov,
   - by email attachment to the permit analyst for this permit, or
   - by hard copy mailed or faxed to the Chief, Permits Division, Office of Protected Resources, NMFS, 1315 East-West Highway, Suite 13705, Silver Spring, MD 20910; phone (301)713-2289; fax (301)713-0376.

2. Written incident reports related to serious injury and mortality events or to exceeding authorized takes, must be submitted to the Chief, Permits Division within two weeks of the incident. The incident report must include a complete description of the events and identification of steps that will be taken to reduce the potential for additional research-related mortality or exceedence of authorized take.

3. An annual report must be submitted to the Chief, Permits Division at the conclusion of each year for which the permit is valid..

4. A final report must be submitted to the Chief, Permits Division within 180 days after expiration of the permit (June 30, 2013), or, if the research concludes prior to permit expiration, within 180 days of completion of the research.

5. Research results must be published or otherwise made available to the scientific community in a reasonable period of time.

Notification and Coordination

1. The Permit Holder must provide written notification of planned field work to the appropriate Assistant Regional Administrator(s) for Protected Resources at the address(es) listed below. Such notification must be made at least two weeks prior to initiation of a field trip/season and must include the locations of the intended field study and/or survey routes, estimated dates of research, and number and roles (for example: PI, CI, veterinarian, boat driver, safety diver, animal restrainer, Research Assistant "in training") of participants.

   Southeast Region (*Email notification preferred*)
   Email: nmfs.ser.research.notification@noaa.gov;
   NMFS, 263 13th Ave South, St. Petersburg, FL 33701; phone (727)824-5312; fax (727)824-5309.

2. To the maximum extent practical, the Permit Holder must coordinate permitted activities with activities of other Permit Holders conducting the same or similar activities on the same species, in the same locations, or at the same times of year to avoid unnecessary disturbance of animals. The appropriate Regional Office may be contacted at the address listed above for information about coordinating with other Permit Holders.

III. APPROACH TO THE ASSESSMENT

NMFS approaches its section 7 analyses of agency actions through a series of steps. The first step identifies those aspects of proposed actions that are likely to have direct and indirect physical, chemical, and biotic effects on listed species or on the physical, chemical, and biotic environment of an action area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in that spatial extent over time. The result of this step includes defining the *action area* for the consultation. The second step of our analyses identifies the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our *exposure analyses*). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent. Once we identify which listed resources are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our *response analyses*).

The final steps of our analyses – establishing the risks those responses pose to listed resources – are different for listed species and designated critical habitat (these represent our *risk analyses*). Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true

biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of species depends on the fate of the populations that comprise them, the continued existence of these "species" depends on the fate of the populations that comprise them. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them – populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our risk analyses reflect these relationships between listed species, the populations that comprise that species, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individual risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the individuals' "fitness," or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable lethal, sub-lethal, or behavioral responses to an action's effect on the environment (which we identify during our response analyses) are likely to have consequences for the individual's fitness.

When individual, listed plants or animals are expected to experience reductions in fitness in response to an action, those fitness reductions are likely to reduce the abundance, reproduction, or growth rates (or increase the variance in these measures) of the populations those individuals represent (*see* Stearns 1992). Reductions in at least one of these variables (or one of the variables we derive from them) is a *necessary* condition for reductions in a population's viability, which is itself a *necessary* condition for reductions in a species' viability. As a result, when listed plants or animals exposed to an action's effects are *not* expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (e.g., Brandon 1978; Mills and Beatty 1979; Stearns 1992; Anderson 2000). As a result, if we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

Although reductions in fitness of individuals is a *necessary* condition for reductions in a population's viability, reducing the fitness of individuals in a population is not always *sufficient* to reduce the viability of the population(s) those individuals represent. Therefore, if we conclude that listed plants or animals are likely to experience reductions in their fitness, we determine whether those fitness reductions are likely to reduce the viability of the populations the individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, variance in these measures, or measures of extinction risk). In this step of our analyses, we use the population's base condition (established in the *Environmental Baseline* and *Status of Listed Resources* sections of this Opinion) as our point of reference. If we conclude that reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent, we would conclude our assessment.

Reducing the viability of a population is not always *sufficient* to reduce the viability of the species those populations comprise. Therefore, in the final step of our analyses, we determine if reductions in a population's viability are likely to reduce the viability of the species those populations comprise using changes in a species' reproduction, numbers, distribution, estimates of extinction risk, or probability of being conserved. In this step of our analyses, we use the species' status (established in the *Status of the Species* section of this Opinion) as our point of reference. Our final determinations are based on whether threatened or endangered species are likely to experience reductions in their viability and whether such reductions are likely to be appreciable.

To conduct these analyses, we rely on all of the evidence available to us. This evidence might consist of monitoring reports submitted by past and present permit holders; reports from NMFS Science Centers; reports prepared by natural resource agencies in States, Tribes, and other countries; reports from non-governmental organizations involved in marine conservation issues; the information provided by the Permits Division when it initiates formal consultation; and the general scientific literature. We supplement this evidence with reports and other documents – environmental assessments, environmental impact statements, and monitoring reports – prepared by other federal and state agencies like the Minerals Management Service, U.S. Coast Guard, and U.S. Navy whose operations extend into the marine environment.

During the consultation, we conducted electronic searches of the general scientific literature using search engines, including *Agricola, Aquatic Sciences and Fisheries Abstracts, Conference Papers Index, Oceanic Abstracts, BioOne, Science Direct, Ingenta Connect, Scopus, JSTOR, Web of Science - Science Citation Index, First Search (Article First, ECO, WorldCat),* and *Google Scholar*. We supplemented these searches with electronic searches of doctoral dissertations and master's theses. These searches specifically tried to identify data or other information that supports a particular conclusion (for example, a study that suggests sea turtle will exhibit a particular response to entanglement) as well as data that does not support that conclusion.

IV. DESCRIPTION OF THE ACTION AREA

Research would take place in Core Sound, North Carolina (NC), in areas typically used by commercial fishermen. The gillnets would be deployed in relatively shallow water (1 - 3 feet) throughout the sound and set almost exclusively on sandy bottom. See Figure 3 for a map of the action area.

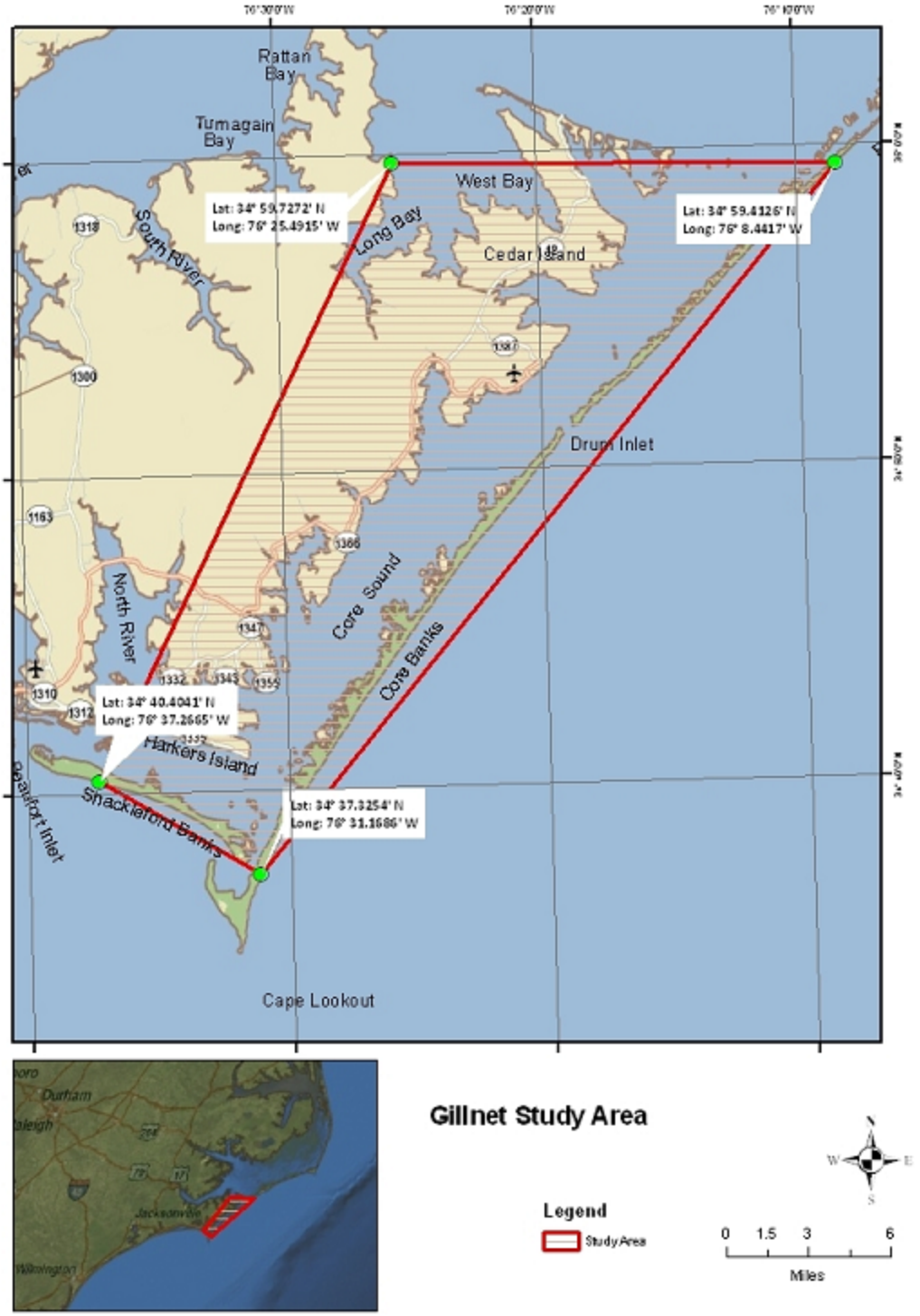


Figure 3: Proposed gillnet study area in Core Sound, NC, for Permit 15135.

V. STATUS OF THE SPECIES/CRITICAL HABITAT

NMFS has determined that the action considered in this Opinion may affect the following listed species provided protection under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.; ESA):

Green turtle, *Chelonia mydas*	*Endangered
Hawksbill turtle, *Eretmochelys imbricata*	Endangered
Kemp's ridley turtle, *Lepidochelys kempii*	Endangered
Leatherback turtle, *Dermochelys coriacea*	Endangered
Loggerhead turtle, *Caretta caretta*	**Threatened

*Green turtles in U.S. waters are listed as threatened except for the Florida breeding population which is listed as endangered. Due to the inability to distinguish between these populations away from the nesting beach, green turtles are considered endangered wherever they occur in U.S. waters.
** NMFS has proposed 9 distinct population segments for the loggerhead sea turtle (75 FR 12598).

The biology and ecology of these species are described below, and inform the effects analysis for this Opinion. Summaries of the global status and trends of these species are presented to provide a foundation for the analysis.

A. Listed Resources Not Considered Further in this Opinion

Shortnose sturgeon, *Acipenser brevirostrum* Endangered
Critical habitat for green, hawksbill, and leatherback sea turtles

Critical habitat has been designated for green (63 FR 46693), hawksbill (63 FR 46693), and leatherback (44 FR 17710) sea turtles. Green and hawksbill critical habitat occur in Puerto Rico, and leatherback critical habitat occurs in the U.S. Virgin Islands. The action area for the proposed activities is Core Sound, North Carolina and, therefore, no sea turtle critical habitat will be affected by this action. As a result, we do not consider sea turtle critical habitat further in this Biological Opinion.

Anadromous fish spend years in the marine environment before returning to natal streams to spawn. However, shortnose sturgeon are more riverine than many of their anadromous counterparts and are not frequently found to travel out of their home rivers and into the marine environment. A shortnose sturgeon occurrence in Core Sound is unlikely (Joe Hightower, North Carolina State University, personal communication) and permit holders have reported no shortnose sturgeon interactions in any of their gillnet research projects within Core and Pamlico Sounds. Additionally, the potential for shortnose sturgeon to be in 1-3 feet of water with sandy bottom in this area is unlikely. Therefore, we do not consider shortnose sturgeon further in this Biological Opinion.

B. Status of Species Considered in this Opinion

Leatherback sea turtle

Distribution. Leatherbacks have a circumglobal distribution, occurring in tropical, temperate, and cold waters. They range farther than any other sea turtle species, having evolved physiological and anatomical adaptations that allow them to exploit cold waters (Frair *et al.* 1972; Greer *et al.* 1973; USFWS 1995). High-latitude leatherback range in the Atlantic includes the North and Barents Seas, Newfoundland and Labrador, Argentina, and South Africa (Goff and Lien 1988; Hughes *et al.* 1998; Luschi *et al.* 2003; Luschi *et al.* 2006; Márquez 1990; Threlfall 1978). Pacific ranges extend to Alaska, Chile, and New Zealand (Brito 1998; Gill 1997; Hodge and Wing 2000).

Leatherbacks also occur in Mediterranean and Indian Ocean waters (Casale *et al.* 2003; Hamann *et al.* 2006b). Associations exist with continental shelf and pelagic environments and sightings occur in offshore waters of 7-27˚ C (CETAP 1982). Juvenile leatherbacks usually stay in warmer, tropical waters >21˚ C (Eckert 2002). Males and females show some degree of natal homing to annual breeding sites (James *et al.* 2005).

Population designations. Leatherbacks break into four nesting aggregations: Pacific, Atlantic, and Indian oceans, and the Caribbean Sea. Detailed population structure is unknown, but is likely dependent upon nesting beach location.

Atlantic Ocean. Nesting aggregations occur along Gabon, Sao Tome and Principe, French Guiana, Suriname, and Florida (Bräutigam and Eckert 2006; Márquez 1990; Spotila *et al.* 1996). Widely dispersed but fairly regular African nesting also occurs between Mauritania and Angola (Fretey *et al.* 2007). Many sizeable populations (perhaps up to 20,000 females annually) of leatherbacks are known to nest in West Africa (Fretey 2001a). The population of leatherbacks nesting on Gabon beaches has been suggested as being the world's largest, with 36,185-126,480 clutches being laid by 5,865-20,499 females annually from 2002-2007 (Witt *et al.* 2009). The total number of females utilizing Gabon nesting beaches is estimated to be 15,730- 41,373 (Witt *et al.* 2009). Genetic analyses support distinct subpopulations within the Atlantic basin, including the St. Croix (U.S.V.I.), Trinidad, and mainland Caribbean (Florida, Costa Rica, Suriname/French Guiana) nesting aggregations (Dutton *et al.* 1999). Recent analysis suggests seven Atlantic stocks including Florida, northern Caribbean, western Caribbean, southern Caribbean-Guyana Shield-Trinidad, West Africa, South Africa, and Brazil (TEWG 2007). North Atlantic leatherbacks likely number 34,000-94,000 individuals, with females numbering 18,800 and the eastern Atlantic segment numbering 4,700 (TEWG 2007). Trends and numbers include only nesting females and are not a complete demographic or geographic cross-section. The largest nesting aggregation in the western North Atlantic occurs in French Guiana and Suriname, likely belongs to a metapopulation whose limits remain unknown (Rivalan *et al.* 2006). Heppell *et al.* (2003) concluded that leatherbacks generally show less genetic structuring than green and hawksbill sea turtles. The French Guiana nesting aggregation has declined ~15% annually since 1987 (NMFS 2001a). However, from 1979-1986, the number of nests increased ~15% annually, possibly indicating the current decline may be linked with the erosion cycle of Guiana beaches (NMFS 2006). Guiana nesting may have increased again in the early 2000s (NMFS 2006).

Suriname nesting numbers have recently increased from more than 10,000 nests annually since 1999 and a peak of 30,000 nests in 2001. Overall, Suriname and French Guiana nesting trends towards an increase (Girondot *et al.* 2007; Hilterman and Goverse 2003). Florida (March-July) and U.S. Caribbean nesting since the early 1980s has increased ~0.3% and 7.5% per year, respectively, but lags behind the French Guiana coast and elsewhere in magnitude (NMFS/SEFSC 2001).

Caribbean Sea. Nesting occurs in Puerto Rico, St. Croix, Costa Rica, Panama, Colombia, Trinidad and Tobago, Guyana, Suriname, and French Guiana (Bräutigam and Eckert 2006; Márquez 1990; Spotila *et al.* 1996).

Indian Ocean. Nesting is reported in South Africa, India, Sri Lanka, and the Andaman and Nicobar islands (Hamann *et al.* 2006b).

Pacific Ocean. Leatherbacks are found from tropical waters north to Alaska within the North Pacific and is the most common sea turtle in the eastern Pacific north of Mexico (Eckert 1993a; Stinson 1984a; Wing and Hodge 2002). The west coast of Central America and Mexico hosts nesting from September-March, although Costa Rican nesting peaks during April-May (Chacón-Chaverri and Eckert 2007; LGL Ltd. 2007). Leatherback nesting aggregations occur widely in the Pacific, including China, Malaysia, Papua New Guinea, Indonesia, Thailand, Australia, Fiji, the Solomon Islands, and Central America (Dutton *et al.* 2007; Limpus 2002). Significant nesting also occurs along the Central American coast (Márquez 1990). Although not generally known to nest on Japanese shores, two nests were identified in the central Ryukyu Islands in 2002 (Kamezaki *et al.* 2002).

In the Pacific, nesting beaches in Mexico and Costa Rica (nesting occurs October through March) are a separate population from the western Pacific beaches (Benson *et al.* 2007a; summary in NMFS and USFWS 2007d; Spotila 2004a). In Costa Rica, leatherbacks nest at Playa Naranjo in Santa Rosa National Park, the second-most important nesting beach on the Pacific coast (Yañez *et al.* 2010), Rio Oro on the Osa Peninsula, and at various beaches in Las Baulas National Park, which includes Playa Langosta and Playa Grande and contains the largest colony of leatherbacks in the Pacific (Spotila 2004a). Females typically lay six clutches per season (average nine days between nests), which incubate for 58–65 days (Lux *et al.* 2003). Limited nesting also occurs along Nicaragua, Panama, El Salvador, and Guatemala.

Habitat. Leatherbacks occur throughout marine waters, from nearshore habitats to oceanic environments (Grant and Ferrell 1993; Schroeder and Thompson 1987; Shoop and Kenney 1992a; Starbird *et al.* 1993). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey (Collard 1990; Davenport and Balazs 1991; Frazier 2001; HDLNR 2002). Aerial surveys off the western U.S. support continental slope waters as having greater leatherback occurrence than shelf waters (Bowlby *et al.* 1994; Carretta and Forney 1993; Green *et al.* 1992; Green *et al.* 1993). Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon *et al.* 2010).

Areas above 30º N in the Atlantic appear to be popular foraging locations (Fossette *et al.* 2009b).

Northern foraging areas were proposed for waters between 35º and 50º N along North American, Nova Scotia, the Gulf of Saint-Laurent, in the western and northern Gulf Stream, the Northeast Atlantic, the Azores front and northeast of the Azores Islands, north of the Canary Islands. Southern foraging was proposed to occur between 5º and 15º N in the Mauritania upwelling, south of the Cape Verde islands, over the Guinea Dome area, and off Venezuela, Guyana and Suriname.

Migration and movement. Leatherback sea turtles migrate throughout open ocean convergence zones and upwelling areas, along continental margins, and in archipelagic waters (Eckert 1998; Eckert 1999; Morreale *et al.* 1994). In a single year, a leatherback may swim more than 9,600 km to nesting and foraging areas throughout ocean basins (Benson *et al.* 2007a; Benson *et al.* 2007b; Eckert 1998; Eckert 2006; Eckert *et al.* 2006; Ferraroli *et al.* 2004; Hays *et al.* 2004; Sale *et al.* 2006). Much of this travel may be due to current and eddy features moving individuals along (Sale and Luschi 2009). The return to nesting beaches may be accomplished by a form of geomagnetic navigation and use of local cues (Sale and Luschi 2009). Leatherback females will either remain in nearshore waters between nesting events, or range widely, presumably to feed on available prey (Byrne *et al.* 2009; Fossette *et al.* 2009a).
Fossette *et al.* (2009b) identified three main migratory strategies in leatherbacks in the North Atlantic (almost all of studied individuals were female). One involved 12 individuals traveling to northern latitudes during summer/fall and returning to waters during winter and spring. Another strategy used by six individuals was similar to this, but instead of a southward movement in fall, individuals overwintered in northern latitudes (30-40º N, 25-30º W) and moved into the Irish Sea or Bay of Biscay during spring before moving south to between 5 and 10º in winter, where they remained or returned to the northwest Atlantic. A third strategy, which was followed by three females remaining in tropical waters for the first year subsequent to nesting and moving to northern latitudes during summer/fall and spending winter and spring in latitudes of 40-50º N.

Satellite tracking data reveal that leatherback females leaving Mexican and Central American nesting beaches migrate towards the equator and into Southern Hemisphere waters, some passing the Galápagos Islands, and disperse south of 10ºS (Dutton *et al.* 2006; Shillinger *et al.* 2010). However, observations of leatherbacks in the Galápagos Islands are rare (Zárate *et al.* 2010).

Nesting site selection in the southwest Pacific appears to favor sites with higher wind and wave exposure, possibly as a means to aid hatchling dispersal (Garcon *et al.* 2010).

Sex ratio. A significant female bias exists in all leatherback populations studied. An examination of strandings and in-water sighting data from the U.S. Atlantic and Gulf of Mexico coasts indicates that 60% of individuals were female. Studies of Suriname nesting beach temperatures suggest a female bias in hatchlings, with estimated percentages of females hatched over the course of each season at 75.4, 65.8, and 92.2% in 1985, 1986, and 1987, respectively (Plotkin 1995). Binckley *et al.* (1998) found a heavy female bias upon examining hatchling gonad histology on the Pacific coast of Costa Rica, and estimated male to female ratios over three seasons of 0:100, 6.5:93.5, and 25.7:74.3. James *et al.* (2007) also found a heavy female bias (1.86:1) as well as a primarily large sub-adult and adult size distribution. Leatherback sex

determination is affected by nest temperature, with higher temperatures producing a greater proportion of females (Mrosovsky 1994; Witzell *et al.* 2005a).

Feeding. Leatherbacks may forage in high-invertebrate prey density areas formed by favorable features (Eckert 2006; Ferraroli *et al.* 2004). Although leatherbacks forage in coastal waters, they appear to remain primarily pelagic through all life stages (Heppell *et al.* 2003). The location and abundance of prey, including medusae, siphonophores, and salpae, in temperate and boreal latitudes likely has a strong influence on leatherback distribution in these areas (Plotkin 1995). Leatherback prey are frequently found in the deep-scattering layer in the Gulf of Alaska (Hodge and Wing 2000). North Pacific foraging grounds contain individuals from both eastern and western Pacific rookeries, although leatherbacks from the eastern Pacific generally forage in the Southern Hemisphere along Peru and Chile (Dutton 2005-2006; Dutton *et al.* 2000; Dutton *et al.* 1998). Mean primary productivity in all foraging areas of western Atlantic females is 150% greater than in eastern Pacific waters, likely resulting in twice the reproductive output of eastern Pacific females (Saba *et al.* 2007). Leatherbacks have been observed feeding on jellyfish in waters off Washington State and Oregon (Eisenberg and Frazier 1983; Stinson 1984a).

Diving. Leatherbacks are champion deep divers among sea turtles with a maximum-recorded dive of over 4,000 m (Eckert *et al.* 1989; López-Mendilaharsu *et al.* 2009). Dives are typically 50-84 m and 75-90% of time duration is above 80 m (Standora *et al.* 1984). Leatherbacks off South Africa were found to spend <1% of their dive time at depths greater than 200 m (Hays *et al.* 2009). Dive durations are impressive, topping 86 min, but routinely 1-14 min (Eckert *et al.* 1989; Eckert *et al.* 1996; Harvey *et al.* 2006; López-Mendilaharsu *et al.* 2009). Most of this time is spent traveling to and from maximum depths (Eckert *et al.* 1989). Dives are continual, with only short stays at the surface (Eckert *et al.* 1989; Eckert *et al.* 1986; Southwood *et al.* 1999). Off Playa Grande, Costa Rica, adult females spent 57–68% of their time underwater, diving to a mean depth of 19 m for 7.4 min (Southwood *et al.* 1999). Off St. Croix, adult females dove to a mean depth of 61.6 m for an average of 9.9 min, and spent an average of 4.9 min at the surface (Eckert *et al.* 1989). During shallow dives in the South China Sea, dives averaged 6.9–14.5 min, with a maximum of 42 min (Eckert *et al.* 1996).

Off central California, leatherbacks dove to 20–30 m with a maximum of 92 m (Harvey *et al.* 2006). This corresponded to the vertical distribution if their prey (Harvey *et al.* 2006). Leatherback prey in the Gulf of Alaska are frequently concentrated in the deep-scattering layer (Hodge and Wing 2000). Mean dive and surface durations were 2.9 and 2.2 min, respectively (Harvey *et al.* 2006). In a study comparing diving patterns during foraging versus travelling, leatherbacks dove shallower (mean of 53.6 m) and moved more slowly (17.2 km/day) while in foraging areas while travelling to or from these areas (81.8 m and 51.0 km/day) (Fossette *et al.* 2009b).

Vocalization and hearing. Information on the hearing capabilities of sea turtles is limited, but the information that is available suggests auditory capabilities are centered in the low-frequency range (< 1 kHz), with hearing thresholds at about 132-140 dB (Lenhardt 1994; Lenhardt *et al.* 1983; Moein Bartol and Ketten 2006; Moein Bartol *et al.* 1999; O'Hara and Wilcox 1990; Ridgway *et al.* 1969). There is some sensitivity to frequencies as low as 60 Hz, and probably as low as 30 Hz (L-DEO 2006).

Status and trends. Leatherback sea turtles received protection on June 2, 1970 (35 FR 8491) under the Endangered Species Conservation Act and, since 1973, have been listed as endangered under the ESA, but declines in nesting have continued worldwide. Breeding females were initially estimated at 29,000-40,000, but were later refined to ~115,000 (Pritchard 1971; Pritchard 1982). Spotila *et al.* (1996) estimated 34,500 females, but later issued an update of 35,860 (Spotila 2004b). The species as a whole is declining and local populations are in danger of extinction (NMFS 2001b; NMFS 2001a).

Heavy declines have occurred at all major Pacific basin rookeries, as well as Mexico, Costa Rica, Malaysia, India, Sri Lanka, Thailand, Trinidad, Tobago, and Papua New Guinea. This includes a nesting decline of 23% between 1984-1996 at Mexiquillo, Michoacán, Mexico (Sarti *et al.* 1996). Fewer than 1,000 females nested on the Pacific coast of Mexico from 1995-1996 and fewer than 700 females are estimated for Central America (Spotila *et al.* 2000). The number of leatherback turtles nesting in Las Baulas National Park declined rapidly during the 1990s, from about 1,500 females during the 1988–89 nesting season, to about 800 in 1990–91 and 1991–92 to 193 in 1993–94 (Williams *et al.* 1996) and 117 in 1998–99 (Spotila *et al.* 2000). Spotila (2004a) reported that between 59 and 435 leatherbacks nest at Las Baulas each year depending on the El Niño–La Niña cycle. Leatherbacks have rarely been observed during NSF-funded seismic surveys in the eastern tropical Pacific (Hauser *et al.* 2008; Holst and Smultea 2008; Holst *et al.* 2005; Smultea and Holst 2003).

Their decline in the western Pacific is equally severe. Nesting at Terengganu, Malaysia is 1% of that in 1950s (Chan and Liew 1996). The South China Sea and East Pacific nesting colonies have undergone catastrophic collapse. Overall, Pacific populations have declined from an estimated 81,000 individuals to <3,000 total adults and subadults (Spotila *et al.* 2000). The number of nesting leatherbacks has declined by an estimated 95% over the past 20 years in the Pacific (Gilman 2009). Drastic overharvesting of eggs and mortality from fishing activities is likely responsible for this tremendous decline (Eckert 1997; Sarti *et al.* 1996).

The Turtle Expert Working Group (2007) estimated the adult leatherback sea turtle population of the North Atlantic to be approximately 34,000-94,000 animals. The range of the estimate is large, reflecting the Working Group's uncertainty in nest numbers and their extrapolation to adults. The Working Group believes that as estimates improve the range will likely decrease. However, this is the most current estimate available. It is important to note that while the analysis provides an estimate of adult abundance for all populations in the greater North Atlantic, it does not provide estimates for the number or origin of leatherbacks in specific foraging areas, nor does it provide an estimate of subadult abundance. Trends in the adult population size estimate were not possible since trends in sex ratio and remigration rates were not available (Turtle Expert Working Group, 2007).

Critical habitat. On March 23, 1979, leatherback critical habitat was identified adjacent to Sandy Point, St. Croix, U.S.V.I. from the 183 m isobath to mean high tide level between 17° 42'12" N and 65°50'00" W (44 FR 17710). This habitat is essential for nesting, which has been increasingly threatened since 1979, when tourism increased significantly, bringing nesting habitat and people into close and frequent proximity. However, studies do not currently support significant critical habitat deterioration.

On Janauary 5, 2010, the NMFS proposed to designate critical habitat for leatherback sea turtles in waters along Washington State (Cape Flattery to the Umpqua River; 63,455 km^2) and California (Point Arena to point Vincente; 119,400 km^2). NOAA is currently working on the Final Rule to designate critical habitat along the U.S. West Coast, and the final rule is expected to be published in the Federal Register in April 2011. The primary constituent elements of these areas include (1) the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (*Chrysaora, Aurelia, Phacellophora,* and *Cyanea*) of sufficient condition, distribution, diversity, and abundance to support individual as well as population growth, reproduction, and development and (2) migratory pathway conditions to allow for safe and timely passage and access to/from/within high use foraging areas.

Hawksbill sea turtle

Distribution. The hawksbill has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical waters of the Atlantic, Indian, and Pacific oceans. Satellite tagged turtles have shown significant variation in movement and migration patterns. In the Caribbean, distance traveled between nesting and foraging locations ranges from a few kilometers to a few hundred kilometers (Byles and Swimmer 1994; Hillis-Starr *et al.* 2000; Horrocks *et al.* 2001; Lagueux *et al.* 2003; Miller *et al.* 1998; Prieto *et al.* 2001).

Population designation. Populations are distinguished generally by ocean basin and more specifically by nesting location. Our understanding of population structure is relatively poor. For example, genetic analysis of hawksbill sea turtles foraging off the Cape Verde Islands identified three closely-related haplotypes in a large majority of individuals sampled that did not match those of any known nesting population in the Western Atlantic, where the vast majority of nesting has been documented (McClellan *et al.* 2010; Monzon-Arguello *et al.* 2010).

Migration and movement. Upon first entering the sea, neonatal hawksbills in the Caribbean are believed to enter an oceanic phase that may involve long distance travel and eventual recruitment to nearshore foraging habitat (Boulon 1994). In the marine environment, the oceanic phase of juveniles (i.e., the "lost years") remains one of the most poorly understood aspects of hawksbill life history, both in terms of where turtles occur and how long they remain oceanic. Nesting site selection in the southwest Pacific appears to favor sites with higher wind and wave exposure, possibly as a means to aid hatchling dispersal (Garcon *et al.* 2010).

Habitat. Hawksbill sea turtles are highly migratory and use a wide range of broadly separated localities and habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). Small juvenile hawksbills (5-21 cm straight carapace length) have been found in association with *Sargassum* spp. in both the Atlantic and Pacific oceans (Musick and Limpus 1997) and observations of newly hatched hawksbills attracted to floating weed have been made (Hornell 1927; Mellgren and Mann 1996; Mellgren *et al.* 1994). Post-oceanic hawksbills may occupy a range of habitats that include coral reefs or other hard-bottom habitats, sea grass, algal beds, mangrove bays and creeks (Bjorndal and Bolten 2010; Musick and Limpus 1997), and mud flats (R. von Brandis, unpublished data in NMFS and USFWS 2007b). Individuals of multiple breeding locations can occupy the same foraging habitat (Bass 1999; Bowen *et al.* 1996; Bowen

et al. 2007; Diaz-Fernandez *et al.* 1999; Velez-Zuazo *et al.* 2008). As larger juveniles, some individuals may associate with the same feeding locality for more than a decade, while others apparently migrate from one site to another (Blumenthal *et al.* 2009a; Mortimer *et al.* 2003; Musick and Limpus 1997). Larger individuals may prefer deeper habitats than their smaller counterparts (Blumenthal *et al.* 2009a). Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon *et al.* 2010).

Hawksbill sea turtles appear to be rare visitors to the Gulf of Mexico, with Florida being the only Gulf state with regular sightings (Hildebrand 1983; NMFS and USFWS 1993; Rabalais and Rabalais 1980; Rester and Condrey 1996; Witzell 1983). Individuals stranded in Texas are generally young (hatchlings or yearlings) originating from Mexican nesting beaches (Amos 1989; Collard and Ogren 1990; Hildebrand 1983; Landry and Costa 1999).

Feeding. Dietary data from oceanic stage hawksbills are limited, but indicate a combination of plant and animal material (Bjorndal 1997).

Diving. Hawksbill diving ability varies with age and body size. As individuals increase with age, diving ability in terms of duration and depth increases (Blumenthal *et al.* 2009b). Studies of hawksbills in the Caribbean have found diurnal diving behavior, with dive duration nearly twice as long during nighttime (35-47 min) compared to daytime (19-26 min Blumenthal *et al.* 2009b; Van Dam and Diez 1997). Daytime dives averaged 5 m, while nighttime dives averaged 43 m (Blumenthal *et al.* 2009b).

Hawksbills have long dive durations, although dive depths are not particularly deep. Adult females along St. Croix reportedly have average dive times of 56 min, with a maximum time of 73.5 min (Starbird *et al.* 1999). Average day and night dive times were 34–65 and 42–74 min, respectively. Immature individuals have much shorter dives of 8.6–14 min to a mean depth of 4.7 m while foraging (Van Dam and Diez 1997).

Vocalization and hearing. Although information is not available regarding hawksbill sea turtle vocalizations or auditory capabilities, green and loggerhead sea turtles have been studied and are likely similar in capacity to their close relative, the hawksbill. The frequency range at which these species hear best is 50-700 Hz, with rapid diminishment of sensitivity outside of this range (Bartol and Ketten 2006; Dow *et al.* 2008; Ketten and Bartol 2006; Ridgway *et al.* 1969). Green and loggerhead sea turtles are likely incapable of hearing frequencies >1,600 Hz (Dow *et al.* 2008; Moein Bartol *et al.* 1999; Ridgway *et al.* 1969).

Status and trends. Hawksbill sea turtles received protection on June 2, 1970 (35 FR 8495) under the Endangered Species Conservation Act and since 1973 have been listed as endangered under the ESA. Although no historical records of abundance are known, hawksbill sea turtles are considered to be severely depleted due to the fragmentation and low use of current nesting beaches (NMFS and USFWS 2007b). Worldwide, an estimated 21,212-28,138 hawksbills nest each year among 83 sites. Among the 58 sites for with historic trends, all show a decline during the past 20 to 100 years. Among 42 sites for which recent trend data are available, 10 (24%) are increasing, three (7%) are stable and 29 (69%) are decreasing. Encouragingly, nesting range along Mexico and Central America appears not to have contracted

and estimates continue to increase as additional dedicated study is conducted in the eastern Pacific (Gaos *et al.* 2010).

Atlantic Ocean. Atlantic nesting sites include: Antigua (Jumby Bay), the Turks and Caicos, Barbados, the Bahamas, Puerto Rico (Mona Island), the U.S. Virgin Islands, the Dominican Republic, Sao Tome, Guadaloupe, Trinidad and Tobago, Jamaica, Martinique, Cuba (Doce Leguas Cays), Mexico (Yucatan Peninsula), Costa Rica (Tortuguero National Park), Guatemala, Venezuela, Bijagos Archipelago, Guinea-Bissau, and Brazil.

Population increase has been greater in the Insular Caribbean than along the Western Caribbean Mainland or the eastern Atlantic (including Sao Tomé and Equatorial Guinea). Nesting populations of Puerto Rico appeared to be in decline until the early 1990s, but have universally increased during the survey periods. Mona Island now hosts 199-332 nesting females annually, and the other sites combined host 51-85 nesting females annually (R.P. van Dam and C.E. Diez, unpublished data in NMFS and USFWS 2007b) C.E. Diez, Chelonia, Inc., in litt. to J. Mortimer 2006). The U.S. Virgin Islands have a long history of tortoiseshell trade (Schmidt 1916). At Buck Island Reef National Monument, protection has been in force since 1988, and during that time, hawksbill nesting has increased by 143% to 56 nesting females annually, with apparent spill over to beaches on adjacent St. Croix (Z. Hillis-Starr, National Park Service, in litt. to J. Mortimer 2006). However, St. John populations did not increase, perhaps due to the proximity of the legal turtle harvest in the British Virgin Islands (Z. Hillis-Starr, National Park Service, in litt. to J. Mortimer 2006). Populations have also been identified in Belize and Brazil as genetically unique (Hutchinson and Dutton 2007). An estimated 50-200 nests are laid per year in the Guinea-Bissau (Catry *et al.* 2009).

Pacific Ocean. American Samoa and Western Samoa host fewer than 30 females annually (Grant *et al.* 1997; Tuato'o-Bartley *et al.* 1993). In Guam, only 5-10 females are estimated to nest annually (G. Balazs, NMFS, in litt. to J. Mortimer 2007; G. Davis, NMFS, in litt. to J. Mortimer 2007) and the same is true for Hawaii, but there are indications that this population is increasing (G. Balazs, pers. comm. in NMFS and USFWS 2007b). Additional populations are known from the eastern Pacific (potentially extending from Mexico through Panama), northeastern Australia, and Malaysia (Hutchinson and Dutton 2007).

Indian Ocean. The Indian Ocean hosts several populations of hawksbill sea turtles (Hutchinson and Dutton 2007; Spotila 2004a). These include western Australian, Andaman and Nicobar islands, Maldives, Seychelles, Burma, East Africa, Egypt, Oman, Saudi Arabia, Sudan, and Yemen.

Critical habitat. On September 2, 1998, the NMFS established critical habitat for hawksbill sea turtles around Mona and Monito Islands, Puerto Rico (63 FR 46693). Aspects of these areas that are important for hawksbill sea turtle survival and recovery include important natal development habitat, refuge from predation, shelter between foraging periods, and food for hawksbill sea turtle prey.

Kemp's ridley sea turtle

Distribution. The Kemp's ridley was formerly known only from the Gulf of Mexico and along the Atlantic coast of the U.S. (TEWG 2000). However, recent records support Kemp's ridley sea turtles distribution extending into the Mediterranean Sea on occasion (Tomas and Raga 2008). The vast majority of individuals stem from breeding beaches at Rancho Nuevo on the Gulf of Mexico coast of Mexico.

Movement and migration. Tracking of post-nesting females from Rancho Nuevo and Texas beaches indicates that turtles move along coastal migratory corridors either to the north or south from the nesting beach (Byles 1989b; Byles and Plotkin 1994; Renaud 1995b; Renaud *et al.* 1996; Shaver 1999; Shaver 2002). These migratory corridors appear to extend throughout the coastal areas of the Gulf of Mexico and most turtles appear to travel in waters less than roughly 164 feet in depth. Turtles that headed north and east traveled as far as southwest Florida, whereas those that headed south and east traveled as far as the Yucatan Peninsula, Mexico (Morreale *et al.* 2007).

Following migration, Kemp's ridley sea turtles settle into resident feeding areas for several months (Byles and Plotkin 1994; Morreale *et al.* 2007). Females may begin returning along relatively shallow migratory corridors toward the nesting beach in the winter in order to arrive at the nesting beach by early spring.

Reproduction. Mating is believed to occur about three to four weeks prior to the first nesting (Rostal 2007), or late March through early to mid April. It is presumed that most mating takes place near the nesting beach (Morreale *et al.* 2007; Rostal 2007). Females initially ovulate within a few days after successful mating and lay the first clutch approximately two to four weeks later; if a turtle nests more than once per season, subsequent ovulations occur within approximately 48 hours after each nesting (Rostal 2007).

Approximately 60% of Kemp's ridley nesting occurs along an approximate 25-mile stretch of beach near Rancho Nuevo, Tamaulipas, Mexico from April to July, with limited nesting to the north (100 nests along Texas in 2006) and south (several hundred nests near Tampico, Mexico in 2006 USFWS 2006). Nesting at this location may be particularly important because hatchlings can more easily migrate to foraging grounds (Putman *et al.* 2010). The Kemp's ridley sea turtle tends to nest in large aggregations or arribadas (Bernardo and Plotkin 2007). The period between Kemp's ridley arribadas averages approximately 25 days, but the precise timing of the arribadas is unpredictable (Bernardo and Plotkin 2007; Rostal *et al.* 1997). Like all sea turtles, Kemp's ridley sea turtles nest multiple times in a single nesting season. The most recent analysis suggests approximately 3.075 nests per nesting season per female (Rostal 2007). The annual average number of eggs per nest (clutch size) is 94 to 100 and eggs typically take 45 to 58 days to hatch, depending on temperatures (Marquez-M. 1994; Rostal 2007; USFWS 2000; USFWS 2001; USFWS 2002; USFWS 2003; USFWS 2004; USFWS 2005; USFWS 2006). The period between nesting seasons for each female is approximately 1.8 to 2.0 years (Marquez *et al.* 1989; Rostal 2007; TEWG 2000). The nesting beach at Rancho Nuevo may produce a "natural" hatchling sex ratio that is female-biased, which can potentially increase egg production as those turtles reach sexual maturity (Coyne and Landry Jr. 2007; Wibbels 2007).

Growth. Kemp's ridleys require approximately 1.5 to two years to grow from a hatchling to a size of approximately 7.9 inches long, at which size they are capable of making a transition to a benthic coastal immature stage, but can range from one to four years or more (Caillouet *et al.* 1995; Ogren 1989; Schmid 1998; Schmid and Witzell 1997; Snover *et al.* 2007; TEWG 2000; Zug *et al.* 1997). Based on the size of nesting females, it is assumed that turtles must attain a size of approximately 23.6 inches long prior to maturing (Marquez-M. 1994). Growth models based on mark-recapture data suggest that a time period of seven to nine years would be required for this growth from benthic immature to mature size (Schmid and Witzell 1997; Snover *et al.* 2007). Currently, age to sexual maturity is believed to range from approximately 10 to 17 years for Kemp's ridleys (Snover *et al.* 2007). However, estimates of 10 to 13 years predominate in previous studies (Caillouet *et al.* 1995; Schmid and Witzell 1997; TEWG 2000).

Habitat. Stranding data indicate that immature turtles in this benthic stage are found in coastal habitats of the entire Gulf of Mexico and U.S. Atlantic coast (Morreale *et al.* 2007; TEWG 2000). Developmental habitats for juveniles occur throughout the entire coastal Gulf of Mexico and U.S. Atlantic coast northward to New England (Morreale *et al.* 2007; Schmid 1998; Wibbels *et al.* 2005). Key foraging areas in the Gulf of Mexico include Sabine Pass, Texas; Caillou Bay and Calcasieu Pass, Louisiana; Big Gulley, Alabama; Cedar Keys, Florida; and Ten Thousand Islands, Florida (Carr and Caldwell 1956; Coyne *et al.* 1995; Ogren 1989; Schmid 1998; Schmid *et al.* 2002; Witzell *et al.* 2005b). Foraging areas studied along the Atlantic coast include Pamlico Sound, Chesapeake Bay, Long Island Sound, Charleston Harbor, and Delaware Bay. Near-shore waters of 120 feet or less provide the primary marine habitat for adults, although it is not uncommon for adults to venture into deeper waters (Byles 1989a; Mysing and Vanselous 1989; Renaud *et al.* 1996; Shaver *et al.* 2005; Shaver and Wibbels 2007b).

Benthic coastal waters of Louisiana and Texas seem to be preferred foraging areas for Kemp's ridley sea turtles (particularly passes and beachfronts), although individuals may travel along the entire coastal margin of the Gulf of Mexico (Landry and Costa 1999; Landry *et al.* 1996; Renaud 1995a). Sightings are less frequent during winter and spring, but this is likely due to lesser sighting effort during these times (Keinath *et al.* 1996; Shoop and Kenney 1992b).

Feeding. Kemp's ridley diet consists mainly of swimming crabs, but may also include fish, jellyfish, and an array of mollusks.

Diving. Kemp's ridley sea turtles can dive from a few seconds in duration to well over two and a half hours, although most dives are from 16 to 34 minutes (Mendonca and Pritchard 1986; Renaud 1995b). Individuals spend the vast majority of their time underwater; over 12-hour periods, 89% to 96% of their time is spent below the surface (Byles 1989b; Gitschlag 1996).

Status and trends. The Kemp's ridley sea turtle was listed as endangered on December 2, 1970 (35 FR 18319). Internationally, the Kemp's ridley is considered the most endangered sea turtle (NRC 1990a; USFWS 1999).

During the mid 20th century, the Kemp's ridley was abundant in the Gulf of Mexico. Historic information indicates that tens of thousands of Kemp's ridleys nested near Rancho Nuevo, Mexico, during the late 1940s (Hildebrand 1963). From 1978 through the 1980s, arribadas were 200 turtles or less, and by 1985, the total number of nests at Rancho Nuevo had dropped to approximately 740 for the entire nesting season, or a projection of roughly 234 turtles (TEWG 2000; USFWS and NMFS 1992). Beginning in the 1990s, an increasing number of beaches in Mexico were being monitored for nesting, and the total number of nests on all beaches in Tamaulipas and Veracruz in 2002 was over 6,000; the rate of increase from 1985 to 1999 was 11.3% annually (TEWG 2000; USFWS 2002). In 2006, approximately 7,866 nests were laid at Rancho Nuevo with the total number of nests for all the beaches in Mexico estimated at about 12,000 nests, which amounted to about 4,000 nesting females based upon three nests per female per season (Rostal 2007; Rostal *et al.* 1997; USFWS 2006). Considering remigration rates, the population included approximately 7,000 to 8,000 adult female turtles at that time (Marquez *et al.* 1989; Rostal 2007; TEWG 2000). Most recently, the 2007 nesting season included an arribada of over 4,000 turtles over a three-day period at Rancho Nuevo (P. Burchfield, pers. comm. in NMFS and USFWS 2007a). The increased recruitment of new adults is illustrated in the proportion of first time nesters, which has increased from 6% in 1981 to 41% in 1994. Average population growth was estimated at 13% per year between 1991 and 1995 (TEWG 1998b). Nesting has also expanded geographically, with a headstart program reestablishing nesting on South Padre Island starting in 1978. Growth remained slow until 1988, when rates of return started to grow slowly (Shaver and Wibbels 2007a). In 2006, 101 nests were laid compared to 51 the year before (NPS 2006).

Critical habitat. NMFS has not designated critical habitat for Kemp's ridley sea turtle.

Green sea turtle

Distribution. Green sea turtles have a circumglobal distribution, occurring throughout tropical, subtropical waters, and, to a lesser extent, temperate waters.

Population designation. Populations are distinguished generally by ocean basin and more specifically by nesting location (Table 2).

Based upon genetic differences, two or three distinct regional clades may exist in the Pacific: western Pacific and South Pacific islands, eastern Pacific, and central Pacific, including the rookery at French Frigate Shoals, Hawaii (Dutton and Balazs In review; Dutton *et al.* 1996). In the eastern Pacific, green sea turtles forage from San Diego Bay, California to Mejillones, Chile. Individuals along the southern foraging area originate from Galapagos Islands nesting beaches, while those in the Gulf of California originate primarily from Michoacán. Green turtles foraging in San Diego Bay and along the Pacific coast of Baja California originate primarily from rookeries of the Islas Revillagigedos (Dutton 2003).

Table 2. Locations and most recent abundance estimates of threatened green sea turtles as annual nesting females (AF), annual nests (AN), annual egg production (EP), and annual egg harvest (EH).

Location	Most recent abundance	Reference
Western Atlantic Ocean		
Tortuguero, Costa Rica	17,402-37,290 AF	(Troëng and Rankin 2005)
Aves Island, Venezuela	335-443 AF	(Vera 2007)
Galibi Reserve, Suriname	1,803 AF	(Weijerman *et al.* 1998)
Isla Trindade, Brazil	1,500-2,000 AF	(Moreira and Bjorndal 2006)
Central Atlantic Ocean		
Ascension Island, UK	3,500 AF	(Broderick *et al.* 2006)
Eastern Atlantic Ocean		
Poilao Island, Guinea-Bissau	7,000-29,000 AN	(Catry *et al.* 2009)
Bioko Island, Equatorial Guinea	1,255-1,681 AN	(Tomas *et al.* 1999)
Mediterranean Sea		
Turkey	214-231 AF	(Broderick *et al.* 2002)
Cyprus	121-127 AF	(Broderick *et al.* 2002)
Israel / Palestine	1-3 AF	(Kuller 1999)
Syria	100 AN	(Rees *et al.* 2005)
Western Indian Ocean		
Eparces Islands	2,000-11,000 AF	(Le Gall *et al.* 1986)
Comoros Islands	5,000 AF	S. Ahamada, pers. comm. 2001
Seychelles Islands	3,535-4,755 AF	J. Mortimer, pers. comm. 2002
Kenya	200-300 AF	(Okemwa and Wamukota 2006)
Northern Indian Ocean		
Ras al Hadd, Oman	44,000 AN	S. Al-Saady, pers. comm. 2007
Sharma, Yemen	15 AF	(Saad 1999)
Karan Island, Saudi Arabia	408-559 AF	(Pilcher 2000)
Jana and Juraid Islands, Saudi Arabia	643 AN	(Pilcher 2000)
Hawkes Bay and Sandspit, Pakistan	600 AN	(Asrar 1999)
Gujarat, India	461 AN	(Sunderraj *et al.* 2006)
Sri Lanka	184 AF	(Kapurisinghe 2006)
Eastern Indian Ocean		
Thamihla Kyun, Myanmar	<250,000 EH	(Thorbjarnarson *et al.* 2000)
Pangumbahan, Indonesia	400,000 EH	(Schulz 1987)
Suka Made, Indonesia	395 AN	C. Limpus, pers. comm. '02

Western Australia	3,000-30,000 AN	R. Prince, pers. comm. 2001
Southeast Asia		
Gulf of Thailand	250 AN	Charuchinda pers. comm. 2001
Vietnam	239 AF	(Hamann *et al.* 2006a)
Berau Islands, Indonesia	4,000-5,000 AF	(Schulz 1984)
Turtle Islands, Philippines	1.4 million EP	(Cruz 2002)
Sabah Turtle Islands, Malaysia	8,000 AN	(Chan 2006)
Sipadan, Malaysia	800 AN	(Chan 2006)
Sarawak, Malaysia	2,000 AN	(Liew 2002)
Enu Island (Aru Islands)	540 AF	Dethmers, in preparation
Terengganu, Malaysia	2,200 AN	(Chan 2006)
Western Pacific Ocean		
Heron Island and southern Great Barrier Reef areas, Australia	5,000-10,000 AF	(Maison *et al.* 2010)
Raine Island and northern Great Barrier Reef areas, Australia	10,000-25,000 AF	(Limpus *et al.* 2003) (Maison *et al.* 2010)
Coringa-Herald National Nature Reserve, Australia	1,445 AF	(Maison *et al.* 2010)
Guam	45 AF	(Cummings 2002)
Phoenix Islands, Kiribati	100-300 AF	(Maison *et al.* 2010)
Ogasawara Islands, Japan	500 AF	(Chaloupka *et al.* 2007) (Maison *et al.* 2010)
Micronesia	500-1,000 AF	(Maison *et al.* 2010)
Marshall Islands	100-500 AF	(Maison *et al.* 2010)
New Caledonia	1,000-2,000 AF	
Central and Eastern Pacific Ocean		
French Frigate Shoals, Hawaii	400 AF	(Balazs and Chaloupka 2006)
Michoacán, Mexico	1,395 AF	C. Delgado, pers. comm. 2006
Central American Coast	184-344 AN	(López and Arauz 2003)
Galapagos Islands, Ecuador	1,650 AF	(Zárate *et al.* 2006)

Growth and reproduction. Most green sea turtles exhibit particularly slow growth rates, which have been attributed to their largely plant-eating diet (Bjorndal 1982). Growth rates of juveniles vary substantially among populations, ranging from <1 cm/year (Green 1993) to >5 cm/year (McDonald Dutton and Dutton 1998), likely due to differences in diet quality, duration of foraging season (Chaloupka *et al.* 2004), and density of turtles in foraging areas (Balazs and Chaloupka 2004; Bjorndal *et al.* 2000; Seminoff *et al.* 2002b). If individuals do not feed sufficiently, growth is stunted and apparently does not compensate even when greater-than-needed resources are available (Roark *et al.* 2009). In general, there is a tendency for green sea turtles to exhibit monotonic growth (declining growth rate with size) in the Atlantic and non-monotonic growth (growth spurt in mid size classes) in the Pacific, although this is not always

the case (Balazs and Chaloupka 2004; Chaloupka and Musick 1997; Seminoff *et al.* 2002b). It is estimated that green sea turtles reach a maximum size just under 100 cm in carapace length (Tanaka 2009). A female-bias has been identified from studies of green sea turtles (Wibbels 2003).

Consistent with slow growth, age-to-maturity for green sea turtles appears to be the longest of any sea turtle species and ranges from ~20-40 years or more (Chaloupka *et al.* 2004; Chaloupka and Musick 1997; Hirth 1997; Limpus and Chaloupka 1997; Seminoff *et al.* 2002b; Zug *et al.* 2002; Zug and Glor 1998). Estimates of reproductive longevity range from 17 to 23 years (Carr *et al.* 1978; Chaloupka *et al.* 2004; Fitzsimmons *et al.* 1995). Considering that mean duration between females returning to nest ranges from 2 to 5 years (Hirth 1997), these reproductive longevity estimates suggest that a female may nest 3 to 11 seasons over the course of her life. Based on reasonable means of three nests per season and 100 eggs per nest (Hirth 1997), a female may deposit 9 to 33 clutches, or about 900 to 3,300 eggs, during her lifetime. Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon *et al.* 2010).

Once hatched, sea turtles emerge and orient towards a light source, such as light shining off the ocean. They enter the sea in a "frenzy" of swimming activity, which decreases rapidly in the first few hours and gradually over the first several weeks (Ischer *et al.* 2009; Okuyama *et al.* 2009). Factors in the ocean environment have a major influence on reproduction (Chaloupka 2001; Limpus and Nicholls 1988; Solow *et al.* 2002). It is also apparent that during years of heavy nesting activity, density dependent factors (beach crowding and digging up of eggs by nesting females) may impact hatchling production (Tiwari *et al.* 2005; Tiwari *et al.* 2006). Precipitation, proximity to the high tide line, and nest depth can also significantly affect nesting success (Cheng *et al.* 2009). Precipitation can also be significant in sex determination, with greater nest moisture resulting in a higher proportion of males (Leblanc and Wibbels 2009). Green sea turtles often return to the same foraging areas following nesting migrations (Broderick *et al.* 2006; Godley *et al.* 2002). Once there, they move within specific areas, or home ranges, where they routinely visit specific localities to forage and rest (Godley *et al.* 2003; Makowski *et al.* 2006; Seminoff and Jones 2006; Seminoff *et al.* 2002a; Taquet *et al.* 2006). It is also apparent that some green sea turtles remain in pelagic habitats for extended periods, perhaps never recruiting to coastal foraging sites (Pelletier *et al.* 2003).

In general, survivorship tends to be lower for juveniles and subadults than for adults. Adult survivorship has been calculated to range from 0.82-0.97 versus 0.58-0.89 for juveniles (Chaloupka and Limpus 2005; Seminoff *et al.* 2003; Troëng and Chaloupka 2007), with lower values coinciding with areas of human impact on green sea turtles and their habitats (Bjorndal *et al.* 2003; Campbell and Lagueux 2005).

Migration and movement. Green sea turtles are highly mobile and undertake complex movements through geographically disparate habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). The periodic migration between nesting sites and foraging areas by adults is a prominent feature of their life history. After departing as hatchlings and residing in a variety of marine habitats for 40 or more years (Limpus and Chaloupka 1997), green sea turtles make their way back to the same beach from which they hatched (Carr *et al.* 1978; Meylan *et al.*

1990). Green sea turtles spend the majority of their lives in coastal foraging grounds. These areas include both open coastline and protected bays and lagoons. While in these areas, green sea turtles rely on marine algae and seagrass as their primary dietary constituents, although some populations also forage heavily on invertebrates. There is some evidence that individuals move from shallow seagrass beds during the day to deeper areas at night (Hazel 2009). However, avoidance of areas of greater than 10 m when moderate depths of 5-10 m with sea grass beds has been found, with speed and displacement from capture locations being similar at night as during the daytime (Senko *et al.* 2010a).

Habitat. Green turtles appear to prefer waters that usually remain around 20º C in the coldest month, but may occur considerably north of these regions during warm-water events, such as El Niño. Stinson (1984b) found green turtles to appear most frequently in U.S. coastal waters with temperatures exceeding 18º C. Further, green sea turtles seem to occur preferentially in drift lines or surface current convergences, probably because of the prevalence of cover and higher prey densities that associate with flotsam. For example, in the western Atlantic Ocean, drift lines commonly containing floating *Sargassum* spp. are capable of providing juveniles with shelter (NMFS and USFWS 1998a). Underwater resting sites include coral recesses, the underside of ledges, and sand bottom areas that are relatively free of strong currents and disturbance. Available information indicates that green turtle resting areas are near feeding areas (Bjorndal and Bolten 2000). Strong site fidelity appears to be a characteristic of juveniles green sea turtles along the Pacific Baja coast (Senko *et al.* 2010b).

Green sea turtles in the Gulf of Mexico tend to remain along the coast (lagoons, channels, inlets, and bays), with nesting primarily occurring in Florida and Mexico and infrequent nesting in all other areas (Landry and Costa 1999; Meylan *et al.* 1995; NMFS and USFWS 1991; USAF 1996). Foraging areas seem to be based upon seagrass and macroalgae abundance, such as in the Laguna Madre of Texas. However, green sea turtles may also occur in offshore regions, particularly during migration and development.

Feeding. While offshore and sometimes in coastal habitats, green sea turtles are not obligate plant-eaters as widely believed, and instead consume invertebrates such as jellyfish, sponges, sea pens, and pelagic prey (Godley *et al.* 1998; Hatase *et al.* 2006; Heithaus *et al.* 2002; Parker and Balazs in press; Seminoff *et al.* 2002a). A shift to a more herbivorous diet occurs when individuals move into neritic habitats, as vegetable mater replaces an omnivorous diet at around 59 cm in carapace length off Mauritania (Cardona *et al.* 2009). This transition may occur rapidly starting at 30 cm carapace length, but animal prey continue to constitute an important nutritional component until individuals reach about 62 cm (Cardona *et al.* 2010). Foraging within seagrass ecosystems by green sea turtles can be significant enough to alter habitat and ecological parameters, such as species composition (Lal *et al.* 2010).

Diving. Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, we presume that those in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed several meters in depth (Hazel *et al.* 2009; NMFS and USFWS 1998a). Recent data from Australia indicate green sea turtles rarely dive deep, staying in upper 8 m of the water column (Hazel *et al.* 2009). Here, daytime dives were shorter and shallower than were nighttime dives. Also, time spent resting and dive duration increased

significantly with decreases in seasonal water temperatures. The maximum recorded dive depth for an adult green turtle was just over 106 m (Berkson 1967), while subadults routinely dive to 20 m for 9-23 min, with a maximum recorded dive of over 1 h (Brill *et al.* 1995; I-Jiunn 2009). Green sea turtles along Taiwan may rest during long, shallow dives (I-Jiunn 2009). Dives by females may be shorter in the period leading up to nesting (I-Jiunn 2009).

Vocalization and hearing. Although very limited information is available regarding green turtle hearing, it is one of the few sea turtle species that have been studied. Based upon auditory brainstem responses green sea turtles have been measured to hear in the 50-1600 Hz range (Dow *et al.* 2008) and 100-800 Hz (Bartol and Ketten 2006) , although cochlear potential suggest a range between 60 and 1000 Hz (Ridgway *et al.* 1969). Maximum sensitivity has been found to be 200-400 Hz for subadults and 600-700 for juveniles (Bartol and Ketten 2006; Ketten and Bartol 2006). This is supported bycochlear potential estimates of 300-500 Hz from Ridgway *et al.* (1969). However, Dow *et al.* (2008) found best sensitivity between 50 and 400 Hz. Outside of this limited range, green turtles are much less sensitive to sound (Ridgway *et al.* 1969). This is similar to estimates for loggerhead sea turtles, which have most sensitive hearing between 250-1,000 Hz, with rapid decline above 1,000 Hz (Moein Bartol *et al.* 1999).

Status and trends. Federal listing of the green sea turtle occurred on July 28, 1978, with all populations listed as threatened except for the Florida and Pacific coast of Mexico breeding populations, which are endangered (43 FR 32800). The International Union for Conservation of Nature (IUCN) has classified the green turtle as "endangered."

No trend data are available for almost half of the important nesting sites, where numbers are based on recent trends and do not span a full green sea turtle generation, and impacts occurring over four decades ago that caused a change in juvenile recruitment rates may have yet to be manifested as a change in nesting abundance. The numbers also only reflect one segment of the population (nesting females), who are the only segment of the population for which reasonably good data are available and are cautiously used as one measure of the possible trend of populations.

Forty six nesting sites worldwide were examined to represent nesting abundance (Seminoff 2004). These included both large and small rookeries believed to be representative of the overall trends for their respective regions. Based on the mean annual reproductive effort, 108,761-150,521 females nest each year among the 46 sites. Overall, of the 26 sites for which data enable an assessment of current trends, 12 nesting populations are increasing, 10 are stable, and four are decreasing. Long-term continuous datasets of 20 years are available for 11 sites, all of which are either increasing or stable. Despite the apparent global increase in numbers, the positive overall trend should be viewed cautiously because trend data are available for just over half of all sites examined and very few data sets span a full green sea turtle generation (Seminoff 2004).

Pacific Ocean. Green turtles are thought to be declining throughout the Pacific Ocean, with the exception of Hawaii, from a combination of overexploitation and habitat loss (Eckert 1993b; Seminoff *et al.* 2002a). In the western Pacific, the only major (>2,000 nesting females) populations of green turtles occur in Australia and Malaysia, with smaller colonies throughout the area. Indonesian nesting is widely distributed, but has experienced large declines over the

past 50 years. Hawaii green turtles are genetically distinct and geographically isolated, and the population appears to be increasing in size despite the prevalence of fibropapillomatosis and spirochidiasis (Aguirre *et al.* 1998).

All other areas. Nesting populations are doing relatively well in the western Atlantic and central Atlantic Ocean. In contrast, populations are doing relatively poorly in Southeast Asia, the eastern Indian Ocean, and perhaps the Mediterranean.

Critical habitat. On September 2, 1998, critical habitat for green sea turtles was designated in coastal waters surrounding Culebra Island, Puerto Rico (63 FR 46693). Aspects of these areas that are important for green sea turtle survival and recovery include important natal development habitat, refuge from predation, shelter between foraging periods, and food for green sea turtle prey.

Loggerhead Sea Turtle

Distribution. Loggerheads are circumglobal occurring throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian oceans. Loggerheads are the most abundant species of sea turtle found in U.S. coastal waters.

Population designations. Five groupings represent loggerhead sea turtles by major sea or ocean basin: Atlantic, Pacific, and Indian oceans, as well as Caribbean and Mediterranean seas. As with other sea turtles, populations are frequently divided by nesting aggregation (Hutchinson and Dutton 2007).

Atlantic Ocean. Western Atlantic nesting locations include The Bahamas, Brazil, and numerous locations from the Yucatán Peninsula to North Carolina (Addison 1997; Addison and Morford 1996; Marcovaldi and Chaloupka 2007). This group comprises five nesting subpopulations: Northern, Southern, Dry Tortugas, Florida Panhandle, and Yucatán. Additional nesting occurs on Cay Sal Bank (Bahamas), Cuba, the Bahamian Archipelago, Quintana Roo (Yucatan Peninsula), Colombia, Brazil, Caribbean Central America, Venezuela, and the eastern Caribbean Islands. Genetic studies indicate that, although females routinely return to natal beaches, males may breed with females from multiple populations and facilitate gene flow Bowen *et al.* (2005). In the eastern Atlantic, we know of five rookeries from Cape Verde, Greece, Libya, Turkey, and the western Africa coast.

Indian Ocean. Loggerhead sea turtles nest along the Indian Ocean in Oman, Yemen, Sri Lanka, Madagascar, South Africa, and possibly Mozambique.

Pacific Ocean. Pacific Ocean rookeries are limited to the western portion of the basin. These sites include Australia, New Caledonia, New Zealand, Indonesia, Japan, and the Solomon Islands.

Population structure in the Pacific is comprised of a northwestern Pacific nesting aggregation in Japan and a smaller southwestern nesting aggregation in Australia and New Caledonia (NMFS 2006e). Genetics of Japanese nesters suggest that this subpopulation is comprised of genetically

distinct nesting colonies (Hatase *et al.* 2002a). Almost all loggerheads in the North Pacific seem to stem from Japanese nesting beaches (Bowen *et al.* 1995; Resendiz *et al.* 1998). The fidelity of nesting females to their nesting beach allowed differentiation of these subpopulations and the

loss of nesting at a beach means a significant loss of diversity and the beach is unlikely to be recolonized (NMFS 2006e).

Reproduction and growth. Loggerhead nesting is confined to lower latitudes temperate and subtropic zones, but is absent from tropical areas (NMFS and USFWS 1991b; NRC 1990b; Witherington *et al.* 2006b). The life cycle of loggerhead sea turtles can be divided into seven stages: eggs and hatchlings, small juveniles, large juveniles, subadults, novice breeders, first year emigrants, and mature breeders (Crouse *et al.* 1987). Hatchling loggerheads migrate to the ocean (to which they are drawn by near ultraviolet light Kawamura *et al.* 2009), where they are generally believed to lead a pelagic existence for as long as 7-12 years (NMFS 2005a). Loggerheads in the Mediterranean, similar to those in the Atlantic, grow at roughly 11.8 cm/yr for the first six months and slow to roughly 3.6 cm/yr at age 2.5-3.5. As adults, individuals may experience a secondary growth pulse associated with shifting into neritic habitats, although growth is generally monotypic (declines with age Casale *et al.* 2009a; Casale *et al.* 2009b). Individually-based variables likely have a high impact on individual-to-individual growth rates (Casale *et al.* 2009b). At 15-38 years, loggerhead sea turtles become sexually mature, although the age at which they reach maturity varies widely among populations (Casale *et al.* 2009b; Frazer and Ehrhart 1985; NMFS 2001b; Witherington *et al.* 2006).

Loggerhead mating likely occurs along migration routes to nesting beaches, as well as in offshore from nesting beaches several weeks prior to the onset of nesting (Dodd 1988a; NMFS and USFWS 1998d). Females usually breed every 2-3 years, but can vary from 1-7 years (Dodd 1988a; Richardson *et al.* 1978). Females lay an average of 4.1 nests per season (Murphy and Hopkins 1984) , although recent satellite telemetry from nesting females along southwest Florida support 5.4 nests per female per season, with increasing numbers of eggs per nest during the course of the season (Tucker 2009). The authors suggest that this finding warrants revision of the number of females nesting in the region. The western Atlantic breeding season is March-August. Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon *et al.* 2010).

The Japanese rookeries are the most significant nesting sites for loggerheads in the North Pacific, with nesting occurring on the Japanese mainland, except for Hokkaido, as well as the Ryukyu Islands to the south (Kamezaki 1989; Kamezaki *et al.* 2003; Sea Turtle Association of Japan 2010; Uchida and Nishiwaki 1995). Nesting generally occurs through summer and fall (April-August, peaking in July), with females returning every two to three years (Iwamoto *et al.* 1985). Nesting females lay at least three nests of 60 -115 eggs per nest each season, with roughly two weeks between nests (Eckert 1993b; Iwamoto *et al.* 1985; Nishimura 1994). Between nests, females appear to swim offshore into the Kuroshio Current, possibly to speed egg development (NMFS and USFWS 1998b; Sato *et al.* 1998).

Nesting in the Gulf of Mexico does occur, although primarily in Florida, with rare nests occurring along North and South Padre Island in Texas (Dodd 1988b; Hildebrand 1983).

Migration and movement. Loggerhead hatchlings migrate offshore and become associated with *Sargassum* spp. habitats, driftlines, and other convergence zones (Carr 1986). After 14-32 years of age, they shift to a benthic habitat, where immature individuals forage in the open ocean and coastal areas along continental shelves, bays, lagoons, and estuaries (Bowen *et al.* 2004; NMFS 2001b). Adult loggerheads make lengthy migrations from nesting beaches to foraging grounds (TEWG 1998a). In the Gulf of Mexico, larger females tend to disperse more broadly after nesting than smaller individuals, which tend to stay closer the nesting location (Girard *et al.* 2009). In the North Atlantic, loggerheads travel north during spring and summer as water temperatures warm and return south in fall and winter, but occur offshore year-round assuming adequate temperature. For immature individuals, this movement occurs in two patterns: a north-south movement over the continental shelf with migration south of Cape Hatteras in winter and movement north along Virginia for summer foraging, and a not-so-seasonal oceanic dispersal into the Gulf Stream as far north as the 10-15˚ C isotherm (Mansfield *et al.* 2009). Wallace *et al.* (2009) suggested differences in growth rate based upon these foraging strategies. There is conflicting evidence that immature loggerheads roam the oceans in currents and eddies and mix from different natal origins or distribute on a latitudinal basis that corresponds with their natal beaches (Monzon-Arguello *et al.* 2009; Wallace *et al.* 2009). McCarthy *et al.* (2010) found that movement patterns of loggerhead sea turtles were more convoluted when sea surface temperatures were higher, ocean depths shallower, ocean currents stronger, and chlorophyll a levels lower.

Individuals in the western Pacific also show wide-ranging movements. Loggerheads hatched on beaches in the southwest Pacific travel have been found to range widely in the southern portion of the basin, with individuals from populations nesting in Australia found as far east as Peruvian coast foraging areas still in the juvenile stage (Boyle *et al.* 2009). Individuals hatched along Japanese coasts have been found to migrate to waters off Baja California via the North Pacific Subtropical Gyre (and the Kuroshio Extension) to feed for several years before migrating back to western Pacific waters to breed (Bowen *et al.* 1995; Nichols 2005; Polovina *et al.* 2006; Polovina *et al.* 2000; Resendiz *et al.* 1998). Adult loggerheads also reside in oceanic waters off Japan (Hatase *et al.* 2002b). Habitat use off Japan may further be partitioned by sex and size (Hatase *et al.* 2002b; Hatase and Sakamoto 2004; Hatase *et al.* 2002c). Loggerheads returning to Japanese waters seem to migrate along nutrient-rich oceanic fronts (Kobayashi *et al.* 2008; Nichols *et al.* 2000; Polovina *et al.* 2000). Individuals bycaught and satellite tracked in Hawaii longline fisheries show individual movement north and south within a thermal range of 15-25º C, or 28-40º N, with juveniles following the 17-20º C isotherm (Kobayashi *et al.* 2008; Nichols *et al.* 2000; Polovina *et al.* 2004). The Transition Zone Chlorophyll Front and Kuroshio Extension Current are likely important foraging areas for juvenile loggerheads (Polovina *et al.* 2004). The Kuroshio Current off Japan may be significant for juvenile and adult loggerheads as a wintering areas for those individuals not migrating south (Hatase *et al.* 2002c).

Sighting and stranding records support loggerhead sea turtles to be common, year-round residents of the Gulf of Mexico, although their abundance is much greater in the northeastern region versus the northwestern (Davis *et al.* 2000; Fritts *et al.* 1983; Landry and Costa 1999). Loggerheads may occur in both offshore habitats (particularly around oil platforms and reefs, where prey and shelter are available; (Davis *et al.* 2000; Fritts *et al.* 1983; Gitschlag and Herczeg 1994; Lohoefener *et al.* 1990; Rosman *et al.* 1987), as well as shallow bays and sounds (which

may be important developmental habitat for late juveniles in the eastern Gulf of Mexico; (Davis *et al.* 2000; Lohoefener *et al.* 1990; USAF 1996). Offshore abundance in continental slope waters increases during the winter in the eastern Gulf of Mexico, as cooler inshore waters force individuals into warmer offshore areas (Davis *et al.* 2000).

Gender, age, and survivorship. Although information on males is limited, several studies identified a female bias, although a single study has found a strong male bias to be possible (Dodd 1988a; NMFS 2001b; Rees and Margaritoulis 2004).

Additionally, little is known about longevity, although Dodd (1988a) estimated the maximum female life span at 47-62 years. Heppell *et al.* (2003) estimated annual survivorship to be 0.81 (southeast U.S. adult females), 0.78-0.91 (Australia adult females), 0.68-0.89 (southeast U.S. benthic juveniles, and 0.92 (Australia benthic juveniles). Survival rates for hatchlings during their first year are likely very low (Heppell *et al.* 2003).

Feeding. Loggerhead sea turtles are omnivorous and opportunistic feeders through their lifetimes (Parker *et al.* 2005). Hatchling loggerheads feed on macroplankton associated with *Sargassum* spp. communities (NMFS and USFWS 1991b). Pelagic and benthic juveniles forage on crabs, mollusks, jellyfish, and vegetation at or near the surface (Dodd 1988a; Wallace *et al.* 2009). Loggerheads in the deep, offshore waters of the western North Pacific feed on jellyfish, salps, and other gelatinous animals (Dodd Jr. 1988; Hatase *et al.* 2002b). Sub-adult and adult loggerheads prey on benthic invertebrates such as gastropods, mollusks, and decapod crustaceans in hard-bottom habitats, although fish and plants are also occasionally eaten (NMFS and USFWS 1998d). Stable isotope analysis and study of organisms on turtle shells has recently shown that although a loggerhead population may feed on a variety of prey, individuals composing the population have specialized diets (Reich *et al.* 2010; Vander Zanden *et al.* 2010).

Diving. Loggerhead diving behavior varies based upon habitat, with longer surface stays in deeper habitats than in coastal ones. Off Japan, dives were shallower than 30 m (Sakamoto *et al.* 1993). Routine dives can last 4–172 min (Byles 1988; Renaud and Carpenter 1994; Sakamoto *et al.* 1990). The maximum-recorded dive depth for a post-nesting female was over 230 m, although most dives are far shallower (9-21 m(Sakamoto *et al.* 1990). Loggerheads tagged in the Pacific over the course of 5 months showed that about 70% of dives are very shallow (<5 m) and 40% of their time was spent within 1 m of the surface (Polovina *et al.* 2003; Spotila 2004a). During these dives, there were also several strong surface temperature fronts that individuals were associated with, one of 20° C at 28° N latitude and another of 17° C at 32° N latitude.

Vocalization and hearing. Information on the hearing capabilities of sea turtles is limited, but available information suggests auditory capabilities are centered in the low-frequency range (< 1 kHz), with hearing thresholds at about 132-140 dB (Lenhardt 1994; Lenhardt *et al.* 1983; Moein Bartol and Ketten 2006; Moein Bartol *et al.* 1999; O'Hara and Wilcox 1990; Ridgway *et al.* 1969). There is some sensitivity to frequencies as low as 60 Hz, and probably as low as 30 Hz (L-DEO 2006).

Status and trends. Loggerhead sea turtles were listed as threatened under the ESA of 1973 on July 28, 1978 (43 FR 32800). The NMFS recently determined that a petition to reclassify loggerhead turtles in the western North Atlantic Ocean as endangered may be warranted due to the substantial scientific and commercial information presented. The recent loggerhead status review (Conant *et al.* 2009) concluded that there are nine loggerhead distinct population segments (DPSs). These include the North Pacific Ocean DPS; the South Pacific DPS; the North Indian Ocean DPS; the Southeast Indo-Pacific Ocean DPS; the Southwest Indian Ocean DPS; the Northwest Atlantic Ocean DPS; the Northeast Atlantic Ocean DPS; the Mediterranean Sea DPS; and the South Atlantic Ocean DPS. While NMFS has not yet officially recognized these DPSs, the information provided in the status review represents the most recent and available information relative to the status of this species. On March 16, 2010 NMFS published a Notice of a Proposed Rule (75 FR 12598) to formally designate the loggerhead with these nine DPS' worldwide. The notice also stated that NMFS plans to reclassify both DPS' within the United States as endangered (N. Pacific DPS and Northwest Atlantic Ocean DPS).

The loggerhead was listed as a threatened species in 1978. Critical habitat has not been designated for the loggerhead.

There is general agreement that the number of nesting females provides a useful index of the species' population size and stability at this life stage, even though there are doubts about the ability to estimate the overall population size (Bjorndal *et al.* 2005). An important caveat for population trends analysis based on nesting beach data is that this may reflect trends in adult nesting females, but it may not reflect overall population growth rates well. Adult nesting females often account for less than 1% of total population numbers. The global abundance of nesting female loggerhead turtles is estimated at 43,320–44,560 (Spotila 2004b).

Atlantic Ocean. In the eastern Atlantic, the Cape Verde Islands support the only known loggerhead nesting assemblage, which is of at least intermediate size (Fretey 2001b); 1,071 nests were observed in 2009 (Lino *et al.* 2010). In 2000, researchers tagged over 1,000 nesting females (Erhart *et al.* 2003). Annual data from monitoring projects in Cyprus, Greece, Israel, Tunisia, and Turkey reveal total annual nesting in the Mediterranean ranging of 3,375-7,085 nests per season (Margaritoulis *et al.* 2003). Libya and the West African coast host genetically-unique breeding populations of loggerhead sea turtles as well (Hutchinson and Dutton 2007). A recently discovered nesting site along the southern Italian shores of the Ionian Sea found particularly high genetic diversity amongst nesting females (Garofalo *et al.* 2009). Nesting at Dalyan Beach, Turkey does not have an apparent trend, with between 50 and 286 nests laid annually for the past 19 years (Turkozan and Yilmaz 2008).

The greatest concentration of loggerheads occurs in the Atlantic Ocean and the adjacent Caribbean Sea, primarily on the Atlantic coast of Florida, with other major nesting areas located on the Yucatán Peninsula of Mexico, Columbia, Cuba, South Africa (EuroTurtle 2006 as cited in LGL Ltd. 2007; Márquez 1990).

Among the five subpopulations, loggerhead females lay 53,000-92,000 nests per year in the southeastern U.S. and the Gulf of Mexico, and the total number of nesting females is 32,000-56,000. All of these are currently in decline or data are insufficient to access trends (NMFS

2001b; TEWG 1998b). Loggerheads from western North Atlantic nesting aggregations may or may not feed in the same regions from which they hatch. Loggerhead sea turtles from the northern nesting aggregation, which represents about 9% of the loggerhead nests in the western North Atlantic, comprise 25-59% of individuals foraging from Georgia up to the northeast U.S. (Bass *et al.* 1998; Norrgard 1995; Rankin-Baransky 1997; Sears 1994; Sears *et al.* 1995). Loggerheads associated with the South Florida nesting aggregation occur in higher frequencies in the Gulf of Mexico (where they represent ~10% of the loggerhead captures) and the Mediterranean Sea (where they represent ~45% of loggerhead sea turtles captured). About 4,000 nests per year are laid along the Brazilian coast (Ehrhart *et al.* 2003).

Because of its size, the south Florida subpopulation of loggerheads may be critical to the survival of the species in the Atlantic, and in the past it was considered second in size only to the Oman nesting aggregation (NMFS 2006e; NMFS and USFWS 1991b). The South Florida population increased at ~5.3% per year from 1978-1990, and was initially increasing at 3.9-4.2% after 1990. An analysis of nesting data from 1989-2005, a period of more consistent and accurate surveys than in previous years, showed a detectable trend and, more recently (1998-2005), has shown evidence of a declining trend of approximately 22.3% (FFWCC 2007a; FFWCC 2007b; Witherington *et al.* 2009). This is likely due to a decline in the number of nesting females within the population (Witherington *et al.* 2009). Nesting data from the Archie Carr Refuge (one of the most important nesting locations in southeast Florida) over the last 6 years shows nests declined from approximately 17,629 in 1998 to 7,599 in 2004, also suggesting a decrease in population size[1]. Loggerhead nesting is thought to consist of just 60 nesting females in the Caribbean and Gulf of Mexico (NMFS 2006f). Based upon the small sizes of almost all nesting aggregations in the Atlantic, the large numbers of individuals killed in fisheries, and the decline of the only large nesting aggregation, we suspect that the extinction probabilities of loggerhead sea turtle populations in the Atlantic are only slightly lower than those of populations in the Pacific.

Pacific Ocean. Abundance has declined dramatically over the past 10-20 years, although loggerheads range widely from Alaska to Chile (NMFS and USFWS 1998d). Pacific nesting is limited to two major locations, Australia and Japan. Eastern Australia supported one of the major global loggerhead nesting assemblages until recently (Limpus 1985). Now, less than 500 females nest annually, an 86% reduction in the size of the annual nesting population in 23 years (Limpus and Limpus 2003). The status of loggerhead nesting colonies in southern Japan and the surrounding region is uncertain, but approximately 1,000 female loggerhead turtles may nest there; a 50-90% decline compared to historical estimates (Bolten *et al.* 1996; Dodd Jr. 1988; Kamezaki *et al.* 2003; STAJ 2002). In addition, loggerheads uncommonly occur in U.S. Pacific waters, and there have been no documented strandings of loggerheads on the Hawaiian Islands in nearly 20 years (1982-1999 stranding data). There are very few records of loggerheads nesting on any of the many islands of the central Pacific, and the species is considered rare or vagrant in this region (USFWS 1998). Overall, Gilman (2009) estimated that the number of loggerheads nesting the Pacific has declined by 80% in the past 20 years.

[1] While this is a long period of decline relative to the past observed nesting pattern at this location, aberrant ocean surface temperatures complicate the analysis and interpretation of these data. Although caution is warranted in interpreting the decreasing nesting trend given inherent annual fluctuations in nesting and the short time period over which the decline has been noted, the recent nesting decline at this nesting beach is reason for concern.

Indian Ocean. The largest known nesting aggregation occurs on Masirah and Kuria Muria Islands in Oman (Ross and Barwani 1982). Extrapolations resulting from partial surveys and tagging in 1977-1978 provided broad estimates of 19,000-60,000 females nesting annually at Masirah Island, while a more recent partial survey in 1991 provided an estimate of 23,000 nesting females (Baldwin 1992; Ross 1979; Ross 1998; Ross and Barwani 1982). Over 3,000 nests per year have been recorded on the Al-Halaniyat Islands, while along the Oman mainland of the Arabian Sea, about 2,000 nests are deposited per year (Salm 1991; Salm *et al.* 1993). Based upon genetic analyses, additional populations nest in Yemen, Sri Lanka, and Madagascar (Hutchinson and Dutton 2007). In the southwestern Indian Ocean, the highest concentration of nesting occurs on the coast of Tongaland, South Africa (Baldwin *et al.* 2003). The total number of females nesting annually in South Africa is estimated to be between 500-2,000 (Baldwin *et al.* 2003). An estimated 800-1,500 loggerheads nest annually on Dirk Hartog Island beaches along Western Australia (Baldwin *et al.* 2003).

Critical habitat. The NMFS has not designated critical habitat for loggerhead sea turtles.

VI. ENVIRONMENTAL BASELINE

Natural Sources of Stress and Mortality

Predation
While in the water, sea turtles face predation primarily by sharks and to a lesser extent by killer whales (Pitman and Dutton 2004). Tiger sharks (*Galeocerdo cuvieri*) and bull sharks (*Carcharhinus leucas*) are the species most often reported to contain sea turtle remains (Compagno 1984, Simpfendorfer *et al*. 2001, Witzell 1987). Predation by white sharks (*Carcharodon carcharias*) has also been reported (Fergusson *et al*. 2000). Hatchlings are preyed upon by herons, gulls, dogfish, and sharks.

Land predators (primarily of eggs and hatchlings) include dogs, pigs, rats, crabs, sea birds, reef fishes, groupers, feral cats, and foxes (Bell *et al.* 1994; Ficetola 2008). In some areas, nesting beaches can be almost completely destroyed and all nests can sustain some level of depredation (Ficetola 2008).

Cold Stunning
All sea turtles except leatherbacks can undergo "cold stunning" if water temperatures drop below a threshold level, which can be lethal. Kemp's ridley sea turtles are particularly prone to this phenomenon along Cape Cod (Innis *et al.* 2009).

Hybridization
A significant natural threat to hawksbill sea turtles is from hybridization of hawksbills with other species of sea turtles. This is especially problematic at certain sites where hawksbill numbers are particularly low.

Natural Beach Erosion
Natural beach erosion events may influence the quality of nesting habitat in the action area. Nesting females may deposit eggs at the base of an escarpment formed during an erosion event

where they are more susceptible to repeated tidal inundation. Erosion, frequent or prolonged tidal inundation, and accretion can negatively affect incubating egg clutches. Short-term erosion events (e.g., atmospheric fronts, northeasters, tropical storms, and hurricanes) are common phenomena throughout sea turtles' nesting range and may vary considerably from year to year. Sea turtles have evolved a strategy to offset these natural events by laying large numbers of eggs and by distributing their nests both spatially and temporally. Thus, the total annual hatchling production is never fully affected by storm-generated beach erosion and inundation, although local effects may be high. Leatherback hatching success is particularly sensitive to nesting site selection, as nests that are overwashed have significantly lower hatching success and leatherbacks nest closer to the high-tide line than other sea turtle species (Caut *et al.* 2009).

Disease and Parasites

Diseases caused by bacteria, fungus, and viruses affect sea turtles in the action area. Sea turtles are also found to have endo- and ectoparasites. A disease known as fibropapilloma (possibly viral in origin) is a major threat to listed turtles in many areas of the world. The disease is characterized by tumorous growths, which can range in size from very small to extremely large, and are found both internally and externally. Large tumors can interfere with feeding and essential behaviors, and tumors on the eyes can cause permanent blindness (Foley *et al.*, 2005). For unknown reasons, the frequency of a disease called fibropapillomatosis is much higher in green sea turtles than in other species and threatens a large number of existing subpopulations. Extremely high incidence has been reported in Hawaii, where affliction rates peaked at 47-69% in some foraging areas (Murakawa *et al.* 2000). A to-date unidentified virus may aid in the development of fibropapillomatosis (Work *et al.* 2009). Viral diseases have not been documented in free-ranging loggerheads, with the possible exception of sea turtle fibropapillomatosis, which may have a viral etiology (Herbst and Jacobson 1995, George 1997). Although fibropapillomatosis reaches epidemic proportions in some wild green turtle populations, the prevalence of this disease in most loggerhead populations is thought to be small.

At least two bacterial diseases have been described in wild loggerhead populations, including bacterial encephalitis and ulcerative stomatitis/obstructive rhinitis/pneumonia (George 1997), and *Bartonella* was recently reported in wild loggerheads from North Carolina (Valentine *et al*. 2007). There are few reports of fungal infections in wild loggerhead populations. Homer *et al*. (2000) documented systemic fungal infections in stranded loggerheads in Florida.

Parasites also affect sea turtles in the action area. For example, a variety of endoparasites, including trematodes, tapeworms, and nematodes have been described in loggerheads (Herbst and Jacobson 1995). Heavy infestations of endoparasites may cause or contribute to debilitation or mortality in sea turtles. Trematode eggs and adults were seen in a variety of tissues including the spinal cord and brain of debilitated loggerheads during an epizootic in South Florida during late 2000 and early 2001. These were implicated as a possible cause of the epizootic (Jacobson *et al*. 2006).

Ectoparasites, including leeches and barnacles, may have debilitating effects on loggerheads. Large marine leech infestations may result in anemia and act as vectors for other disease producing organisms (George 1997). Barnacles are generally considered innocuous although some burrowing species may penetrate the body cavity resulting in mortality (Herbst and

Jacobson 1995). Green sea turtles with an abundance of barnacles have been found to have a much greater probability of having health issues (Flint *et al.* 2009). Heavy loads of barnacles are associated with unhealthy or dead stranded loggerheads (Deem *et al.* 2009).

Although many health problems have been described in wild populations through the necropsy of stranded turtles, the significance of diseases on the ecology of wild populations is not known (Herbst and Jacobson 1995). However, several researchers have initiated health assessments to study health problems in free-ranging turtle populations.

Anthropogenic Sources of Stress and Mortality

Poaching
In the U.S., killing of nesting turtles is infrequent. However, on some beaches, human poaching of turtle nests and clandestine markets for eggs has been a problem (Ehrhart and Witherington 1987). From 1983 to 1989, the Florida Marine Patrol made 29 arrests for illegal possession of turtle eggs (figure not apportioned by species). In Palm Beach, Martin, and St. Lucie counties only (Florida coastal areas with what may be the highest prevalence of egg poaching), there were 33 arrests for possession or sale of sea turtle eggs from 1980 to 2002. Egg poaching is a more serious problem in Puerto Rico (Matos 1987).

Contaminants
Multiple municipal, industrial and household sources as well as atmospheric transport introduce various pollutants such as pesticides, hydrocarbons, organochlorides (e.g. DDT and PCBs), metals, and other pollutants that may cause adverse health effects to listed turtles in the action area (Iwata, 1993; Grant and Ross, 2002; Garrett, 2004; Hartwell, 2004).

The metals arsenic, cadmium, copper, mercury, selenium, and zinc bioaccumulate, with cadmium in highest concentration in leatherbacks versus any other marine vertebrate (Caurant *et al.* 1999; Gordon *et al.* 1998). A diet of primarily jellyfish, which have high cadmium concentrations, is likely the cause (Caurant *et al.* 1999). Loggerhead sea turtles have higher mercury levels than any other sea turtle studied, but concentrations are an order of magnitude less than many toothed whales (Godley *et al.* 1999; Pugh and Becker 2001b). Arsenic occurs at levels several fold more concentrated in loggerhead sea turtles than marine mammals or seabirds. Blood levels of metals are lower in Kemp's ridley sea turtles than in other sea turtles species or similar to them, with copper (215 ng/g to 1,300 ng/g), lead (0 to 34.3 ng/g), mercury (0.5 ng/g to 67.3 ng/g), silver (0.042 ng/g to 2.74 ng/g), and zinc (3,280 ng/g to 18,900 ng/g) having been identified (Innis *et al.* 2008; Orvik 1997). It is likely that blood samples can be used as an indicator of metal concentration. Mercury has been identified in all turtle species studied, but are generally an order of magnitude lower than toothed whales.

Organochlorine pesticides have also been found (Mckenzie *et al.* 1999). PCB concentrations are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (PCB 209: 500-530 ng/g wet weight Davenport *et al.* 1990; Oros *et al.* 2009). Females from sexual maturity through reproductive life should have lower levels of contaminants than males because contaminants are shared with progeny through egg formation.

Toxin burdens in Kemp's ridley sea turtles include DDT, DDE, PCBs, PFOA, PFOS, chlordane, and other organochlorines (Keller *et al.* 2005; Keller *et al.* 2004a; Lake *et al.* 1994; Rybitski *et al.* 1995). These contaminants have the potential to cause deficiencies in endocrine, developmental and reproductive health, and are known to depress immune function in loggerhead sea turtles (Keller *et al.* 2006; Storelli *et al.* 2007a). Along with loggerheads, Kemp's ridley sea turtles have higher levels of PCB and DDT than leatherback and green sea turtles (Pugh and Becker 2001a).

Green sea turtles have been found to contain the organochlorines chlordane, lindane, endrin, endosulfan, dieldrin, DDT and PCB (Gardner *et al.* 2003; Miao *et al.* 2001). Levels of PCBs found in eggs are considered far higher than what is fit for human consumption (van de Merwe *et al.* 2009). The heavy metals copper, lead, manganese, cadmium, and nickel have also been found in various tissues and life stages (Barbieri 2009). Arsenic also occurs in very high levels in green sea turtle eggs (van de Merwe *et al.* 2009).

These contaminants have the potential to cause deficiencies in endocrine, developmental, and reproductive health, and depress immune function in loggerhead sea turtles (Keller *et al.* 2006; Storelli *et al.* 2007). DDE has not been found to influence sex determination at levels below cytotoxicity (Keller and McClellan-Green 2004; Podreka *et al.* 1998). Flame retardants have been measured from healthy individuals (Hermanussen *et al.* 2008). Tissues taken from loggerheads sometimes contain very high levels of organochlorines chlorobiphenyl, chlordanes, lindane, endrin, endosulfan, dieldrin, PFOS, PFOA, DDT, and PCB (Alava *et al.* 2006; Corsolini *et al.* 2000; Gardner *et al.* 2003; Keller *et al.* 2005; Keller *et al.* 2004a; Keller *et al.* 2004b; Mckenzie *et al.* 1999; Monagas *et al.* 2008; Oros *et al.* 2009; Perugini *et al.* 2006; Rybitski *et al.* 1995; Storelli *et al.* 2007b). It appears that levels of organochlorines have the potential to suppress the immune system of loggerhead sea turtles and may affect metabolic regulation (Keller *et al.* 2004c; Keller *et al.* 2006; Oros *et al.* 2009). These contaminants could cause deficiencies in endocrine, developmental, and reproductive health (Storelli *et al.* 2007b). It is likely that the omnivorous nature of loggerheads makes them more prone to bioaccumulating toxins than other sea turtle species (Godley *et al.* 1999; Mckenzie *et al.* 1999).

Heavy metals, including arsenic, barium, cadmium, chromium, iron, lead, nickel, selenium, silver, copper, zinc, and manganese, have also been found in a variety of tissues in levels that increase with turtle size (Anan *et al.* 2001; Fujihara *et al.* 2003; Garcia-Fernandez *et al.* 2009; Gardner *et al.* 2006; Godley *et al.* 1999; Saeki *et al.* 2000; Storelli *et al.* 2008). These metals likely originate from plants and seem to have high transfer coefficients (Anan *et al.* 2001; Celik *et al.* 2006; Talavera-Saenz *et al.* 2007).

Perfluorinated compounds in the forms of PFOA and PFOS have been identified in the blood of Kemp's ridley turtles at concentrations of 39.4 ng/mL and 3.57 ng/mL, respectively (Keller *et al.* 2005). PFCAs have also been detected. It is likely that age and habitat are linked to PFC bioaccumulation.

Also of concern is the spread of antimicrobial agents from human society into the marine environment. Exposure to sewage effluent may also result in green sea turtle eggs harboring

antibiotic-resistant strains of bacteria (Al-Bahry *et al.* 2009). Loggerhead sea turtles may harbor antibiotic-resistant bacteria, which may have developed and thrived as a result of high use and discharge of antimicrobial agents into freshwater and marine ecosystems (Foti *et al.* 2009).

Beach Erosion and Control Methods

Beach erosion and control methods are the largest land threat to sea turtle recovery. Natural beach erosion and accretion that occurs necessitates human activities such as armoring, beach nourishment, groins, jetties, sand fences, and other coastal construction. Many of these beach erosion and control methods impact turtles' terrestrial nesting stage in the action area.

Beach nourishment hampers nesting success, but only in the first year post-nourishment before hatching success increases (Brock *et al.* 2009). The quality of beach habitat seaward of armoring structures on eroding sections of coastline can be expected to diminish as the shoreline recedes. Impacts also can occur if the installation of structures takes place during the nesting season. Unmarked nests can be crushed or uncovered by heavy equipment. Vibrations and water runoff from jetting operations during installation of structures can damage nests as well.

Construction of groins and jetties during the nesting season may result in the destruction of nests, disturbance of females attempting to nest, and disorientation of emerging hatchlings from project lighting. Following construction, the presence of groins and jetties may interfere with nesting turtle access to the beach, result in a change in beach profile and width (downdrift erosion, loss of sandy berms, and escarpment formation), trap hatchlings, and concentrate predatory fishes, resulting in higher probabilities of hatchling predation.

Sand fences, also known as snow fences and drift fences, are erected to build and stabilize dunes by trapping sand moving along the beach and by preventing excessive sand loss. Additionally, these fences can protect dune systems by deterring foot traffic. Sand fences are constructed of narrowly spaced wooden or plastic slats or plastic fabric. If improperly placed, sand fencing may act as a barrier to nesting females or trap hatchlings (National Research Council 1990a). The placement of sand fencing during the nesting season may result in destruction of unmarked nests.

In addition to shoreline protection activities, there are a variety of other coastal construction activities that may affect sea turtles. These include construction, repair, and maintenance of upland structures and dune crossovers; installation of utility cables; installation and repair of public infrastructure (such as coastal highways and emergency evacuation routes); and construction equipment and lighting associated with any of these activities. Many of these activities may alter nesting habitat and harm nests, adults, and hatchlings as described previously for coastal armoring.

Ecosystem Degradation

In addition to impacting the terrestrial zone, anthropogenic disturbances also threaten coastal marine habitats, particularly areas rich in seagrass and marine algae. These impacts include contamination from herbicides, pesticides, oil spills, and other chemicals, as well as structural degradation from excessive boat anchoring and dredging (Francour *et al.* 1999; Lee Long *et al.* 2000; Waycott *et al.* 2005). Further, the introduction of alien algae species threatens the stability

of some coastal ecosystems and may lead to the elimination of preferred dietary species of green sea turtles (De Weede 1996).

Benthic habitat alteration by mobile fishing gear, especially trawls and dredges, constitutes a globally significant physical disturbance to the marine environment and has significant effects on marine biodiversity (Watling and Norse 1998). Mobile fishing gear has been shown to result in short and long-term changes in benthic community composition, including species groups on which loggerheads forage (Gordon *et al*. 1998). The National Research Council (1994) found that habitat alteration by fishing activities is perhaps the least understood of the important environmental effects of fishing. Trawling destroys habitat utilized by Kemp's ridley sea turtles for feeding and construction activities can produce hazardous runoff. The effects of benthic habitat alteration on loggerhead prey abundance and distribution, and the effects of these potential changes on loggerhead populations, have not been determined but are of concern. Hawksbills are typically associated with coral reefs, which are among the world's most endangered marine ecosystems (Wilkinson 2000).

Human Presence

Human presence, especially on shore, can disturb both juvenile and adult sea turtles.
The ever-growing human population in coastal areas and the corresponding increase in recreational boating, fishing, and diving can result in behavioral disturbances to resting, foraging, and migrating turtles. Continuous, intense boat traffic in neritic habitats may result in abandonment of previously used foraging or resting areas, and intense diver/snorkeler activity may result in displacement of turtles from preferred resting or foraging areas.

The greatest threat posed by humans on the beach at night is disturbance of female turtles before they have finished nesting. From the time a female exits the surf until she has begun covering her nest, she is highly vulnerable to disturbance, especially prior to and during the early stages of egg laying. Females that abort a nesting attempt may attempt to nest again at or near the same location or select a new site later that night or the following night. However, repeated interruption of nesting attempts may cause a turtle to construct her nest in a sub-optimum incubation environment, postpone nesting for several days, prompt movement many kilometers from the original chosen nesting site, or result in the shedding of eggs at sea (Murphy 1985). Direct harassment may also cause adult turtles to reduce the time spent covering the nest (Johnson *et al*. 1996). Visitors using flashlights or lanterns or lighting campfires on the beach at night during the nesting season may deter nesting females from coming ashore and may disorient hatchlings (Mortimer 1989). In addition, heavy pedestrian traffic may compact sand over unmarked nests (Mann 1977), although the effect of this compaction has not been determined and may be negligible (Arianoutsou 1988). Depending on the nesting substrate, pedestrian traffic over nests near the time of emergence can cause nests to collapse and result in hatchling mortality (Mann 1977, Dutton *et al*. 1994). A study in Japan found loggerhead nests laid in beach areas with pedestrian access had higher rates of dead pipped hatchlings than nests laid in restricted beach zones (Kudo *et al*. 2003).

Beach Cleaning

Beach cleaning to collect debris and trash may damage nests and hatchlings. Several methods are used to clean beaches, including mechanical raking, hand raking, and picking up debris by hand.

In mechanical raking, heavy machinery can repeatedly traverse nests and potentially compact the sand above them. Mann (1977) suggested that mortality within nests might increase when externally applied pressure from beach-cleaning machinery is common on soft beaches with large-grain sand. Beach cleaning vehicles also may leave ruts along the beach that hinder or trap emergent hatchlings (Hosier *et al*. 1981). Mechanically pulled rakes and hand rakes, particularly if the tongs are longer than 10 cm, penetrate the beach surface and may disturb incubating nests or uncover pre-emergent hatchlings near the surface of the nest.

Recreational Beach Equipment
The use and storage of lounge chairs, cabanas, umbrellas, catamarans, and other types of recreational equipment on the beach can hamper or deter nesting by adult females and trap or impede hatchlings during their nest to sea migration. The documentation of non-nesting emergences (also referred to as false crawls) at these obstacles is becoming increasingly common as more recreational beach equipment is left on the beach at night. Sobel (2002) describes nesting turtles being deterred by wooden lounge chairs that prevented access to the upper beach.

Artificial Lighting
Lights on or adjacent to nesting beaches alter nesting adult behavior and is often fatal to emerging hatchlings as they are drawn to light sources and away from the sea (Bourgeois *et al.* 2009; Cowan *et al.* 2002; Deem *et al.* 2007; Witherington 1992; Witherington and Bjorndal 1991). Witherington (1986) noted that loggerheads aborted nesting attempts at a greater frequency in lighted areas. Because adult females rely on visual brightness cues to find their way back to the ocean after nesting, those turtles that nest on lighted beaches may become disoriented (unable to maintain constant directional movement) or misoriented (able to maintain constant directional movement but in the wrong direction) by artificial lighting and have difficulty finding their way back to the ocean. In some cases, misdirected nesting females have crawled onto coastal highways and have been struck and killed by vehicles.

Beach Vehicular Driving
The presence of vehicles on the beach has the potential to negatively impact sea turtles by running over nesting females, hatchlings, stranded turtles that have washed ashore, and nests. In addition, the ruts left by vehicles in the sand may prevent or impede hatchlings from reaching the ocean following emergence from the nest (Mann 1977, Hosier *et al*. 1981, Cox *et al*. 1994, Hughes and Caine 1994). Hatchlings impeded by vehicle ruts are at greater risk of death frompredation, fatigue, desiccation, and being crushed by additional vehicle traffic. Vehicle lights and vehicle movement on the beach after dark can deter females from nesting and disorient hatchlings. Sand compaction due to vehicles on the beach may hinder nest construction and hatchling emergence from nests. Driving directly above incubating egg clutches can cause sand compaction, which may decrease hatching success and directly kill pre-emergent hatchlings (Mann 1977). Additionally, vehicle traffic on nesting beaches may contribute to erosion, especially during high tides or on narrow beaches where driving is concentrated on the high beach and foredune.

Operating privately owned vehicles on nesting beaches for recreational purposes or beach access is allowed on certain beaches in North Carolina. These areas are Fort Fisher State Recreation Area, Carolina Beach, Freeman Park, Onslow Beach, Emerald Isle, Indian Beach/Salter Path,

Pine Knoll Shores, Atlantic Beach, Cape Lookout National Seashore, Cape Hatteras National Seashore, Nag's Head, Kill Devil Hills, Town of Duck, and Currituck Banks.

Marina and Dock Development
Developing marinas and private or commercial docks in inshore waters can negatively impact turtles through destruction or degradation of foraging habitat. Sanger and Holland (2002) found that docks were not a major source of environmental contamination in South Carolina; however, dock construction was associated with suburban development, which represented a major source of environmental degradation to tidal creeks and associated marsh habitats. Dock proliferation may also result in increased boat and vessel traffic and higher propeller and collision related mortality. Fueling facilities at marinas can result in the discharge of oil, gas, and sewage into sensitive estuarine habitats.

Entanglement with Marine Debris
Sea turtles have been found entangled in a wide variety of materials, including steel and monofilament line, synthetic and natural rope, plastic onion sacks, and discarded plastic netting materials (Balazs 1985; Plotkin and Amos 1988). The alignment of persistent marine debris along convergences, rips, and driftlines, and the concentration of young sea turtles along these fronts, increases the likelihood of entanglement at this life history stage (Carr 1987, Witherington 2002).

Power Generation
The entrainment and entrapment of turtles in saltwater cooling intake systems of coastal power plants has been documented in North Carolina (Carolina Power and Light Company 2003). Average annual incidental capture rates for most coastal plants from which captures have been reported amount to several turtles per plant per year.

Numerous alternative energy source projects are under consideration in state and Federal waters off most states, and a growing number are operating as pilots or test facilities. Wind power, generated by enormous windmills sited in neritic habitats, is cause for concern with regard to the effects of construction, artificial lighting, noise, and potential ecosystem alterations on turtles. The conversion of wave or tidal energy into power is cause for concern when these projects are located in turtle habitats, especially adjacent to nesting beaches. Each of these facilities is likely to be tethered to the seafloor and connected via benthic cables to the shore.

Vessel Strikes
Propeller and collision injuries from boats and ships are common in sea turtles. From 1997 to 2005, 14.9% of all stranded loggerheads in the U.S. Atlantic and Gulf of Mexico were documented as having sustained some type of propeller or collision injuries although it is not known what proportion of these injuries were post or ante-mortem. The incidence of propeller wounds has risen from approximately 10% in the late 1980s to a record high of 20.5% in 2004 (NMFS, unpublished data).

Military Activities
Military training activities that occur on coastal bases in the southeast U.S. (*i.e*., Camp Lejeune Marine Corps Base in North Carolina) have the potential to increase non-nesting emergences of nesting females, run over nesting females and emerging hatchlings, and destroy nests.

Ingestion of Marine Debris
Ingestion of plastic and other marine debris is another source of morbidity and mortality (Stamper *et al.* 2009). Sea turtles have been found to ingest a wide variety of debris items, such as plastic bags, raw plastic pellets, plastic and styrofoam pieces, tar balls, and balloons. In a review of available information on debris ingestion, Balazs (1985) reported that tar balls were the second most prevalent type of debris ingested by sea turtles. Effects of debris ingestion can include direct obstruction of the gut, absorption of toxic byproducts, and reduced absorption of nutrients across the gut wall (Balazs 1985). Studies conducted by Lutz (1990) revealed that both loggerhead and green turtles actively ingested small pieces of latex and plastic sheeting. Physiological data indicated a possible interference in energy metabolism or gut function, even at low levels of ingestion. Persistence of the material in the gut lasted from a few days to 4 months (Lutz 1990). Sublethal effects of debris ingestion have an unknown, but potentially great, negative effect on the demography of sea turtles (Bjorndal *et al*. 1994).

Plastic ingestion is very common in leatherbacks and can block gastrointestinal tracts leading to death (Mrosovsky *et al.* 2009). Green sea turtles stranded in Brazil were all found to have ingested plastics or fishing debris (n=34), although mortality appears to have results in three cases (Tourinho *et al.* 2009). Marine debris ingestion can also be a widespread issue for loggerhead sea turtles. More than one-third of loggerheads found stranded or bycaught had injected marine debris in a Mediterranean study, with possible mortality resulting in some cases (Lazar and Gračan 2010).

Convergence lines, including *Sargassum* rafts, constitute an important habitat for neonate and juvenile loggerheads (Witherington 2002). Convergence at these habitats sweeps together neonate sea turtles with the floating substrates they forage among, but these same forces also concentrate buoyant petroleum, plastics, and other anthropogenic debris. Neonate turtles ingest this debris at a high frequency and incur mortality from its effects.

Fisheries Interactions
Fisheries interactions are the largest in-water threat to sea turtle recovery. Wallace *et al.* (2010) estimated that between 1990 and 2008, at least 85,000 sea turtles were captured as bycatch in fisheries worldwide. This estimate is likely at least two orders of magnitude low, resulting in a likely bycatch of nearly half a million sea turtles annually (Wallace *et al.* 2010).

Of all commercial and recreational fisheries in the U.S., shrimp trawling is the most detrimental to the recovery of sea turtle populations. In a 1990 study, the National Academy of Sciences estimated that between 5,000 and 50,000 loggerheads were killed annually by the offshore shrimping fleet in the southeast U.S. Atlantic and Gulf of Mexico (National Research Council 1990a). Mortality associated with shrimp trawls was estimated to be 10 times greater than that of all other human-related factors combined. Most of these turtles were neritic juveniles, the life

stages most critical to the stability and recovery of sea turtle populations (Crouse *et al*. 1987, Crowder *et al*. 1994).

Other trawl fisheries operating in waters under Federal jurisdiction that are known to capture sea turtles include, but are not limited to, summer flounder, calico scallop, Atlantic sea scallop, blue crab, whelk, cannonball jellyfish, horseshoe crab, and mid-Atlantic directed finfish trawl fisheries and the *Sargassum* fishery. The summer flounder fishery is the only trawl fishery (other than the shrimp fishery) with federally mandated TED use, in certain areas, as a result of high mortality rates. In the winter of 1991-1992, Epperly *et al*. (1995a) estimated a total of 1,063 sea turtle captures in the flounder fishery, and 89 to 191 of the captures were estimated as mortalities.

Dredge fishing gear is the predominant gear used to harvest sea scallops off the mid- and northeastern Atlantic coast. Sea scallop dredges are composed of a heavy steel frame and cutting bar located on the bottom part of the frame and a bag, made of metal rings and mesh twine, attached to the frame. The gear is fished along the bottom and weighs from 500-1,000 pounds (National Research Council 2002). Turtles can be struck and injured or killed by the dredge frame and/or captured in the bag where they may drown or be further injured or killed when the catch and heavy gear are dumped on the vessel deck.

Pound nets are fixed gear composed of a series of poles driven into the bottom upon which netting is suspended. Pound nets basically operate like a trap with the pound constructed of a series of funnels leading to a bag that is open at the top, and a long (200 to 400 m) linear "hedge" or leader of netting that extends from shallow to deeper water where the pound is located. In some configurations, the leader is suspended from the surface by a series of stringers or vertical lines. Sea turtles incidentally captured in the pound, which is composed of small mesh webbing, are usually safe from injury and may be released easily when the fishermen pull the nets (Mansfield *et al*. 2002a). However, sea turtle mortalities have been documented in the leader of certain pound nets. Large mesh leaders (greater than 12-inch stretched mesh) may act as a gillnet, entangling sea turtles by the head or foreflippers (Bellmund *et al*. 1987) or may act as a barrier against which turtles may be impinged (NMFS, unpublished data).

Pots/traps are commonly used to target crabs, lobsters, and fishes. These traps vary in size and configuration, but all are attached to a surface float by means of a vertical line leading to the trap. Turtles can become entangled in vertical lines below the surface of the water and subsequently drown. In other instances, stranded turtles have been recovered entangled in vertical lines with the trap in tow.

Bycatch, particularly by longline fisheries, is a major source of mortality for turtles (Crognale *et al.* 2008; Fossette *et al.* 2009a; Gless *et al.* 2008; Petersen *et al.* 2009). Wallace *et al.* (2010) estimated that between 1990 and 2008, at least 85,000 sea turtles were captured as bycatch in fisheries worldwide. This estimate is likely at least two orders of magnitude low, resulting in a likely bycatch of nearly half a million sea turtles annually (Wallace *et al.* 2010); many of these turtles are expected to be leatherbacks.

Fisheries in the State of North Carolina impact sea turtles within the action area. The gillnet fisheries and their history was previously explained in the Consultation History section. Haul seines and channel nets have been reported to take loggerheads in North Carolina (NMFS 2001), but it is not known how many, if any, loggerhead mortalities are caused by these fisheries. In South Carolina, channel nets are required to use TEDs (Epperly *et al*. 2002).

Dredging/Sand Mining

Periodic dredging of sediments from navigational channels is necessary to provide for the passage of large commercial, military, and recreational vessels. The negative impacts of dredging include destruction or degradation of habitat and incidental mortality of sea turtles. Channelization of inshore and nearshore habitat and the subsequent disposal of dredged material in the marine environment can destroy or disrupt resting or foraging grounds (including grass beds and coral reefs) and may affect nesting distribution by altering physical features in the marine environment (Hopkins and Murphy 1980).

Climate Change

Climate change has the potential to impact listed sea turtles through sea level rise and increased temperatures. One of the most certain consequences of climate change is rising sea levels (Titus and Narayanan 1995), which will result in increased erosion rates along nesting beaches. This could particularly impact areas with low-lying beaches where sand depth is a limiting factor, as the sea will inundate nesting sites and decrease available nesting habitat (Daniels *et al*. 1993, Fish *et al*. 2005, Baker *et al*. 2006). The loss of habitat as a result of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis *et al*. 2006, Baker *et al*. 2006). On some undeveloped beaches, shoreline migration will have limited effects on the suitability of nesting habitat. Bruun (1962) hypothesized that during a sea level rise a typical beach profile will maintain its configuration but will be translated landward and upward. However, along developed coastlines, and especially in areas where erosion control structures have been constructed to limit shoreline movement, rising sea levels will cause severe effects on nesting females and their eggs. Erosion control structures can result in the permanent loss of dry nesting beach or deter nesting females from reaching suitable nesting sites (National Research Council 1990a). Nesting females may deposit eggs seaward of the erosion control structures potentially subjecting them to repeated tidal inundation.

Increasing temperatures may increase feminization of nests (Hawkes *et al.* 2007b; James *et al.* 2006; McMahon and Hays 2006; Mrosovsky *et al.* 1984). Rapidly increasing global temperatures may result in warmer incubation temperatures and highly female-biased sex ratios (e.g., Glen and Mrosovsky 2004). Future impacts from climate change and global warming may result in significant changes in hatchling sex ratios. The fact that hawksbill turtles exhibit temperature-dependent sex determination (Wibbels 2003) suggests that there may be a skewing of future hawksbill cohorts toward strong female bias (since warmer temperatures produce more female embryos). Climate change may also affect loggerhead sex ratios. Loggerhead turtles exhibit temperature-dependent sex determination. Loggerhead sea turtles are very sensitive to temperature as a determinant of sex while incubating. Ambient temperature increase by just 1º-

2º C can potentially change hatchling sex ratios to all or nearly all female in tropical and subtropical areas (Hawkes *et al.* 2007a). Over time, this can reduce genetic diversity, or even population viability, if males become a small proportion of populations (Hulin *et al.* 2009).

Scientific Research

Sea turtles in the action area have been the subject of numerous scientific research activities as authorized by NMFS permits. Research activities for sea turtles range from photographing, weighing, and tagging sea turtles incidentally taken in fisheries, instrument attachment, blood and fecal sampling, biopsy sampling, lavage, and performing laparoscopy on intentionally captured turtles. Four permits, including the proposed action, authorize takes for sea turtle mortality. There are currently 7 active permits directed towards sea turtles in the action area.

Table 3. Current research permits authorizing directed takes of the target sea turtle species in the action area.

Permit No.	Permit Holder	Expiration Date
1551	NMFS Southeast Fisheries Science Center (SEFSC)	July 1, 2013
1552	NMFS SEFSC	June 30, 2011
1570	NMFS SEFSC	December 31, 2011
1571	NMFS SEFSC	December 31, 2011
1576	NMFS NEFSC	September 30, 2011
13543	South Carolina Department of Natural Resources	April 30, 2014
14249	Coonamessett Farm Foundation, Inc	October 31, 2014

Table 4. Types of research activities authorized by active permits. The sex and age class of animals affected varies by permit, as does the time of year and frequency of activity. Current proposed action is in **bold.**

Permit No.	Capture	Blood sampling	Fecal sampling / lavage	Laparo-scopy	Tissue sampling	Attach instruments	Tags or marks	Mortality
1551	√	√	√	√	√	√	√	
1552					√		√	
1570	√				√		√	√
1571					√		√	
1576	√				√		√	√
13543							√	
14249	√	√			√	√	√	√
15135	√							√

Before any research permit is issued, the proposal must be reviewed under the permit regulations (i.e., must show a benefit to the species). In addition, since issuance of the permit is a federal activity, issuance of the permit by the NMFS must also be reviewed for compliance with section 7(a)(2) of the ESA to ensure that issuance of the permit does not result in jeopardy to the species.

Authorized "takes" by harassment represent substantial research effort relative to species abundance in the action area with repeated disturbances of individuals likely to occur each year. However, all permits for sea turtles contain conditions requiring the permit holders to coordinate their activities with the NMFS regional offices and other permit holders and, to the extent possible, share data to avoid unnecessary duplication of research.

The fact that multiple permitted "takes" of listed sea turtles is already permitted and is expected to continue to be permitted in the future, means that short term behavioral harassment expected to listed sea turtles from similar research activities has the ability to contribute to or even exacerbate the non-lethal stress responses generated from other threats occurring in the action area. The point at which this leads to a measurable cumulative impact on the survival and recovery of listed whales and/or sea turtles, however, is uncertain. Our ability to detect long-term effects from research activities will depend on several factors including our ability to better detect sub-lethal effects from research actions as well as funding and prioritizing long-term studies investigating survival and reproductive abilities of listed species targeted by similar types of research in the past. This may lead to statistically significant trends showing whether or not repeated non-lethal disturbances by research activities are affecting the ability of listed sea turtles to survive and recover in the wild to an appreciable degree.

Lack of Effective International Protection

Sea turtles are migratory and therefore require participation between multiple countries to create an umbrella of protection and recovery techniques throughout their entire range. The Inter-American Convention for the Protection and Conservation of Sea Turtles provides the legal framework for countries in the Americas and the Caribbean to take actions for the benefit of sea turtles. Regional Fishery Management Organizations (RFMO's) such as the International Commission for the Conservation of Atlantic Tunas can create recommendations aimed at sea turtle bycatch under its managed fisheries; however, this is not an RFMO's main function. The Convention on Trade in Endangered Species (CITES) regulates the trade of sea turtles; most, but not all nations have signed on to CITES and some nations have been found in violation of their signatory duties under CITES. The lack of a major international agreement to conserve and protect sea turtles is a major obstacle to sea turtle protection and recovery.

Conservation and Management

In 1999, the North Carolina sea turtle stranding network noted significant increases in sea turtle strandings throughout Pamlico Sound. Subsequent observations and consultations between state, federal, and industry representatives implicated the large mesh southern flounder fishery as a primary cause of sea turtle takes in this area (Gearhart 2001). This resulted in an emergency rule closing southeastern Pamlico Sound to large mesh gillnets. The North Carolina Division of Marine Fisheries (NCDMF) applied for and received a section 10 Incidental Take Permit in 2000 establishing the Pamlico Sound Gillnet Restricted Area (PSGNRA). The PSGNRA was part of a conservation plan to protect sea turtles and monitors limited shallow water gillnet operations along the Outer Banks and mainland side of Pamlico Sound in the fall of each year.

In the summer and fall of 2009, a NMFS alternative platform gillnet observer program throughout Core Sound, North Carolina (adjacent to Pamlico Sound) indicated increased sea turtle interactions in large mesh gillnet fisheries. Subsequenty, the NCDMF implemented

management measures (e.g. yardage restrictions, mesh restrictions) in an attempt to eliminate these interactions. Subsequent NMFS and NCDMF observations continue to depict sea turtle interactions in these large mesh gillnet fisheries.

NMFS has implemented a series of regulations aimed at reducing potential for incidental mortality of sea turtles from commercial fisheries in the action area. These include sea turtle release gear requirements for the Atlantic Highly Migratory Species Fishery, Gulf of Mexico reef fish, and South Atlantic snapper-grouper fishery, and TED requirements for Southeast shrimp trawl fishery. NMFS published a final rule on July 6, 2004, to implement management measures to reduce bycatch and bycatch mortality of Atlantic sea turtles in the Atlantic pelagic longline fishery (69 FR 40734). The management measures include mandatory circle hook and bait requirements, and mandatory possession and use of sea turtle release equipment to reduce bycatch mortality. In the Hawaii-based longline swordfish fishery which required vessels to switch from using a J-shaped hook with squid bait to a wider circle-shaped hook with fish bait has reduced capture rates of leatherback and loggerhead turtles significantly by 83% and 90% respectively (Gilman *et al.*, 2007). There was also a highly significant reduction in the proportion of turtles that swallowed hooks (versus being hooked in the mouth or body or entangled) and a highly significant increase in the proportion of caught turtles that were released after removal of all terminal tackle, which could lead to the likelihood of turtles surviving the interaction (Read 2007).

NMFS has implemented a series of regulations aimed at reducing potential for incidental mortality of sea turtles in commercial shrimp trawl fisheries. In particular, NMFS has required the use of TEDs in southeast United States shrimp trawls since 1989 and in summer flounder trawls in the Mid-Atlantic area (south of Cape Charles, Virginia) since 1992. It has been estimated that TEDs exclude 97 percent of the sea turtles caught in such trawls (Cox *et al.*, 2007). These regulations have been refined over the years to ensure that TEDs are properly installed and used where needed to minimize the impacts on sea turtles. On August 3, 2007, NMFS published a final rule required selected fishing vessels to carry observers on board to collect data on sea turtle interactions with fishing operations, to evaluate existing measures to reduce sea turtle takes, and to determine whether additional measures to address prohibited sea turtle takes may be necessary (72 FR 43176).

In March 2002, NMFS published new restrictions for the use of gillnets with larger than 8-inch stretched mesh operating in federal waters (3-200 nautical miles) off North Carolina and Virginia. These restrictions were published in an interim final rule under the authority of the ESA (67 FR 13098) and were implemented to reduce the impact of the monkfish and other large-mesh gillnet fisheries on ESA-listed sea turtles in areas where sea turtles are known to concentrate. In addition to regulations, outreach programs have been established and data on sea turtle interactions with recreational fisheries has been collected through the Marine Recreational Fishing Statistical Survey.

NMFS published a final rule (66 FR 67495, December 31, 2001) detailing handling and resuscitation techniques for sea turtles that are incidentally caught during scientific research or fishing activities. Those participating in fishing activities or scientific

research are required to handle and resuscitate (as necessary) sea turtles as prescribed in the final rule. These measures help to prevent mortality of hard-shelled turtles caught in fishing or scientific research gear. There is also an extensive network of Sea Turtle Stranding and Salvage Network participants along the Atlantic and Gulf of Mexico coasts who not only collect data on sea turtle mortality, but also rescue and rehabilitate any live stranded sea turtles that are encountered.

VII. Effects of the Proposed Action

Pursuant to Section 7(a)(2) of the ESA, federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The proposed activities authorized by permit 15135 would expose loggerhead, Kemp's ridley, leatherback, hawksbill, and green sea turtles to gillnets with and without LED lights attached, handling, and tagging. In this section, we describe the potential physical, chemical, or biotic stressors associated with the proposed action, the probability of individuals of listed species being exposed to these stressors based on the best scientific and commercial evidence available, and the probable responses of those individuals (given probable exposures) based on the available evidence. As described in the *Approach to the Assessment* section, for any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, and lifetime reproductive success), the assessment would consider the risk posed to the viability of the population(s) those individuals comprise and to the listed species those populations represent. The purpose of this assessment is to determine if it is reasonable to expect the proposed studies to have effects on listed species that could appreciably reduce their likelihood of surviving and recovering in the wild.

For this consultation, we are particularly concerned about behavioral disruptions that may result in animals that fail to feed or breed successfully or fail to complete their life history because these responses are likely to have population-level consequences. The proposed permit would authorize non-lethal "takes" by harassment of listed species during research activities. The ESA does not define harassment nor has NMFS defined the term pursuant to the ESA through regulation. However, the Marine Mammal Protection Act of 1972, as amended, defines harassment as any act of pursuit, torment, or annoyance which has the potential to injure a sea turtle or sea turtle population in the wild or has the potential to disturb a sea turtle or sea turtle population in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [16 U.S.C. 1362(18)(A)]. The latter portion of this definition (that is, "...causing disruption of behavioral patterns including...migration, breathing, nursing, breeding, feeding, or sheltering") is almost identical to the U.S. Fish and Wildlife Service's regulatory definition of "harass"[2] pursuant to the ESA. For this Opinion, we define harassment similarly: an intentional or unintentional human act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents.

[2] An intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3)

A. Potential Stressors

The assessment for this consultation identified the following potential stressors: 1) gillnet capture or entanglement; 2) handling (including marking, measuring, etc.); 3) tagging; 4) LED lights; and 5) unintentional mortality/removal of sea turtles from the population (see Table 5 for take numbers by species associated with each stressor). Activities are expected to occur in Core Sound, North Carolina until December 31, 2012.

Table 5. Possible stressors to listed sea turtles associated with proposed permit No. 15135.

Species	Life Stage	Take	Take Action	Procedures
Green sea turtle	Adult/Subadult/ Juvenile	16	Capture, Handle, Release	Bycatch reduction gillnet experiment; mark, flipper tag; mark, PIT tag; measure; photo/video
Green sea turtle	Adult/Subadult/ Juvenile	15	Unintentional mortality	Bycatch reduction gillnet experiment; measure; unintentional mortality
Kemp's ridley sea turtle	Adult/Subadult/ Juvenile	13	Capture, Handle, Release	Bycatch reduction gillnet experiment; mark, flipper tag; mark, PIT tag; measure; photo/video
Kemp's ridley sea turtle	Adult/Subadult/ Juvenile	5	Unintentional mortality	Bycatch reduction gillnet experiment; measure; unintentional mortality
Loggerhead sea turtle	Adult/Subadult/ Juvenile	10	Capture, Handle, Release	Bycatch reduction gillnet experiment; mark, flipper tag; mark, PIT tag; measure; photo/video
Loggerhead sea turtle	Adult/Subadult/ Juvenile	5	Unintentional mortality	Bycatch reduction gillnet experiment; measure; unintentional mortality
Hawksbill sea turtle	Adult/Subadult/ Juvenile	2	Capture, Handle, Release	Bycatch reduction gillnet experiment; mark, flipper tag; mark, PIT tag; measure; photo/video; including unintentional mortality
Leatherback sea turtle	Adult/Subadult/ Juvenile	2	Capture, Handle, Release	Bycatch reduction gillnet experiment; mark, flipper tag; mark, PIT tag; measure; photo/video; including unintentional mortality

Based on a review of available information, we determined that the presence of LED lights on gillnets would not pose a risk to listed species. LED lights associated with the proposed studies are not expected to pose a measurable risk to listed sea turtles given that they are non-toxic and have very little potential to break free of the gillnet. We expect the lights to be non-toxic, as they are encased in polycarbonate and designed for rugged use in the longline industry. The only possible toxicity within the light unit is from the two Energizer AA batteries inside the sealed unit which are protected from water with two "o" rings. Electralume LED lights have been tested to over 2300 feet without failure, and in the proposed study they would be in the water at a depth of no more than three feet. Energizer batteries would be used and contain less than 12 grams of lithium per cell. All lights will be inspected for failure during each deployment and retrieval of the net. In addition, the lights will be attached to the nets with longline clips which are designed to hold large pelagic fish to the longline and we do not expect that lights will separate from the net and become marine debris. Thus, the LED configuration and clips would pose very minimal risk to sea turtles in the way of toxicity or marine debris.

Accordingly, the effects analysis of this consultation focused on the following potential stressors: 1) gillnet capture or entanglement; 2) handling (including marking, measuring, etc.); 3) tagging; and 4) unintentional mortality/removal of sea turtles from the population.

B. Exposure Analysis

Exposure analyses identify the co-occurrence of ESA-listed species with the actions' effects in space and time, and identify the nature of that co-occurrence. The Exposure Analysis identifies, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the actions' effects and the population(s) or subpopulation(s) those individuals represent.

Table 5 identifies the numbers of different species of sea turtles that are expected to be exposed until December 31, 2012 in Core Sound, North Carolina. Each species would be exposed to gillnets with LED light attachments, handling, and tagging.

In the Core Sound, North Carolina, proposed activities could capture 18 Kemp's ridley, 15 loggerhead, 31 green, 2 hawksbill, and 2 leatherback sea turtles. Of the captured turtles, 5 Kemp's ridleys, 5 loggerheads, 15 greens, 2 hawksbills, and 2 leatherbacks could be possible observed mortalities. (Post-release mortalities are also estimated in the Responses of Sea Turtles to Gillnet Capture portion of the effects section.)

Take Number Calculations. A power analysis was conducted to determine how many matched pair net sets (or total number of yards of gillnet deployed) would be required to result in a similar LED gillnet catch reduction to the Wang *et al*. (2009) study. This analysis also determined the number of takes that could occur per species throughout the study.

A total yardage of 1,000 yard per vessel was chosen because a goal of the proposed study is to identify a commercial gillnet gear that may have the potential to be utilized by fishermen and allow for increased protection for sea turtles. It was determined that a reduction of yardage less than 1,000 yards per vessel may not offset operational costs. Therefore, the chosen yardage of 1,000 yards per vessel would be enough to make it worthwhile for the fishery while at the same

time being statistically valid study design to obtain the desired reduction in sea turtle bycatch. In addition, a yardage of 1,000 would provide statistical power to detect bycatch reduction potential in the LED light nets. The power analysis conducted is reported as follows.

The problem considered in the statistical design was that standard gillnets are exhibiting some degree of turtle catch. Therefore, the experimental LED lighted net, which has shown the capability in another study to reduce sea turtle catch, was to be compared against the standard in a matched pairs design. The proposed study would deploy two independent 1,000-yard nets per day. Each 1,000 yard net would have ten 100-yard segments alternating control/no lights and experimental/LED lights attached. Thus, each 1,000 yard deployment will result in 5 matched pairs. With two deployments per day for 30 days, this design would produce 5x2x30=300 matched pairs of 100-yard gillnet segments.

NMFS alternative platform observations in Core Sound, North Carolina from 2009 recorded 23 turtle interactions from a total of 31,747 yards of gillnet. This is a CPUE of 23 turtles/31,747 * 1,000 yards = 0.72 turtles per 1,000 yards of gillnet, or approximately 0.7 turtles per 1,000 yards of gillnet. The CPUE of 0.7 turtles per 1,000 yards translates to 0.07 turtles per each 100-yard gillnet segment. The power curve (on right) shows that, for the proposed study using 300 matched pairs of 100-yard units provides almost 100% power to detect an 80% reduction in turtle interaction rate, about 95% power to detect a 70% reduction, and about 85% power to detect a 60% reduction.

For the estimation of turtle take from this netting yardage, the following Table 6 shows estimated turtle take for several possible reduction scenarios using the proposed 300 matched pairs of 100-yard gillnet segments. The left side of the table calculates estimates using the estimated interaction proportion for control net segments, namely 0.07 or 7%. The right half of the table incorporates uncertainty using the upper 95% confidence limit for the estimated interaction proportion, 0.10 or 10%. So, using the upper 95% confidence limit to incorporate uncertainty, and in the worst case scenario that the experimental net did not reduce interactions, the proposed study could expect around 60 turtle interactions.

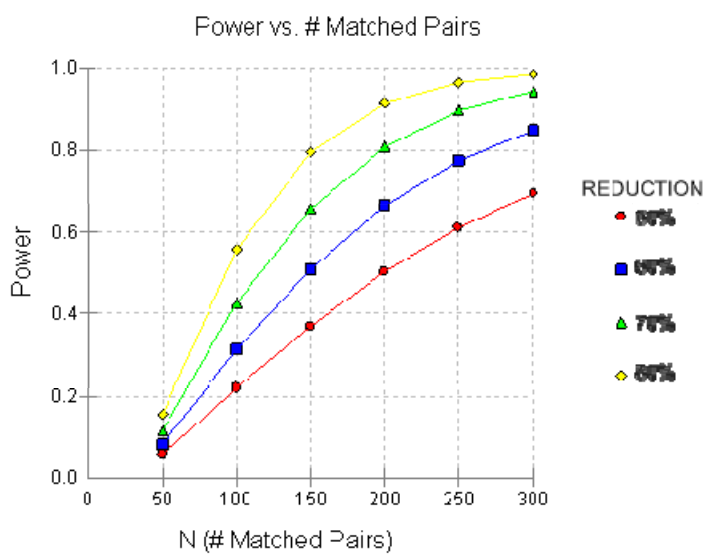


Table 6. Estimated Expected Interactions in Proposed Study using N=300 Matched Pairs

SCENARIO	Using Estimated Proportion=0.07		Total Est. Turtle Take	Using Upper 95% Conf. Lim=0.10		Total Est. Turtle Take
	Standard Net	**Exptl. Net**		**Standard Net**	**Exptl. Net**	
Exptl. Net shows no reduction	21	21	42	30	30	60
Exptl. Net shows 25% reduction	21	15.75	37	30	22.5	53
Exptl. Net shows 50% reduction	21	10.5	32	30	15	45
Exptl. Net shows 75% reduction	21	5.25	26	30	7.5	38

Using the proportions of captures by species and status upon capture (alive or dead), Tables 6-8 were generated for estimated sea turtle takes by species. Data was again used from the NMFS 2009 alternative platform observer program and showed a total of 23 observed sea turtle takes. Applying the relative proportion by species relative to the total number of sea turtle interactions observed shows about half of the interactions were green sea turtles. Of the remaining half, Kemp's ridley and loggerhead sea turtles were evenly split.

Table 7. Sea turtle takes observed in Core Sound by NMFS alternative platform survey from June - November 2009 depicted by species and disposition.

Species	Alive	Dead	Totals	Rel. % of Total
Green	7	5	12	52
Kemp's	5	1	6	26
Loggerhead	4	1	5	22
Totals	**16**	**7**	**23**	**100**

Using the worst case scenario of estimated takes (n=60) from table 6 above, and applying the proportion of takes by species and status (dead or alive) from Table 7 observed in Core Sound, a breakdown of anticipated takes by species and status for the proposed study was generated in Table 8. In case of the unlikely event of increased ineractions during the study year, an additional two mortalities are requested for each species including a request of two rare hawksbill and two rare leatherback sea turtle interactions.

Table 8. Requested sea turtle takes for Core Sound 2010 Gillnet Light Study. Take estimates based upon above power analysis, estimated takes, and applying proportions from direct observations.

Species	Alive	Dead	Total
Green	16	15	31
Kemp's ridley	13	3	16
Loggerhead	10	3	13
Totals	**39**	**21**	**60**
Hawksbill	na *	na *	2
Leatherback	na *	na *	2
Grand Total			**64**

* Interactions with Hawksbill and Leatherback are requested as rare event; takes are not anticipated for these species.

Duration of Exposure. Under proposed permit 15135, exposure to proposed activities would occur until the expiration of the permit, December 31, 2012. The duration of each exposure depends on the duration of net entanglement, and duration of handling for tagging and measuring purposes, and whether or not resuscitation is needed. For a sea turtle that is captured, retrieved, tagged, and measured, we expect that turtle to be exposed for a maximum of 14 hours. This exposure is based on a worst case scenario that estimates that a sea turtle could potentially be caught immediately in a set gillnet, as gillnets could remain in the water for a maximum of 12 hours unattended, and then would need to be resuscitated, which would take 2 hours. A more normal exposure scenario would be 8 hours and 30 minutes. This estimate describes a situation in which a turtle may be caught in a net for the entire time it's set at the low end of the time scale (net sets are anywhere from 8-12 hours), and then handled for measuring and tagging at 30 minutes. We expect that nets would be set on the low end of the time range, since the project has also incorporated marine mammal avoidance measures.

The matched pair sampling design would allow for a total of ten matched paired samples each fishing day. The proposed study would be conducted for 30 days (60 fishing trips) for a total of the 300 matched net set pairs.

Stocks Exposed. This biological opinion treats sea turtle populations in the Atlantic Ocean as distinct from the Pacific Ocean populations for the purposes of this consultation. This approach is supported by interagency policy on the recognition of distinct vertebrate populations

(61 Federal Register 4722). This approach is also consistent with traditional jeopardy analyses: the loss of sea turtle populations in the Atlantic basin would result in a significant gap in the distribution of each turtle species, which makes these populations biologically significant. Finally, the loss of these sea turtle populations in the Atlantic basin would dramatically reduce the distribution and abundance of these species and would, by itself, appreciably reduce the entire species‘ likelihood of surviving and recovering in the wild.

There are two listed populations of green sea turtle that were listed before the 1978 ESA amendments that restricted population listings to "distinct population segments of vertebrate species." These are the Florida & Mexico's Pacific coast breeding colonies (endangered) and green sea turtles in all other areas (threatened). Due to the inability to distinguish between these populations away from the nesting beach, green turtles are considered endangered wherevery they occur in U.S. waters.

C. Response Analysis

As discussed in the *Approach to the Assessment* section of this Opinion, response analyses determine how listed resources are likely to respond after being exposed to an action’s effects on the environment or directly on listed species themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might reduce the fitness of individuals. Ideally, response analyses would consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences. We examine responses on a range of increasing severity to the individuals, which includes behavioral, sub-lethal, and lethal responses. Afterward, we examine the populations’ potential responses to the loss of individuals.

1. Responses of Sea Turtles to Gillnet Capture

The proposed permit amendment 15135 would authorize capture of up to 68 sea turtles (for a take breakdown by species and disposition, see Table 1) in shallow water gillnets. Capture would be necessary to achieve a discernable reduction in sea turtle catch between control nets and experimental nets with LED lights.

Turtles would be captured using a large mesh gillnet. Both control and experimental gillnets would be constructed identically (5 3/4 inch stretch mesh; 15 meshes deep; # 177 twine; 20 lb lead core lead line, and 5/16 inch float line). Green (Lindgen-Pitman Elactralume) LED fishing lights would be placed along the floatline at 10 m intervals along the nets. The floatline would have floating buoy lines (~5 ft in length) attached to each end. Reduced line length is made feasible because the nets would be deployed in shallow water (1-3 feet). Nets will be set during night time hours until daylight for a total of 8-12 hours unattended.

We evaluated the effects of gillnet capture to sea turtle species and found that sea turtles exhibit short-term physical and physiological manifestations with evidence of long-term effects to the fitness of some individuals. In the following section, we outlined typical responses of sea turtles for all species examined in this Opinion. We also outlined factors that could influence the way in which a sea turtle may respond to capture or various factors influencing the intensity of

capture effects. We found that a percentage of sea turtles may die as a result of capture, either in the net or upon post-release. The preceeding section 2 (Species' Response to Effects of Capture) examines each species' response as a result of the removal of turtles from the population.

Effects Resulting from Capture

A sea turtle can experience effects that are either sublethal or lethal when it is captured in a gillnet, and there are multiple factors that influence severity of capture effects. Capture could cause physical injuries such as restricted access to air, intense struggling, injuries to soft tissue or the shell, and physiologic injuries such as induction of a systemic stress response, hypoxia, or various other changes in blood chemistry (Gregory *et al.* 1996, Boettcher 2000, Jessop *et al*. 2004). Finally, when a turtle is so entangled that it cannot breathe properly or cannot reach the surface for air, the turtle can drown as a result of forced submergence (Sasso and Epperly 2006).

Physical Injuries

Physical injuries have been observed during scientific studies. Turtles in North Carolina that Snoddy and Williard (2010) recovered post-release had injuries due to barnacles on the soft tissue being ripped off by the gillnet. Another turtle was seen to have some pink inflammation and pink markings from the gillnet (Snoddy and Williard 2010). Snoddy *et al.* (2009) classified all sea turtles caught in their gillnets according to physical grade A through D based on reflex response level, activity level, and presence-absence and severity of net-inflicted physical external injuries. Out of 18 turtles captured, most were physical grade B (medium activity level, all reflexes present and good, minor injuries) and C (medium activity level, missing or delayed reflexes, moderate injuries).

Factors Making Sea Turtles Prone to Capture Injuries

There are many factors that make sea turtles prone to capture injuries. Sea turtles are particularly prone to entanglement as a result of their body configuration and behavior. Records of stranded or entangled sea turtles reveal that fishing debris can wrap around the neck or flipper, or body of a sea turtle and severely restrict swimming or feeding. Sea turtles may also experience constriction of appendages as a result of the entanglement. Constriction may cut off blood flow, causing deep gashes, some severe enough to remove an appendage.

Factors Influencing Intensity of Capture Injuries

Some factors may influence the intensity of effects resulting from capture, such as the size or species of the turtle, ambient water temperature, and multiple submergences. Larger sea turtles are capable of longer voluntary dives than small turtles, so juveniles may be more vulnerable to entanglement stress. Larger turtles have a larger lung capacity than smaller turtles and, the bigger the turtle, the greater chance it has of reaching the surface after being entangled. Larger turtles are more susceptible to injury if dropped on deck or when coming into contact with the vessel while in the water (Ryder *et al*. 2006). Leatherbacks could be more vulnerable to injury than other species because of their friable skin, softer tissue, bone structure, and increased susceptibility to anoxia (Ryder *et al*. 2006). During the warmer months, routine metabolic rates are higher, so the impacts of the stress due to entanglement may be magnified at that time.

Wounds and Wound Healing
Turtles that receive entanglement injuries must go through a period of wound healing, during which they may become more susceptible to other injuries or stressors. The injury healing process may affect the physiological stress response. Concentrations of circulating corticosterone were significantly different between loggerheads with healing injuries and their controls (Alderson 2009). Loggerheads show a high resiliency to injuries, as most injuries examined by Alderson (2009) in a study were found to be predominantly healed.

Physiological Injuries/Stress
Capture may result in profound physiological changes which are detectable by analysis of blood chemistry. Since sea turtles rely on anaerobic metabolism during periods of activity, struggles to escape fishing gear would likely result in the build-up of lactate, metabolic acidosis, and changes in ion concentrations in sea turtles' blood that could have deleterious effects on normal physiological function (Stabenau *et al.* 1991, Hoopes *et al*. 2000, Harms *et al*. 2003, Stabenau and Vietti 2003). In addition, an increase in the adrenal steroid hormone corticosterone could result (Aguirre *et al*. 1995, Gregory *et al*. 1996, Jessop *et al.* 2004). The presence of elevated levels of heat shock proteins (HSP) in sea turtle blood may also be indicative of the degree of stress experienced by turtles as a result of capture (Southwood and Swimmer 2006).

Sea turtles that are forcibly submerged undergo respiratory and metabolic stress that can lead to severe disturbance of their acid-base balance. Sea turtles subjected to forced submergence exhibit alterations in blood lactate concentration indicative of metabolic acidosis, as well as shifts in blood ion concentrations (sodium, chloride, and potassium) indicative of disruptions in cellular homeostasis compensation for respiratory acidosis (Stabenau *et al*. 1991, Harms *et al*. 2003, Stabenau and Vietti 2003, Snoddy *et al*. 2009).

Factors Intensifying Physiological Injury/Stress
It is likely that the rapidity and extent of the physiological changes that occur during forced submergence are functions of the intensity of struggling as well as the length of submergence (Lutcavage and Lutz, 1997). As an example, increased entanglement time and decreased physical grade account for an increase in plasma lactate and glucose (Snoddy *et al*. 2009). In addition, elevated levels of phosphorous found in sea turtle blood can indicate tissue damage, since inorganic phosphates leak out of damaged cells and into the bloodstream (Bishop *et al.* 2004). Hypoxia and restraint from entanglement can cause changes in sea turtle blood chemistry. They can exhibit a decrease in blood pH (Harms *et al.* 2003). Gregory *et al.* (1996) noted a 3-fold increase above control values for plasma corticosterone, a hormone which indicates stress.

Post-Release Vulnerability
Sea turtles become very vulnerable after release, which could lead to additional stress or even mortality. Prolonged anaerobiosis due to entanglement in fishing gear or restraint may leave sea turtles exhausted and vulnerable to other threats upon release from gear (Snoddy *et al*. 2009). These sea turtles subjected to forced submergence may require extended periods of time at the surface to rest, recover, and repay oxygen debt (Stabineau and Vietti 2003). Severe disruption of physiological homeostasis and induction of the systemic stress response may result in alterations of normal diving and foraging patterns and leave sea turtles susceptible to other threats, such as

predators, boat strikes, and further encounters with commercial fisheries (Southwood and Swimmer 2006). Finally, capture and handling activities could have markedly affected a turtle's metabolic rate (St. Aubin and Geraci 1988), reproduction (Mahmoud and Licht 1997), and hormone levels (Gregory *et al.*1996).

Factors Affecting the Intensity of Post-Release Vunerability
Many factors can affect the intensity of post-release vulnerability. Entanglement time, depth of entanglement, and severity of entanglement may have an effect on the health status of turtles upon release from a gillnet and effect probability of post-release survival (Snoddy *et al.* 2009). Turtles are probably more susceptible to lethal metabolic acidosis if they experience multiple captures in a short period of time, because they would not have had time to process lactic acid loads (*in* Lutcavage and Lutz 1997).

Post-Release Recovery Descriptions
Although it appears that entanglement netting can result in temporary changes in blood chemistry of sea turtles and other vulnerabilities, it also appears that animals immediately placed back into a marine environment after removal from the gear can recover from the short-term stress of capture (Hoopes *et al.* 2000). Some researchers report that the effects of the entanglement and forced submergence are expected to dissipate within a day (Stabenau and Vietti 1999). Hoopes *et al*. (2000) conclude that entanglement netting is an appropriate "low-stress" method for researchers working on turtles in shallow, coastal areas. Capturing sea turtles in nets is stressful to the turtle, however this stress does not always appear to be life threatening.

Sublethal effects that might have an impact on sea turtles are loss of growth, delayed development, diminished productivity, and delayed time to maturity. These remain very different to quantify with the amount of information available. Sublethal effects might outweigh lethal effects due to impacts at the population level, but these effects are uncertain.

Post-Release Mortality
Sea turtles caught in shallow water gillnets (such as those to be used in the proposed study) are frequently released alive, however their fate remains uncertain. The incidence of in-net mortality for turtles caught in shallow-set gillnets is low compared with deep-set gillnets (Gearhart 2001, Price 2005). It is speculated that sea turtles caught in shallow-set gillnets are still capable of reaching the surface to breathe and therefore the risk of drowning in the nets is reduced (Gearhart 2001). However, there is the possibility that turtles may get the bottom of the net tightly wrapped around their neck or flipper, preventing them from reaching the surface - even in a shallow net. Observer reports and data from fishermen indicate that most sea turtles released from shallow gillnets are typically released alive (Gearhart 2001). However, their fate after release remains unknown. Injuries and physiological stresses occurring as a result of net entanglement could lead to post-release mortality (Lutcavage and Lutz 1991, Harms *et al*. 2003, Stabenau and Vietti 2003, Snoddy *et al*. 2009).

Rates of sea turtle post-release mortality have not yet been adequately quantified, and available estimates remain controversial. Current estimates are based on a combination of known recorded mortality, cessation of transmissions from satellite tags, and captive studies where captured turtles were placed in tanks and turtles were observed over time (longline capture, Aguilar *et al.*

1995). The range of available post-release mortality estimates for *longline* entanglement or hooking is extremely variable and reported at 8-95% post-release mortality (Swimmer *et al*. 2002). The range of available post-release mortality estimates for *gillnet* entanglement in North Carolina (Cape Fear River) could be as low as 7.1% and as high as 28.6% (Snoddy and Williard 2010).
Snoddy and Williard (2010) studied movements and post-release mortality of juvenile sea turtles released from gillnets in the lower Cape Fear River, North Carolina. In their study, 14 juvenile green and Kemp's ridley turtles were satellite tagged in the Cape Fear River and tracked to decipher post-release mortality within the first 30 days after release from shallow water gillnets (set for 4 hours). The study also combined a blood biochemistry analysis by taking blood samples prior to release. Mortalities were either confirmed (located the carcass), suspected (displayed satellite transmission patterns indicative of mortality), or survivors (did not display satellite transmission patterns indicative of mortality). There was one confirmed mortality, three suspected mortalities, and 10 survivors. Snoddy and Williard estimate that post-release mortality from 4-hour-soaked shallow water gillnets could be as low as 7.1% and as high as 28.6%.

Blood samples were also taken prior to release in order to determine if confirmed or suspected dead turtles had different values for plasma concentrations. The confirmed mortality had a very high plasma lactate concentration compared with baseline values reported in literature, producing a plasma concentration of Na^+ that was approximately two times the mean of suspected mortalities and survivors, a plasma concentration of Cl^- that was approximately three times higher than the mean for suspected mortalities and survivors, and the highest plasma concentration of K^+ in the study. This difference was not statistically significant, probably due to low sample size.

Expected Post-Release Mortality
Assessing the extent of non-lethal capture effects on individual turtles is difficult. The limited observer information makes it difficult to estimate the survival rate for entangled turtles. However, only active turtles that appear healthy would be released. The permit would require the resuscitation of comatose turtles and the transfer of turtles to rehabilitation facilities if necessary. This required treatment and care if needed would be expected to minimize the chances of post-release mortality.

After examining the available post-release mortality estimates for gillnets in the action area, we determined that the best available estimates are from the Snoddy and Williard (2010) study described above. We decided to err on the side of caution in analyzing the effects of the research using Snoddy and Williard's high range post-mortality estimate (28.6%), to assume that approximately 30% of the remaining 13 Kemp's ridley, 10 loggerhead, 16 green, 2 hawksbill, and 2 leatherback could be expected to die post-release (see Table 1 for take numbers and disposition). While the fishery and net soak time of the Snoddy and Williard's study (where the 30% figure came from) is not identical to the one that would be involved in the issuance of this permit 15135, it is similar and use of 30% represents a reasonable, conservative estimate based on available knowledge. Therefore, applying the 30% and conservatively rounding would mean that an additional 4 Kemp's ridley, 3 loggerhead, 5 green, 1 hawksbill, and 1 leatherback could die post-release. The following response section 2 analyzes the species' response as a result of the potential removal of these numbers of species from their populations.

Capture Response Summary
In conclusion, we expect sea turtles to respond similarly to the literature reported above. We expect that capture could result in physical or phyisiological injury or stress responses to individual turtles. A number of factors, such as size, species, water temperature, severity of entanglement, and others can intensify the effects resulting from capture. Some turtles may die as a direct result of being entangled in the net, or some time after release (post-release mortality). NMFS expects that, while most turtles will suffer none or short-term injuries and recover relatively quickly, some turtles are estimated to perish from the proposed capture activities. Thus, a discussion of these deaths to the sea turtle populations follows below.

2. Species' Response to Effects of Capture

Actions that result in mortality affect listed species through the impact of the loss of individual animals and also through the loss of the reproductive potential of each animal to its respective population. Similarly, serious injuries to listed species due to an action that result in an animal's inability to reproduce affects a listed species due to the loss of that animal's reproductive potential. These effects have the potential to reduce the likelihood of survival and recovery of the species as a whole.

Sea turtle mortality as a result of the proposed activities affects listed species through the obvious impact of the loss of individual turtles and also through the loss of the reproductive potential of each turtle lost to the population. NRC (1990) estimates that the reproductive value of an adult loggerhead is 584 times that of an egg or hatchling, because so few eggs or hatchlings survive to maturity. Sea turtles are long-lived and some species delay sexual maturity for several decades. For example, loggerheads and green turtles may reach sexual maturity at 22 to 30 years of age, or 30 to 60 years of age, respectively. While exact numbers vary between species, all can lay hundreds of eggs every 2 to 4 years. Thus, the death of adult or juvenile females could potentially preclude the production of thousands of eggs and hatchlings, though most of these would not survive to sexual maturity. NMFS is not aware of a disproportionate mortality of female sea turtles in this gillnet fishery, and none is anticipated for the activities specified in the proposed action. Mortality of males would preclude their contribution to future generations, though it is difficult to quantify this impact given the minimal data on male sea turtles. The sea turtles killed in this gillnet fishery, based on current information, are primarily (and perhaps exclusively) immature.

Loggerhea Sea Turtles
The northern subpopulation has not shown a detectable increase at nesting beaches. Although long-term data show an increase in the south Florida subpopulation, recent date collected under the standardized Index Nesting Beach Survey (INBS) program indicate a possible increasing trend in 2010.

The proposed permit would authorize the take of 10 loggerheads, of which 3 are estimated to be potential post-release mortalities. In addition, the proposed permit authorizes 5 observed loggerhead mortalities during capture. Thus, the proposed permit could potentially result in 8 lethal takes of loggerhead sea turtles. Based on studies of loggerheads in North Carolina from strandings and in-water population studies, the proportionate representation of northern

loggerheads from that group is about 28-32% (NOAA Fisheries, unpublished data; Bass *et al*. 1998). Applying this proportion to the anticipated lethal takes, approximately 2-3 immature loggerheads of the northern subpopulation would be killed. Although other subpopulations may contribute, the remaining 5-6 loggerheads would likely be from the southern subpopulation. The total number of loggerhead turtles occupying Pamlico Sound (a larger adjacent sound also in the Pamlico-Albemarle Estuarine Complex) during the fall months is in the many thousands, given that a fishery caught an average of 2,370 individual loggerheads a year in the mid-90's. If that fishery caught the entire transient loggerhead population in Pamlico Sound, then the maximum mortality in the permit might represent less than 1% of the transient population. The Turtle Expert Working Group has estimated that the total benthic loggerhead population in U.S. waters is over 200,000. However, this estimate has been called into question. The estimate is expected to be correct on the order of magnitude level, so a removal of 8 lethal takes from this loggerhead population would represent approximately .01%.

It is difficult to measure the effect that these removal percentages would have on the entire population. Since the northern subpopulation is the most vulnerable and represents only a small percentage, it is likely that the annual reproductive output from the northern subpopulation will produce individuals that would survive and replace the loss of 8 loggerheads. Therefore, the capture methodology as proposed is not likey to reduce the viability of this population as listed under the ESA. Thus, the activities from the proposed activities would not be expected to directly or indirectly reduce appreciably the likelihood of both the survival and recovery of the loggerhead sea turtle in the wild by reducing the reproduction, numbers, and distribution of this species.

Kemp's Ridley Sea Turtles

The proposed permit would authorize the take of 13 Kemp's ridley sea turtles, of which 4 are estimated to be potential post-release mortalities. In addition, the proposed permit authorizes 5 observed Kemps ridley mortalities during capture. Thus, the proposed permit could potentially result in 9 lethal takes of Kemp's ridley sea turtles. The total population of Kemp's ridleys is not known, but nesting has been increasing significantly in the past several years with a favorable trajectory toward recovery goals. The rapid increase in nesting indicates that juvenile survivorship is high and is providing an increasing number of new recruits to the population. The majority of Kemp's ridley turtles taken in this fishery are juveniles. The additional anticipated lethal take of 9 Kemp's ridley sea turtles would not likely reverse the increases observed in the nesting population. Therefore, the capture methodology as proposed is not likey to reduce the viability of this population as listed under the ESA. Thus, the proposed activities would not be expected to, directly or indirectly, reduce appreciably the likelihood of both survival and recovery of the Kemp's ridley in the wild by reducing the reproduction, numbers, and distribution of the species.

Green Sea Turtles

The proposed permit would authorize the take of 16 green sea turtles, of which 5 are estimated to be potential post-release mortalities. In addition, the proposed permit authorizes 15 observed green sea turtle mortalities during capture. Thus, the proposed permit could potentially result in 20 lethal takes of green sea turtles. The take is anticipated to include only juveniles/subadults. The total population of green sea turtles is not known, but nesting activity in Florida and the

major Caribbean nesting beach at Tortuguero, Costa Rica, has increased over the long-term. At Tortuguero, Costa Rica, the estimated number of emergences was under 20,000 in 1971 and over 40,000 in 1996 with a high estimate of over 100,000 emergences in 1995 (Bjorndal *et al*. 1999a). Significant increases in the populations of small juvenile green turtles have also been detected in Florida. A long-term in-water monitoring study in the Indian River Lagoon of Florida has tracked the population of juvenile green turtles in a foraging environment and noted significant increases in catch-per-unit effort (CPUE) (more than doubling) 1988-1990. Catches of benthic immature turtles at the St. Lucie Power Plant intake canal have also been increasing since 1992 (Martin and Ernst 2000). Thus, a significant loss of juveniles over a long time span could have a time lag effect on the breeding population. The increased juveniles recorded in Florida may be the effect of some historical event and may not represent the current stresses to the population.

Based on increases in nesting activity and the increases in CPUE documented at limited in-water study sites, NMFS anticipates that the additional loss of 20 juvenile greens to the breeding population over the permit duration would not have a significant effect on the distribution and reproduction of the population. Therefore, the capture methodology as proposed is not likey to reduce the viability of this population as listed under the ESA. Thus, the proposed activities would not be expected to, directly or indirectly, reduce appreciably the likelihood of both the survival and recovery of the green sea turtle in the wild by reducing the reproduction, numbers, and distribution of the species.

Leatherback and Hawksbill Sea Turtles

The proposed activities are not expected to involve leatherback or hawksbill sea turtles. NMFS expects these takes to be very unlikely, but possible. Therefore, 2 lethal takes are authorized for each in the rare chance there could be an interaction. The determination of whether the loss of 2 leatherbacks will affect the breeding population is confounded by the fact that some nesting populations are increasing while the largest western Atlantic nesting assemblage in French Guiana-Suriname trans-boundary area is decreasing. The total Atlantic and Caribbean population size for hawksbills is not known. Of the 65 geopolitical units worldwide, where estimates of relative hawksbill nesting density exist, 38 of them have hawksbill populations that are suspected or known to be in decline and an additional 18 have experienced "well-substantiated declines" (NMFS and USFWS 1995). NMFS believes, however, the additional annual loss of 2 individuals would not significantly affect the rate of recruitment to the breeding population of either species. Therefore, the capture methodology as proposed is not likey to reduce the viability of these populations as listed under the ESA. Thus, the proposed activities would not be expected to, directly or indirectly, reduce appreciably the likelihood of both the survival and recovery of the leatherback and hawksbill sea turtles in the wild by reducing the reproduction, numbers, and distribution of these species.

3. Responses of Sea Turtles to Handling

The proposed permit amendment 15135 would authorize the handling of up to 68 sea turtles (for a take breakdown by species and disposition, see Table 1) that were captured in shallow water gillnets. All sea turtles would be counted, measured, and identified by species. A curved carapace length and curved carapace width would be measured and recorded for each animal. Every attempt would be made to take photographs of all captured sea turtles before release and

recorded by date, location, study and net type. Additional information on the capture would also be recorded such as the location in the net where the turtle was captured and how the animal was entangled.

Handling, measuring, photographing, and weighing can result in raised levels of stressor hormones in sea turtles similar to that reported above. The additional on-board holding time imposes an additional stressor on turtles that are already acidotic (Hoopes *et al.* 2000). It has been suggested that the muscles used by sea turtles for swimming might also be used during lung ventilation (Butler *et al.* 1984). Thus, an increase in breathing effort in negatively buoyant animals may have heightened lactate production. However, the handling, measuring, photographing and weighing procedures are simple, non-invasive, with a relatively short time period and NMFS does not expect that individual turtles would normally experience more than short-term stresses as a result of these activities. In conclusion, the handling methodology as proposed is not likely to reduce the viability of individual loggerhead, Kemp's ridley, green, hawksbill, or leatherback sea turtles. Therefore, the handling methodology as proposed is not likey to reduce the viability of these populations as listed under the ESA.

4. Respose of Sea Turtles to Tagging

The proposed permit amendment 15135 would authorize the tagging of up to 68 sea turtles (for a take breakdown by species and disposition, see Table 1) that were captured in shallow water gillnets. All live turtles captured in good condition would be tagged with two Inconel tags in the rear flippers and one pit tag in the left front flipper. All tagging equipment including the PIT tag applicator and Inconel tag pliers would be washed and disinfected following each application and prior to use on another animal.

Tagging activities are minimally invasive. Tag retention is a large concern for scientific studies. Plastic tags can become brittle, break and fall off underwater, and titanium tags can bend during implantation and thus not close properly, leading to tag loss. Tag malfunction can result from rusted or clogged applicators or applicators that are worn from heavy use (Balazs 1999). Turtles that have lost external tags must be re-tagged if captured again at a later date, which subjects them to additional effects of tagging. Turtles can experience some discomfort during the tagging procedures and these procedures will produce some level of pain. The discomfort is usually short and highly variable between individuals (Balazs 1999). Most barely seem to notice, while a few others exhibit a marked response. However, NMFS expects the stresses to be minimal and short-term and that the small wound site should heal completely in a short period of time.

PIT tags have been used with a wide variety of animal species that include fish (Clugston 1996; Skalski *et al.* 1998; Dare 2003), amphibians (Thompson 2004), reptiles (Cheatwood *et al.* 2003; Germano and Williams 2005), birds (Boisvert and Sherry 2000; Green *et al.* 2004), and mammals (Wright *et al.* 1998; Aguirre *et al.* 2002). PIT tags have the advantage of being encased in glass, which makes them inert, and are positioned inside the turtle where loss or damage due to abrasion, breakage, corrosion or age over time is virtually non-existent (Balazs 1999). There is a lower rate of loss with PIT tags than with conventional methods, possibly leading to less retagging, and hence reduced interference as well as data of increased reliability

and scientific value (Broderick and Godley 1999). Retagging possibility is also decreased by using PIT tags, as captured animals are scanned to determine the existence of a PIT tag.

When PIT tags are inserted into animals that have large body sizes relative to the size of the tag, empirical studies have generally demonstrated that the tags have no adverse effect on the growth, survival, reproductive success, or behavior of individual animals (Skalski *et al.* 1998, Hockersmith *et al.* 2003). NMFS expects the stresses to be minimal and short-term, and that the small wound resulting from the insertion of the tag would heal completely in a short period of time. NMFS does not expect that individual turtles would experience more than short term stresses during the application of the PIT tags. The proposed tagging methods have been regularly employed in sea turtle research with little lasting impact on the individuals tagged and handled (Balazs 1999). No problems with tagging have been reported by existing NMFS permit holders. Existing NMFS permit holders also report that turtle discomfort was observed to be temporary, as the turtles exhibit normal behavior shortly after tagging and swim normally after release. The applicant will also be required to follow procedures designed to minimize the risk of either introducing a new pathogen into a population or amplifying the rate of transmission from animal to animal of an endemic pathogen when handling animals.

In summary, turtles may experience some discomfort during the application of tagging procedures, and these procedures would likely produce some sort of pain. The discomfort appears to be highly variable between individuals (Balazs 1999). NMFS expects the stresses to be minimal or short-term, and that the small wound site resulting from tag application to the flipper would heal completely in a short period of time. NMFS does not expect that individuals would experience more than short-term stresses during the application of tags. In conclusion, the tagging methodology as proposed is not likely to reduce the viability of individual loggerhead, Kemp's ridley, green, hawksbill, or leatherback sea turtles. Therefore, the tagging methodology as proposed is not likey to reduce the viability of these populations as listed under the ESA.

VIII. Cumulative Effects

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. According to the Consultation Handbook (USFWS and NMFS 1998), the "reasonably certain to occur" clause may include such indicators of actions such as approval of an action by state, tribal, or local agencies or government; indications that granting authorities for the action are imminent; project sponsor's assurance that actions will proceed, etc. Although speculative non-federal actions are not factored into the analysis, "reasonably certain to occur" does not require a guarantee that an action will occur. Therefore, a degree of uncertainty is acceptable when characterizing cumulative effects.

Future federal actions, North Carolina state fishery plans and regulations dealing with bycatch of sea turtles, as well as scientific studies contributing to conservation or recovery of these turtles will require consultation under the ESA and such studies are not included in the *Cumulative Effects* section of this Opinion. Sources queried for the information on non-federal activities

include the U.S. Census Bureau and Lexis-Nexus news and law online search engine. On Nexis, we reviewed bills passed from 2008-2010 and pending bills under consideration were included as further evidence that actions are reasonably certain to occur. In addition, statutes already in place that continue to provide the authority of state agencies to regulate anthropogenic effects were reviewed. State regulation is critical for future anthropogenic impacts in a region. North Carolina's future legislation would address or continue to address alternative energy development; water supply and contamination concerns; wildlife diseases; ecosystem, natural resource, and endangered species recovery and protection; and regulation of fisheries and invasive species.

Other than this legislation, no future non-federal actions are expected to occur that would not trigger section 7 consultation in the future. Based on this analysis, we do not expect this action to result in cumulatively adverse effects on listed sea turtles.

IX. Integration and Synthesis of Effects

As explained in the *Approach to the Assessment* section, risks to listed individuals are measured using changes to an individual's "fitness" – i.e., the individual's growth, survival, annual reproductive success, and lifetime reproductive success. When listed plants or animals exposed to an action's effects are not expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the population(s) those individuals represent or the species those populations comprise (Anderson 2000; Brandon 1978; Mills and Beatty 1979; Stearns 1992). As a result, if the assessment indicates that listed plants or animals are not likely to experience reductions in their fitness, we conclude our assessment.

The narrative that follows integrates and synthesizes the information contained in the *Status of the Species*, the *Environmental Baseline*, and the *Effects of the Action* sections of this Opinion to assess the risk the proposed activities pose to these sea turtles. There are known cumulative effects (i.e., from future state, local, tribal, or private actions) that fold into our risk assessment for this species.

The proposed issuance by PR1 of scientific research Permit No. 15135 to Blake Price of the North Carolina Division of Marine Fisheries, for research on multiple sea turtle species in North Carolina, would authorize directed take of Kemp's ridley, green, loggerhead, hawksbill, and loggerhead sea turtles in Core Sound, North Carolina. All turtles are endangered (or treated as endangered) throughout their range. The proposed activities under this permit include gillnet capture, handling, and tagging of sea turtles. The *Status of listed resources* section identified fishery interactions as the primary reason for the reduction in population size for the sea turtles while in water, and beach erosion control methods as the primary reason for the reduction in population size for the sea turtles while on land. Other threats to the survival and recovery of listed sea turtle species include: 1) natural phenomena - including predation, cold-stunning, hybridization, natural beach erosion, disease, and parasites; and 2) anthropogenic effects - including poaching, contaminants, ecosystem degradation, human presence, entanglement, power generation, vessel strikes, military activities, ingestion and entanglement in marine debris, climate change, lack of international protection, scientific and research permits, and conservation measures. Reasonably likely future actions described in the *Cumulative effects* section include

state legislation to address alternative energy development; water supply and contamination concerns; wildlife diseases; ecosystem, natural resource, and endangered species recovery and protection; and regulation of fisheries and invasive species.

Some sea turtle populations seem to be increasing, while others are decreasing. The leatherback species as a whole is declining and local populations are in danger of extinction (NMFS 2001b; NMFS 2001a). For leatherback nesting populations, some are increasing while the largest western Atlantic nesting assemblage in French Guiana-Suriname trans-boundary area is decreasing. The total Atlantic and Caribbean population size for hawksbills is not known. Although no historical records of abundance are known for hawksbill sea turtles, they are considered to be severely depleted due to the fragmentation and low use of current nesting beaches (NMFS and USFWS 2007b). Among 42 hawksbill nesting sites for which recent trend data are available, 10 (24%) are increasing, three (7%) are stable and 29 (69%) are decreasing. Internationally, the Kemp's ridley is considered the most endangered sea turtle (NRC 1990a; USFWS 1999). The total population of Kemp's ridleys is not known, but nesting has been increasing significantly in the past several years with a favorable trajectory toward recovery goals. The rapid increase in nesting indicates that juvenile survivorship is high and is providing an increasing number of new recruits to the population. The total population of green sea turtles is not known, but nesting activity in Florida and the major Caribbean nesting beach at Tortuguero, Costa Rica, has increased over the long-term. At Tortuguero, Costa Rica, the estimated number of emergences was under 20,000 in 1971 and over 40,000 in 1996 with a high estimate of over 100,000 emergences in 1995 (Bjorndal *et al*. 1999a). The global abundance of nesting female loggerhead turtles is estimated at 43,320–44,560 (Spotila 2004b). The northern loggerhead subpopulation has not shown a detectable increase at nesting beaches. Although long-term data show an increase in the south Florida loggerhead subpopulation, recent date collected under the standardized Index Nesting Beach Survey (INBS) program indicate a possible increasing trend in 2010.

The purpose of the proposed activities (Permit 15135) would be to uncover whether LED lights are a significant deterrent to sea turtles in NC gillnet fisheries which could significantly reduce their bycatch while maintaining fishery yield. Table 1 outlines take number request by species and activity under the proposed action. The proposed amendment would authorize 68 sea turtle takes for the entire study (broken down by species and procedure in Table 1). Each turtle would be captured by gillnet, handled for measurements, and tagged.

Exposure to the proposed activities would occur until the expiration of the permit, December 31, 2012. The duration of each exposure depends on the duration of net entanglement and duration of handling for tagging and measuring purposes. For a sea turtle that is captured, retrieved, tagged, and measured, we expect that turtle to be exposed at a maximum of 14 hours. This exposure is based on a worst case scenario that estimates that a sea turtle could potentially be caught immediately in a set gillnet, as gillnets could remain in the water for a maximum of 12 hours unattended, and then would need to be resuscitated, which would take 2 hours. A more normal exposure scenario would be 8 hours and 30 minutes. This lower-end estimate describes a situation in which a turtle may be caught in a net for the entire time it's set at the short end of the time scale (net sets are anywhere from 8-12 hours), and then handled for measuring and tagging at 30 minues. We expect that nets would be set on the low end of the time range.

NMFS expects tagging stress to be minimal or short-term, and that the small wound site resulting from tag application to the flipper would heal completely in a short period of time. NMFS does not expect that individuals would experience more than short-term stresses during the application of tags. Similarly, NMFS expects that handling (handling, measuring, photographing and weighing) procedures are simple, non-invasive, with a relatively short time period and NMFS does not expect that individual turtles would normally experience more than short-term stresses as a result of these activities. No individual sea turtles are expected to experience a fitness reduction from tagging or handling.

We believe that capture could result in physical or phyisiological injury or stress responses to individual turtles. A number of factors, such as size, species, water temperature, severity of entanglement, and others can intensify the effects resulting from capture. Some turtles may die as a direct result of being entangled in the net, or some time after release (post-release mortality). NMFS expects that, while most turtles will suffer none or short-term injuries and recover relatively quickly, some turtles are estimated to perish from the proposed capture activities. Since some individual turtles are expected to experience a fitness reduction during capture, we analyzed the effects of removal of these turtles from each respective population and determined that the proposed activities would not be expected to, directly or indirectly, reduce appreciably the likelihood of both the survival and recovery of each sea turtle species in the wild by reducing the reproduction, numbers, and distribution of these species.

X. Conclusion

After reviewing the current status of leatherback, Kemp's ridley, green, hawksbill, and loggerhead sea turtles, the environmental baseline for the action area, the anticipated effects of the proposed activities, and the cumulative effects, it is NMFS' biological opinion that the activities authorized by the proposed issuance of an amendment to scientific research Permit No. 15135 are not likely to jeopardize the continued existence of leatherback, Kemp's ridley, green, hawksbill, and loggerhead sea turtles. Critical habitat that has been designated is not within the action area and is not affected by the proposed activity.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or benefit listed species or their habitats. In order to avoid or minimize adverse effects to listed species we recommend:

1. *Assessment of Permit Conditions*. The Permits Division should periodically assess the effectiveness of its permit conditions, including those for notification and coordination of research.

2. *Long-Term Monitoring of Tag or Net Interaction Wound Sites*. PR1 should encourage permit holders to communicate with one another to fully monitor and realize long-term effects of wound sites.

In order for PR3 to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, listed species or their habitats, PR1 should notify PR3 of any conservation recommendations they implement in their final action.

REINITIATION NOTICE

This concludes formal consultation on the proposed issuance of amendment to Permit No 15135 to Blake Price of the North Carolina Division of Marine Fisheries, for research on multiple sea turtle species in North Carolina. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion (e.g., results of a study on the effects of gillnet capture of Kemp's ridley sea turtles reveals effects that were not considered in the Opinion); (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

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