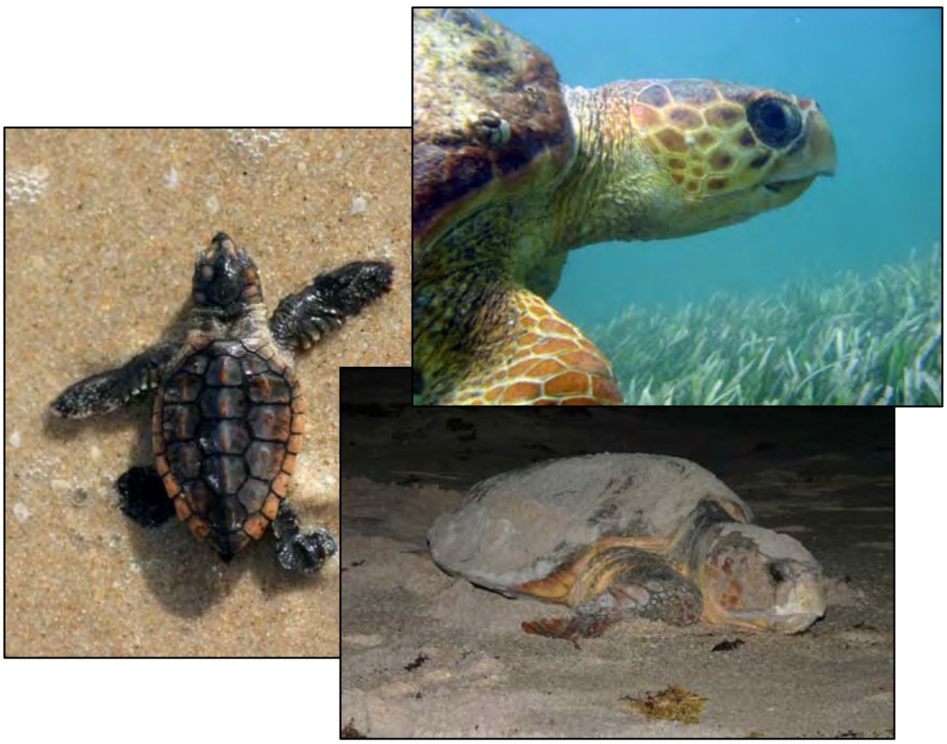
DRAFT

Recovery Plan for the Northwest Atlantic Population of the
Loggerhead Sea Turtle
(*Caretta caretta*)

Second Revision



U.S. Department of Commerce
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

U.S. Department of the Interior

U.S. FISH AND WILDLIFE SERVICE

DRAFT

Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (*Caretta caretta*)

Second Revision

Original Approved: September 19, 1984
First Revision Approved: December 26, 1991

Approved: ____
James W. Balsiger, Ph.D., Acting Assistant Administrator for Fisheries
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Silver Spring, Maryland

Date: ______________________

Approved: ____
Sam D. Hamilton, Regional Director, Southeast Region
U.S. Fish and Wildlife Service
Atlanta, Georgia

Date: ______________________

PREFACE

The Endangered Species Act of 1973, as amended (16 USC 1531 *et seq.*) (ESA), establishes policies and procedures for identifying, listing, and protecting species of wildlife that are endangered or threatened with extinction. The purposes of the ESA are "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, [and] to provide a program for the conservation of such endangered species and threatened species..." The ESA defines an "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." A "threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."

The Secretaries of the Department of the Interior and the Department of Commerce are responsible for administering the ESA's provisions as they apply to the loggerhead turtle. Day-to-day management authority for endangered and threatened species under the Departments' jurisdictions has been delegated to the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS), respectively. FWS and NMFS (collectively referred to as the Services) share Federal jurisdiction for sea turtles, with FWS having lead responsibility on nesting beaches and NMFS having lead responsibility in the marine environment.

To help identify and guide species recovery needs, section 4(f) of the ESA directs the Secretaries to develop and implement recovery plans for listed species. Such plans are to include: (1) a description of site-specific management actions necessary to conserve the species or populations; (2) objective, measurable criteria which, when met, will allow the species or populations to be removed from the endangered and threatened species list; and (3) estimates of the time and funding required to achieve the plan's goals. Section 4 of the ESA and regulations (50 CFR Part 424) promulgated to implement its listing provisions also set forth the procedures for reclassifying and delisting species on the Federal lists. A species can be delisted if the Secretary of the Interior and/or the Secretary of Commerce determines that the species no longer meets the endangered or threatened status based upon the following five factors listed in section 4(a)(1) of the ESA:

(1) the present or threatened destruction, modification, or curtailment of its habitat or range;
(2) overutilization for commercial, recreational, scientific, or educational purposes;
(3) disease or predation;
(4) the inadequacy of existing regulatory mechanisms; and
(5) other natural or manmade factors affecting its continued existence.

Further, a species may be delisted, according to 50 CFR Part 424.11(d), if the best scientific and commercial data available substantiate that the species or population is neither endangered nor threatened for one of the following reasons: (1) extinction, (2) recovery, or (3) original data for classification of the species were in error.

NMFS approved the initial recovery plan for the loggerhead on September 19, 1984. This initial plan was a multi-species plan for all six species of sea turtles occurring in the U.S. On December 26, 1991, NMFS and FWS approved a separate recovery plan for the U.S. population of the loggerhead, focusing on the Atlantic. A separate plan for U.S. Pacific populations of the loggerhead was approved in 1998. In 2001, NMFS and FWS initiated the process to revise the 1991 plan for the loggerhead. An Atlantic Loggerhead Recovery Team, consisting of species experts, was established to draft this revision.

Since approval of the first revised plan in 1991, significant research has been accomplished and important recovery activities have been undertaken. As a result, we have a greater knowledge of the species and its status. This second revision of the recovery plan for the Atlantic loggerhead addresses current threats and needs, highlights conservation accomplishments that have been undertaken since the species was listed, and specifically addresses the planning requirements of the ESA.

DISCLAIMER

Recovery plans delineate such reasonable actions as may be necessary, based upon the best scientific and commercial data available, for the conservation and survival of listed species. Plans are published by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, sometimes prepared with the assistance of recovery teams, contractors, state agencies, and others. Recovery plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in the plan formulation, other than the Services. They represent the official position of the Services only after they have been signed by the U.S. Fish and Wildlife Service Regional Director and/or National Marine Fisheries Service Assistant Administrator. Recovery plans are guidance and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

LITERATURE CITATION SHOULD READ AS FOLLOWS:

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ADDITIONAL COPIES MAY BE OBTAINED FROM:

> National Marine Fisheries Service
> Office of Protected Resources
> 1315 East-West Highway, 13th Floor
> Silver Spring, Maryland 20910

This recovery plan can be downloaded from:

> National Marine Fisheries Service's Office of Protected Resources website:
> http://www.nmfs.noaa.gov/pr/pdfs/recovery/draft_loggerhead.pdf
>
> U.S. Fish and Wildlife Service's Jacksonville Field Office's website:
> http://www.fws.gov/northflorida

RECOVERY TEAM

The Services gratefully acknowledge the commitment and efforts of the members of the Recovery Team for the Northwest Atlantic population of the loggerhead sea turtle in the development of this revised recovery plan.

Alan B. Bolten, Ph.D.
(Team Leader)
Archie Carr Center for Sea Turtle Research
University of Florida

Larry B. Crowder, Ph.D.
Duke University Marine Laboratory

Mark G. Dodd
Georgia Department of Natural Resources

Sandra L. MacPherson
U.S. Fish and Wildlife Service

John A. Musick, Ph.D.
The Virginia Institute of Marine Science
College of William and Mary

Barbara A. Schroeder
National Marine Fisheries Service

Blair E. Witherington, Ph.D.
Florida Fish and Wildlife Conservation Commission

Kristy J. Long
(Assistant to the Team)
National Marine Fisheries Service

ACKNOWLEDGMENTS

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Additional thanks go to the following individuals for their technical assistance during the preparation of the recovery plan: Gloria Bell (U.S. Fish and Wildlife Service), Kelly Bibb (U.S. Fish and Wildlife Service), Karen Bjorndal (Archie Carr Center for Sea Turtle Research, University of Florida), Benjamin Bolker (Department of Zoology, University of Florida), Michael Bresette (Quantum Resources, Inc.), Therese Conant (National Marine Fisheries Service), Debby Crouse (U.S. Fish and Wildlife Service), Peter Eliazar (Archie Carr Center for Sea Turtle Research, University of Florida), Allen Foley (Florida Fish and Wildlife Conservation Commission), Matthew Godfrey (North Carolina Wildlife Resources Commission), DuBose Griffin (South Carolina Department of Natural Resources), Ann Marie Lauritsen (U.S. Fish and Wildlife Service), Kate Mansfield (The Virginia Institute of Marine Science, College of William and Mary), Anne Meylan (Florida Fish and Wildlife Conservation Commission), Sally Murphy (South Carolina Department of Natural Resources), Susan Pultz (National Marine Fisheries Service), James Spotila (Drexel University), Wendy Teas (National Marine Fisheries Service), Chuck Underwood (U.S. Fish and Wildlife Service).

EXECUTIVE SUMMARY

Recovery Units: The Recovery Team designated the following five recovery units for the Northwest Atlantic population of the loggerhead. The first four recovery units represent nesting assemblages in the southeast U.S. The boundaries of these four recovery units were delineated based on geographic isolation and geopolitical boundaries. The fifth recovery unit is a combination of all other nesting assemblages within the Northwest Atlantic

Northern Recovery Unit: The Northern Recovery Unit is defined as loggerheads originating from nesting beaches from the Florida-Georgia border through southern Virginia (the northern extent of the nesting range).

Peninsular Florida Recovery Unit: The Peninsular Florida Recovery Unit is defined as loggerheads originating from nesting beaches from the Florida-Georgia border through Pinellas County on the west coast of Florida, excluding the islands west of Key West, Florida.

Northern Gulf Recovery Unit: The Northern Gulf Recovery Unit is defined as loggerheads originating from nesting beaches from Franklin County on the northwest Gulf coast of Florida through Texas (the western extent of U.S. nesting range).

Dry Tortugas Recovery Unit: The Dry Tortugas Recovery Unit is defined as loggerheads originating from nesting beaches throughout the islands located west of Key West, Florida, because these islands are geographically separated from other recovery units.

Greater Caribbean Recovery Unit: The Greater Caribbean Recovery Unit is composed of all nesting assemblages of loggerheads within the Greater Caribbean, outside the U.S.

Current Status: The Recovery Team evaluated the status and trends of the five identified recovery units.

Northern Recovery Unit: The loggerhead nesting trend from daily beach surveys showed a significant decline of 1.6% annually. Nest totals from aerial surveys conducted by SCDNR showed a 1.7% annual decline in nesting in South Carolina since 1980. Overall, there is strong statistical evidence to suggest the Northern Recovery Unit has sustained a long-term decline.

Peninsular Florida Recovery Unit: An analysis of index nesting beach survey data has shown a decline in nesting. Results of the analysis indicated that there has been a decrease of 28% over the 18-year period from 1989-2006 (95% CI: -51.4% to -25.7%) and a 43% decline since 1998. The mean annual rate of decline for the 18-year period was 1.9%.

Northern Gulf Recovery Unit: Evaluation of long-term nesting trends for the Northern Gulf Recovery Unit is difficult because of changed and expanded beach coverage. However, there are 10 years of Florida index nesting beach survey data for the Northern

Gulf Recovery Unit. A log-linear regression showed a significant declining trend (P=0.005) of 6.3% annually.

Dry Tortugas Recovery Unit: The nesting trend data for the Dry Tortugas Recovery Unit are from beaches that are not part of the index nesting beach survey program but are part of the statewide nesting beach survey program. There are 9 years of data for this recovery unit. A simple linear regression accounting for temporal autocorrelation revealed no trend in nesting numbers. Because of the annual variability in nest totals, a longer time series is needed to detect a trend.

Greater Caribbean Recovery Unit: Evaluation of long-term nesting trends for the Greater Caribbean Recovery Unit is difficult because of the lack of long-term standardized surveys on loggerhead nesting beaches throughout the region, changing survey effort at monitored beaches, and scattered and low-level nesting by loggerheads at many locations. The most complete data are from Quintana Roo, Yucatan, Mexico, where an increasing trend was reported over a 15-year period from 1987-2001. However, nesting since 2001 has declined and the previously reported increasing trend appears to not have been sustained (J. Zurita, personal communication, 2006).

RECOVERY GOAL: To ensure that each recovery unit meets its Recovery Criteria alleviating threats to the species so that protections under the ESA are no longer necessary and so that the Northwest Atlantic population of the loggerhead sea turtle can be removed from the List of Endangered and Threatened Wildlife.

RECOVERY OBJECTIVES:

1. Ensure the number of nests in each recovery unit is increasing and this increase corresponds to an increase in the number of nesting females.
2. Ensure the in-water abundance of juveniles in both neritic and oceanic habitats is increasing and is increasing at a greater rate than strandings of similar age classes.
3. Manage sufficient nesting beach habitat to ensure successful nesting.
4. Manage sufficient feeding, migratory, and internesting marine habitats to ensure successful growth and reproduction.
5. Minimize legal harvest.
6. Implement scientifically based nest management plans.
7. Minimize nest predation.
8. Recognize and respond to mass/unusual mortality or disease events appropriately.
9. Develop and implement local, state, Federal, and international legislation to ensure long-term protection of loggerheads and their terrestrial and marine habitats.
10. Minimize bycatch in domestic and international commercial and artisanal fisheries.
11. Minimize trophic changes from fishery harvest and habitat alteration.
12. Minimize marine debris ingestion and entanglement.
13. Minimize boat strike mortality.

<u>DEMOGRAPHIC RECOVERY CRITERIA FOR U.S. NESTING POPULATIONS</u>:

1. **<u>Number of Nests and Number of Nesting Females</u>**

   a. **Northern Recovery Unit**

      (1) There is statistical confidence (95%) that the annual rate of increase over a generation time of 50 years is 2% or greater and the total annual number of nests has increased to 14,012 or greater for this recovery unit (approximate distribution of nests is NC=14% [1,963], SC=65% [9,141], and GA=21% [2,908]).

      (2) This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

   b. **Peninsular Florida Recovery Unit**

      (1) There is statistical confidence (95%) that the annual rate of increase over a generation time of 50 years is statistically detectable (1%) and the total annual number of nests has increased to 107,940 or greater for this recovery unit.

      (2) This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

   c. **Dry Tortugas Recovery Unit**

      (1) There is statistical confidence (95%) that the annual rate of increase over a generation time of 50 years is 3% or greater and the total annual number of nests has increased to 1,074 or greater for this recovery unit.

      (2) This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

   d. **Northern Gulf Recovery Unit**

      (1) There is statistical confidence (95%) that the annual rate of increase over a generation time of 50 years is 3% or greater and the total annual number of nests has increased to 3,988 or greater for this recovery unit (approximate distribution of nests (2002-2006) is FL= 93% [3,778] and AL=7% [260]).

      (2) This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

   e. **Greater Caribbean Recovery Unit**

      (1) The total annual number of nests at a minimum of three nesting assemblages, averaging greater than 100 nests annually (e.g., Yucatan, Mexico; Cay Sal Bank, Bahamas) are increasing over a generation time of 50 years.

2. **Trends in Abundance on Foraging Grounds**
A network of in-water sites, both oceanic and neritic, distributed across the foraging range is established and monitoring is implemented to measure abundance. There is statistical confidence (95%) that a composite estimate of relative abundance from these sites is increasing for at least one generation.

3. **Trends in Neritic Strandings Relative to In-water Abundance**
Stranding trends are not increasing at a rate greater than the trends in in-water relative abundance for similar age classes for at least one generation.

LISTING FACTOR RECOVERY CRITERIA:

1. **Present or Threatened Destruction, Modification, or Curtailment of a Species Habitat or Range**
   a. **Terrestrial**
      (1) Beach armoring, shoreline stabilization structures, and all other barriers to nesting are categorized and inventoried for areas under U.S. jurisdiction. A peer-reviewed strategy is developed and implemented to ensure that the percentage of nesting beach free of barriers to nesting is stable or increasing relative to baseline levels.
      (2) Beach sand placement projects conducted in areas under U.S. jurisdiction are in compliance with state and FWS criteria and are conducted in a manner that accommodates loggerhead needs and does not degrade or eliminate nesting habitat.
      (3) At least 1,581 km of loggerhead nesting beaches and adjacent uplands (current amount as identified in Appendix 4) under U.S. jurisdiction are maintained within conservation lands in public (Federal, state, or local) or private (NGO and private conservation lands) ownership that are managed in a manner compatible with sea turtle nesting.
      (4) A peer-reviewed model is developed that describes the effects of sea level rise on the nesting range of loggerheads, and steps have been taken to mitigate such effects.
      (5) Nesting beaches outside U.S. jurisdiction are managed for compatibility with loggerhead nesting.
   b. **Marine (estuarine, neritic, and oceanic)**
   A peer-reviewed, comprehensive strategy is developed and implemented to identify, prioritize, and protect marine habitats (e.g., feeding, migratory, inter-nesting) important to loggerheads.

2. **Overutilization for Commercial, Recreational, Scientific, or Educational Purposes**
   a. Legal harvest (both commercial and subsistence) in the Caribbean, Atlantic, and Mediterranean is identified and quantified. A strategy is developed and implemented to minimize legal harvest through international agreements.

b. A scientifically based nest management plan outlining strategies for protecting nests (under U.S. jurisdiction) from natural and manmade impacts is developed and implemented.

3. **Disease or Predation**
   a. Ecologically sound predator control programs are implemented to ensure that the annual rate of mammalian predation on nests (under U.S. jurisdiction) is 10% or below within each recovery unit based on standardized surveys[1].
   b. A peer-reviewed strategy is developed to recognize, respond to, and investigate mass/unusual mortality or disease events.

4. **Inadequacy of Existing Regulatory Mechanisms**
   a. Light management plans, which meet minimum standards identified in the Model Lighting Ordinance (Witherington and Martin 2000), are developed, fully implemented, and effectively enforced on nesting beaches under U.S. jurisdiction. Annual percentage of total nests with hatchlings disoriented or misoriented by artificial lighting does not exceed 10% based on standardized surveys[2].
   b. Specific and comprehensive Federal legislation is developed, promulgated, implemented, and enforced to ensure long-term protection of loggerheads and their terrestrial and marine habitats post-delisting, including protection from fishery interactions.
   c. State and local legislation is developed and/or maintained, promulgated, implemented, and enforced to ensure long-term (including post-delisting) protection of loggerheads and their terrestrial and marine habitats, including protection from fishery interactions.
   d. Foreign nations with significant loggerhead foraging or migratory habitat have implemented national legislation and have acceded to international and multi-lateral agreements to ensure long-term protection of loggerheads and their habitats. Nations that have important foraging or migratory habitat include Canada, Mexico, Cuba, The Bahamas, Turks and Caicos Islands, Panama, Spain, Portugal, Morocco, and Cape Verde Islands.
   e. Nations that conduct activities affecting loggerheads in foraging or migratory habitats in the North Atlantic Basin and the western Mediterranean have implemented national legislation and have acceded to international and multi-lateral agreements to ensure long-term protection of loggerheads and their habitats throughout the high seas and in foreign EEZs.

5. **Other Natural or Manmade Factors Affecting Its Continued Existence**
   a. A peer-reviewed strategy is developed and fully implemented to minimize fishery interactions and mortality for each domestic commercial fishing gear type that has loggerhead bycatch.
   b. A peer-reviewed strategy is developed and fully implemented in cooperation with relevant nations to minimize fishery interactions and mortality of loggerheads in foreign EEZs and on the high seas.

c. A peer-reviewed strategy is developed and fully implemented to quantify, monitor, and minimize effects of trophic changes on loggerheads (e.g., diet, growth rate, fecundity) from fishery harvests and habitat alterations.
d. A peer-reviewed strategy is developed and fully implemented to quantify, monitor, and minimize the effects of marine debris ingestion and entanglement in the U.S. EEZ, foreign EEZs, and the high seas.
e. A peer-reviewed strategy is developed and fully implemented to minimize boat strike mortality in the U.S. EEZ.

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LIST OF ACRONYMS AND ABBREVIATIONS

The following are standard abbreviations for acronyms and terms found throughout this document:

ACCSTR - Archie Carr Center for Sea Turtle Research, University of Florida
ADCNR - Alabama Department of Conservation and Natural Resources
ADEM - Alabama Department of Environmental Management
ASMFC - Atlantic States Marine Fisheries Commission
CCL - Curved Carapace Length
CFR - Code of Federal Regulations
CITES - Convention on the International Trade in Endangered Species of Wild Fauna and Flora
CMTTP - Cooperative Marine Turtle Tagging Program
COE - U.S. Army Corps of Engineers
DOD - Department of Defense
DOS - U.S. Department of State
DTRU - Dry Tortugas Recovery Unit
EEZ - Exclusive Economic Zone
EPA - Environmental Protection Agency
ESA - Endangered Species Act of 1973, as amended
FAO-COFI - Food and Agriculture Organization-Committee on Fisheries
FDEP - Florida Department of Environmental Protection
FFWCC - Florida Fish and Wildlife Conservation Commission
FMC - Fishery Management Council
FMP - Fishery Management Plan
FPL - Florida Power and Light Company
FR - Federal Register
FWS - U.S. Fish and Wildlife Service
FWS-ES - U.S. Fish and Wildlife Service-Ecological Services
GDNR - Georgia Department of Natural Resources
GIS - Geographic Information System
GMFMC - Gulf of Mexico Fishery Management Council
GSMFC - Gulf States Marine Fisheries Commission
HCP - Habitat Conservation Plan
IAC - Inter-American Convention for the Conservation and Protection of Marine Turtles
ICCAT - International Commission for the Conservation of Atlantic Tunas
INBS - Index Nesting Beach Survey
MAFMC - Mid-Atlantic Fishery Management Council
MMS - Minerals Management Service
mtDNA - Mitochondrial Deoxyribonucleic Acid
MTSG - Marine Turtle Specialist Group
NCDENR - North Carolina Department of Environment and Natural Resources
NCWRC - North Carolina Wildlife Resources Commission
NEFMC - New England Fishery Management Council
NGO - Non-governmental Organization
NGRU - Northern Gulf Recovery Unit

NM - National Monument
NMFS - National Marine Fisheries Service
NOAA - National Oceanic and Atmospheric Administration
NOS - National Ocean Service
NPS - National Park Service
NRU - Northern Recovery Unit
NS - National Seashore
NWR - National Wildlife Refuge
PFRU - Peninsular Florida Recovery Unit
SAFMC - South Atlantic Fishery Management Council
SCDHEC - South Carolina Department of Health and Environmental Control
SCDNR - South Carolina Department of Natural Resources
SCDPRT - South Carolina Department of Parks, Recreation and Tourism
SCL - Straight Carapace Length
SEFSC - Southeast Fisheries Science Center
SP - State Park
SRA - State Recreation Area
STSSN - Sea Turtle Stranding and Salvage Network
TED - Turtle Excluder Device
TEWG - Turtle Expert Working Group
TPWD - Texas Parks and Wildlife Department
UCF - University of Central Florida
USC - U.S. Code
USCG - U.S. Coast Guard
USGS-NWHC - U.S. Geological Survey-National Wildlife Health Center
VIMS - The Virginia Institute of Marine Science

PART I. BACKGROUND

A. BRIEF OVERVIEW

The loggerhead sea turtle (*Caretta caretta*) was listed as threatened throughout its range on July 28, 1978, under the Endangered Species Act of 1973, as amended (ESA) (FWS and NMFS 1978, 43 FR 32800) and has received Federal protection since that time.

Loggerhead sea turtles inhabit the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans. Within the continental U.S., loggerheads nest from Texas to Virginia. Major nesting concentrations in the U.S. are found on the coastal islands of North Carolina, South Carolina, and Georgia, and on the Atlantic and Gulf coasts of Florida (NMFS 1984). Within the western Atlantic, loggerheads also nest in Mexico, the Bahamas, and the wider Caribbean (Figure 1).

Figure 1. Estimated annual number of loggerhead nests in the southeastern U.S., The Bahamas, and Mexico, 2001-2005.

From a global perspective, the U.S. nesting aggregation is of paramount importance to the survival of the species and is second in size only to that which nests on islands in the Arabian Sea off Oman (Ross 1982, Ehrhart 1989). The status of the Oman colony has not been evaluated recently, but its location in a part of the world that is vulnerable to disruptive events (e.g., political upheavals, conflicts, catastrophic oil spills) is cause for considerable concern (Meylan *et al*. 1995). The loggerhead nesting aggregations in Oman, the U.S., and Australia account for about 88% of nesting worldwide (NMFS and FWS 1991).

The highly migratory behavior of loggerheads makes them shared resources among many nations. Therefore, conservation efforts for loggerhead populations in one country may be jeopardized by activities in another. Protecting loggerheads on U.S. nesting beaches and in U.S. waters alone, therefore, is not sufficient to ensure the continued existence of the species. However, sea turtle protection programs in many countries are not well organized or supported and, in this context, protection of the U.S. loggerhead population takes on international significance. Although this revised recovery plan focuses on activities to recover the loggerhead in the U.S., it also recognizes and encourages cooperative efforts with other nations to ensure the survival and recovery of the species in the North Atlantic.

B. TAXONOMY

The loggerhead was first described by Linnaeus in 1758 and named *Testudo caretta*. Over the next two centuries more than 35 names were applied to the species (Dodd 1988), but there is now general agreement on *Caretta caretta* as the valid name. While Deraniyagala described an Indo-Pacific form as *C. gigas* in 1933, he revised that view in 1939 to hold that *gigas* was a subspecies of *C. caretta*. The genus has generally been regarded as monotypic since that time. The subspecific designation of *gigas* has likewise been challenged persuasively (Brongersma 1961, Pritchard 1979). Dodd (1988) has declared flatly that "the diagnostic characters used to distinguish *C. c. gigas* from *C. c. caretta* are not valid." Thorough synonymies and taxonomic reviews of this form are given most recently by Pritchard and Trebbau (1984) and Dodd (1988). Subspecies assignments are not supported based on genetic evidence (Bowen 2003).

C. SPECIES DESCRIPTION

The carapace of adult and juvenile loggerheads is reddish-brown. The dorsal and lateral head scales and the dorsal scales of the flippers are also reddish-brown, but with light to medium yellow margins. The unscaled areas of the integument (neck, shoulders, limb bases, inguinal area) are dull brown dorsally and light to medium yellow laterally and ventrally. The plastron is medium to light yellow, and the thick, bony carapace is covered by non-overlapping scutes that meet along seam lines. There are 11 or 12 pairs of marginal scutes, five pairs of costals, five vertebrals, and a nuchal (precentral) scute that is in contact with the first pair of costal scutes. Ventrally the plastron is composed of paired gular, humeral, pectoral, abdominal, femoral, and anal scutes and connected to the carapace by three pairs of poreless inframarginal scutes. Mean straight carapace length (SCL) of adults in the southeast U.S. is approximately 92 cm; corresponding weight is approximately 113 kg. Hatchlings vary from light to dark brown to dark gray dorsally and lack the reddish-brown coloration of adults and juveniles. Flippers are dark gray to brown above with distinct white margins. The ventral coloration of the plastron and other areas of the integument are generally yellowish to tan. The carapace has three keels and the plastron has two keels. At emergence, hatchlings average 45 mm in SCL and weigh approximately 20 g (Dodd 1988).

D. DISTRIBUTION AND POPULATION SIZE

The loggerhead occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans. However, the majority of loggerhead nesting is at the western rims of the Atlantic and Indian Oceans (Figure 2). The most recent reviews show that only two loggerhead nesting beaches have greater than 10,000 females nesting per year (Baldwin *et al*. 2003, Ehrhart *et al*. 2003, Kamezaki *et al*. 2003, Limpus and Limpus 2003, Margaritoulis *et al*. 2003): South Florida (U.S.) and Masirah (Oman). Those beaches with 1,000 to 9,999 females nesting each year are Georgia through North Carolina (U.S.), Quintana Roo and Yucatán (Mexico), Cape Verde Islands (Cape Verde, eastern Atlantic off Africa), and Western Australia (Australia). Smaller nesting aggregations with 100 to 999 nesting females annually occur in the Northern Gulf of Mexico (U.S.), Dry Tortugas (U.S.), Cay Sal Bank (The Bahamas), Sergipe and Northern Bahia (Brazil), Southern Bahia to Rio de Janerio (Brazil), Tongaland (South Africa), Mozambique, Arabian Sea Coast (Oman), Halaniyat Islands (Oman), Cyprus, Peloponnesus (Greece), Island of Zakynthos (Greece), Turkey, Queensland (Australia), and Japan.

Although the major nesting concentrations in the U.S. are found in South Florida, loggerheads nest from Texas to Virginia. Total estimated nesting in the U.S. has fluctuated between 47,000 and 90,000 nests per year over the last decade (FFWCC, unpublished data; GDNR, unpublished data; SCDNR, unpublished data; NCWRC, unpublished data). About 80% of loggerhead nesting in the southeast U.S. occurs in six Florida counties (Brevard, Indian River, St. Lucie, Martin, Palm Beach, and Broward Counties). Adult loggerheads are known to make considerable migrations between foraging areas and nesting beaches (Schroeder *et al*. 2003, Foley *et al*. in press). During non-nesting years, adult females from U.S. beaches are distributed in waters off the eastern U.S. and throughout the Gulf of Mexico, The Bahamas, Greater Antilles, and Yucatán.

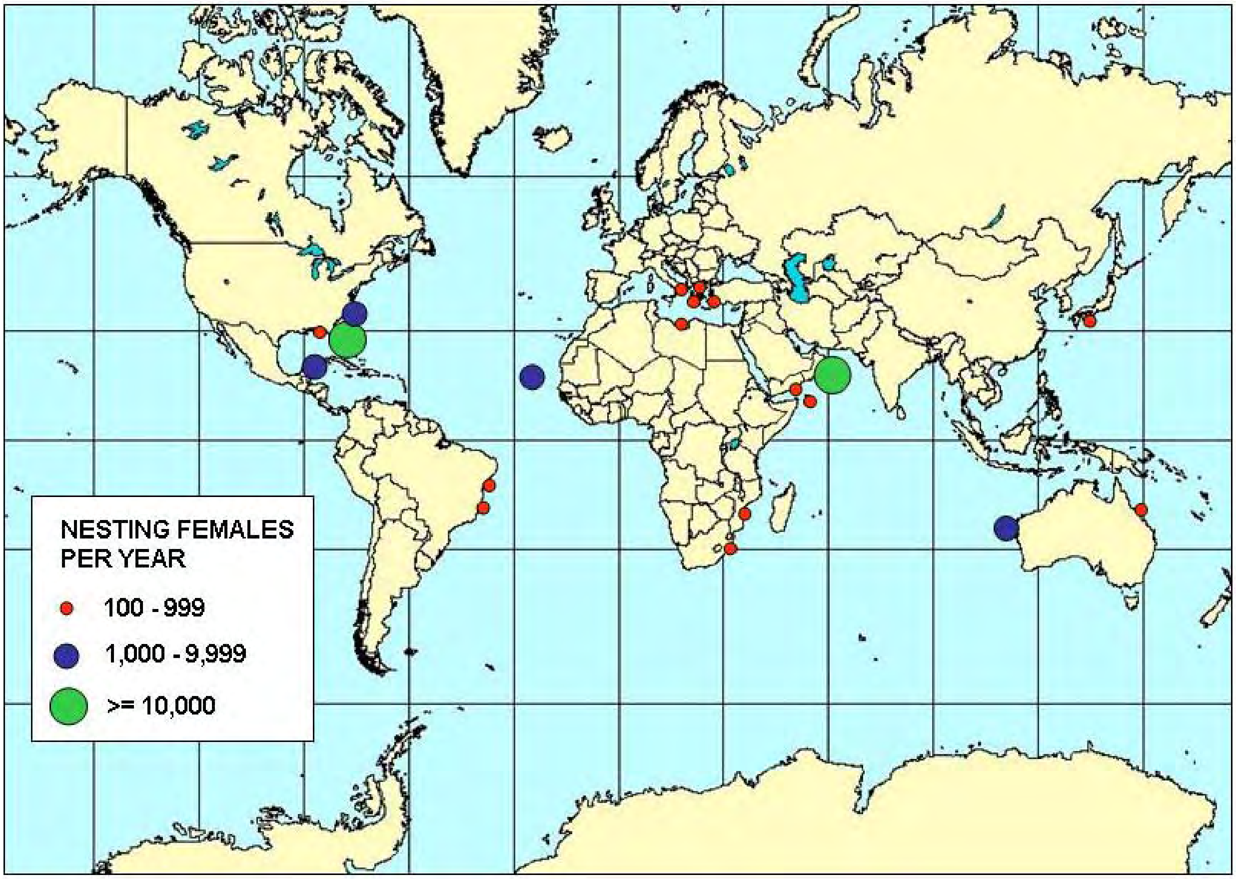

Figure 2. Global distribution of loggerhead nesting assemblages.

The loggerhead is commonly found throughout the North Atlantic including the Gulf of Mexico, the northern Caribbean, The Bahamas archipelago, and eastward to West Africa, the western Mediterranean, and the west coast of Europe. In contrast to determining population size on nesting beaches, determining population size in the marine environment has been very localized (Bjorndal and Bolten 2000). At present, there are no data on population size in the oceanic habitat.

E. POPULATION STATUS AND TRENDS

E.1. NESTING POPULATIONS

Numbers of nests and nesting females are often highly variable from year to year due to a number of factors including environmental stochasticity, periodicity in ocean conditions, anthropogenic effects, and density-dependent and density-independent factors affecting survival, somatic growth, and reproduction (Meylan 1982, Hays 2000, Chaloupka 2001, Solow *et al*. 2002). Despite these sources of variation, and because female turtles exhibit strong nest site fidelity, a nesting beach survey can provide a valuable assessment of changes in the adult female population, provided that the study is sufficiently long and effort and methods are standardized (Meylan 1982, Gerrodette and Brandon 2000, Reina *et al*. 2002).

Two important sources of variation with regard to nesting trends are remigration interval and clutch frequency. These two demographic parameters affect the number of nests laid during a nesting season. For example, if the mean remigration interval (i.e., the length of time between successive nesting migrations) of females in a population increases as a result of environmental conditions, a subsequent decrease in numbers of nests does not necessarily indicate a decrease in adult females. Similarly, if clutch frequency decreases, a subsequent decrease in numbers of nests does not necessarily equate to a decrease in adult females. Alternatively, if remigration interval decreases and/or clutch frequency increases, a subsequent increase in numbers of nests does not necessarily equate to an increase in adult females.

With regard to loggerheads nesting in the southeast U.S., we have no information that indicates a change in clutch frequency or remigration interval has occurred. Therefore, standardized time series data on the number of nests were evaluated to determine whether trends could be detected for U.S. nesting assemblages. Within a nesting season, the number of nesting females is directly related to the number of nests deposited. Clutch frequency for loggerheads has been reported as 3-4 nests per females per season (see Table 2). The conversion from number of nests to number of females nesting within a season is a simple division of nests divided by clutch frequency.

The Recovery Team designated five recovery units for the Northwest Atlantic population of the loggerhead. Four of these recovery units represent nesting assemblages in the southeast U.S. A fifth recovery unit is a combination of all other nesting assemblages of turtles that nest outside the U.S., but occur within U.S. waters during some portion of their lives.

The Recovery Team evaluated the status and trends of the Northwest Atlantic loggerhead population for each of the five recovery units. The biological basis and delineations of all recovery units are described in detail in Part II, Recovery Program. The five recovery units representing nesting assemblages are:

1. Northern Recovery Unit (FL/GA border through southern VA)
2. Peninsular Florida Recovery Unit (FL/GA border through Pinellas County, FL)
3. Dry Tortugas Recovery Unit (islands located west of Key West, FL)
4. Northern Gulf Recovery Unit (Franklin County, FL, through TX)
5. Greater Caribbean Recovery Unit (Mexico through Venezuela, The Bahamas, Lesser Antilles, and Greater Antilles)

Northern Recovery Unit (NRU)

The Northern Recovery Unit is the second largest loggerhead nesting aggregation in the Northwest Atlantic. Annual nest totals from northern beaches averaged 5,206 nests from 1990-2006, a period of near-complete surveys of NRU nesting beaches (GDNR, unpublished data; NCWRC, unpublished data, SCDNR, unpublished data), representing approximately 1,270 nesting females per year (4.1 nests per female, Murphy and Hopkins 1984). The loggerhead nesting trend from daily beach surveys showed a significant decline of 1.6% annually. Nest totals from aerial surveys conducted by SCDNR showed a 1.7% annual decline in nesting in South Carolina since 1980. Overall, there is strong statistical evidence to suggest the Northern

Recovery Unit has sustained a long-term decline. Preliminary nest counts from 2007 are below average and are not likely to change the reported declining trend.

Standardized Ground Surveys of Nesting Beaches

Historically, survey effort on Northern Recovery Unit beaches has been variable, making it difficult to assess nesting trends. In order to standardize the data used in our analyses, we included only annual nest totals from beaches that met the following criteria: (1) nesting surveys were initiated in May; (2) surveys were conducted daily throughout the nesting season; and (3) the survey area was standardized throughout the duration of the study, although we allowed for small changes in beach length (± 0.5 km).

Sea turtle project coordinators from GDNR, NCWRC, and SCDNR supplied nesting data for the analysis. Generally, coordinators used information from annual nesting reports to ensure data met standardized survey protocols. If survey start and end dates were not included in reports, first and last nest dates were used to determine the beginning and end of the survey period. When annual reports were not available, coordinators relied on interviews with field personnel to confirm historic survey effort data.

The dataset used for this analysis included the summed annual nest totals from all beaches with an uninterrupted time-series of at least 20 years. Ten beaches from North Carolina, South Carolina, and Georgia met the criteria for inclusion in the analysis. In addition, we included nesting data from Cape Island, South Carolina, because of its relative importance as a Northern Recovery Unit nesting beach. Cape Island increased in size from approximately 8 km to 13 km during the study period and, therefore, did not meet the criteria for standardized survey length. However, Cape Island is the highest density nesting beach in the Northern Recovery Unit and represented approximately 17% of total nesting in 2006. We included data from Cape Island to ensure our sample was representative of Northern Recovery Unit trends. The sample of 11 beaches included in the analysis represented approximately 30% of Northern Recovery Unit nesting in 2006.

Figure 3 shows summed nest totals from 11 Northern Recovery Unit beaches (Hammocks Beach State Park, Onslow Beach, Bald Head Island, Cape Island, Edisto Beach State Park, Edisto Beach, Fripp Island, Pritchards Island, Wassaw Island, Blackbeard Island, and Little Cumberland Island) from 1983-2006. To examine trends in annual nest totals, we used a log-linear regression with an autoregressive error correction to account for temporal correlation in annual nest totals. Results from the regression analysis showed a significant (P=0.03) declining trend of 1.6% annually in loggerhead nesting.

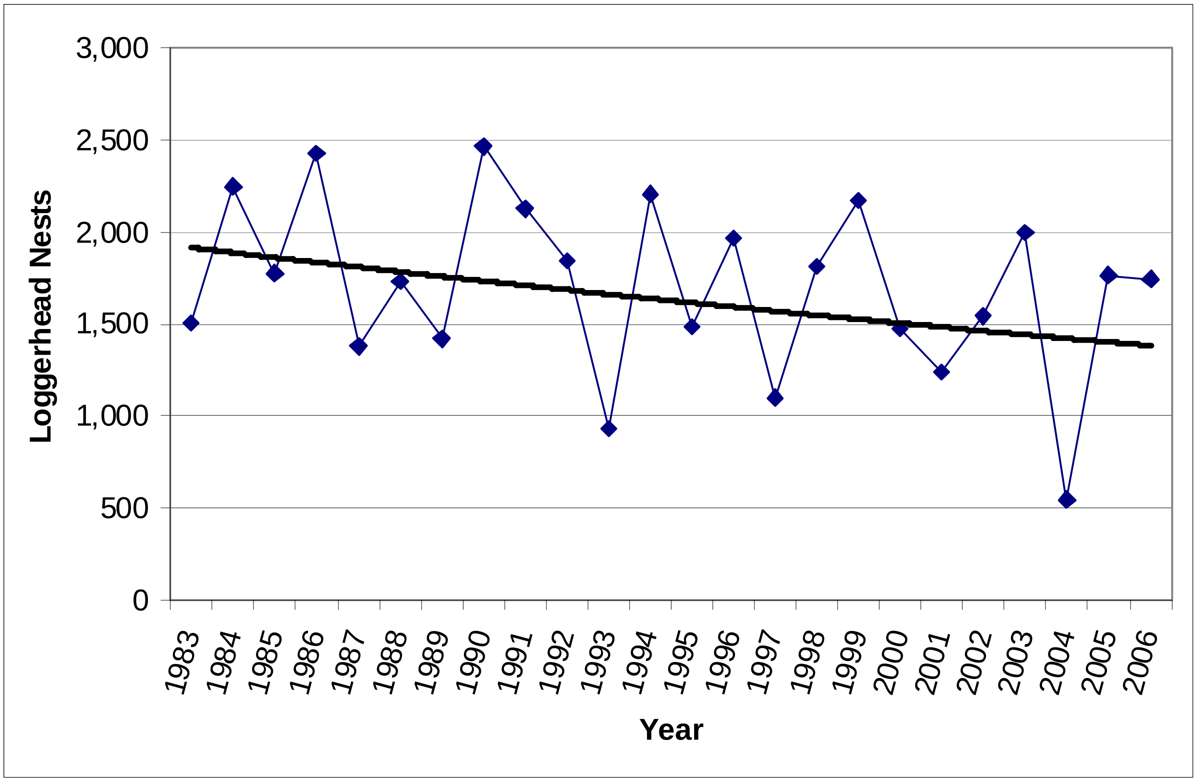

Figure 3. Summed annual loggerhead nest counts from 11 Northern Recovery Unit beaches (Hammocks Beach State Park, Onslow Beach, Bald Head Island, Cape Island, Edisto Beach State Park, Edisto Island, Fripp Island, Pritchards Island, Wassaw Island, Blackbeard Island, and Little Cumberland Island) from 1983-2006.

Standardized Aerial Surveys of Nesting Beaches

Standardized aerial surveys of nesting beaches conducted by SCDNR represent an additional dataset for assessing Northern Recovery Unit nesting trends (Hopkins-Murphy *et al*. 2001). Beginning in 1980, nests were surveyed from the side window of a fixed wing aircraft. Twelve surveys were conducted biweekly during June and July each year for the entire South Carolina coast with the exception of Myrtle Beach. Surveys were conducted in 3-year blocks separated by blocks of two years during which complete surveys were not conducted. An annual nest total was derived by estimating the percent nesting represented by the 12 flight days (after adjusting for bias from ground truth beaches) and then extrapolating to an overall total for the season (from a summary composite curve of nesting) (Hopkins-Murphy *et al*. 2001). Figure 4 shows loggerhead nest estimates from South Carolina aerial surveys, 1980-2006. A log-linear regression with autoregressive error correction showed a significant ($P<0.02$) annual decrease of 1.7% in loggerhead nesting. The South Carolina data represent 63% of Northern Recovery Unit nesting totals in 2006 (SCDNR, unpublished data).

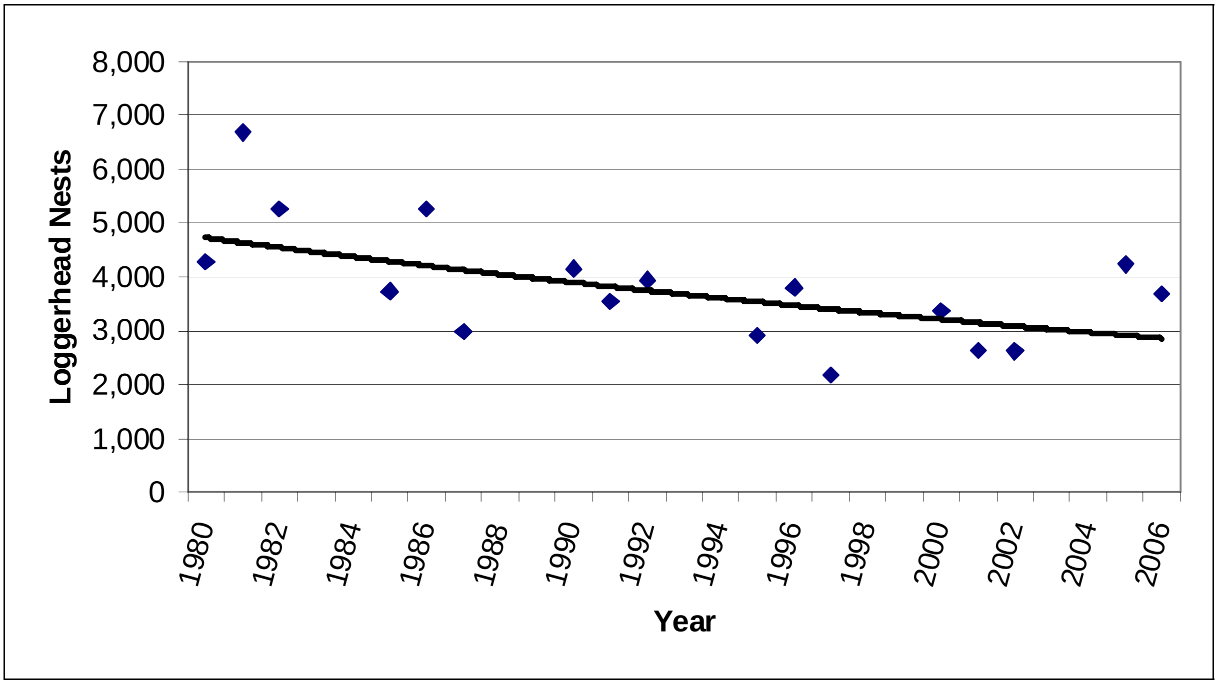

Figure 4. Annual loggerhead nest estimates for South Carolina from aerial surveys, 1980-2006.

Peninsular Florida Recovery Unit (PFRU)

The Peninsular Florida Recovery Unit is the largest loggerhead nesting assemblage in the Northwest Atlantic. A statewide near-complete census of sea turtle nesting in Florida undertaken from 1989 to 2006 reveals a mean of 65,631 loggerhead nests per year representing approximately 16,008 females nesting per year (4.1 nests per female, Murphy and Hopkins 1984) for the Peninsular Florida Recovery Unit (FFWCC, unpublished data). This near-complete census provides the best statewide estimate of total abundance, but because of variable survey effort, these numbers cannot be used to assess trends.

Loggerhead nesting trends are best assessed using standardized nest counts made at index nesting beach sites surveyed with constant effort over time. An analysis of these data has shown a decline in nesting from 1989-2006 (Figure 5, Witherington *et al*. in review). The analysis that reveals this decline uses nest-count data from 345 representative Atlantic-coast index zones (total length = 301 km) and 23 representative zones on Florida's southern Gulf coast (total length = 23 km). The spatial and temporal coverage (annually, 109 days and 368 zones) accounted for an average of 69% of statewide loggerhead nesting activity between 1989 and 2006. Negative binomial regression models that fit restricted cubic spline curves to aggregated nest-counts were used in trend evaluations. Results of the analysis indicated that there had been a decrease of 28% over the 18-year period (95% CI: -51.4% to -25.7%) and a 43% decline since 1998. The mean annual rate of decline for the 18-year period was 1.9%. Preliminary nest counts from 2007 are low and are likely to steepen the estimated decline.

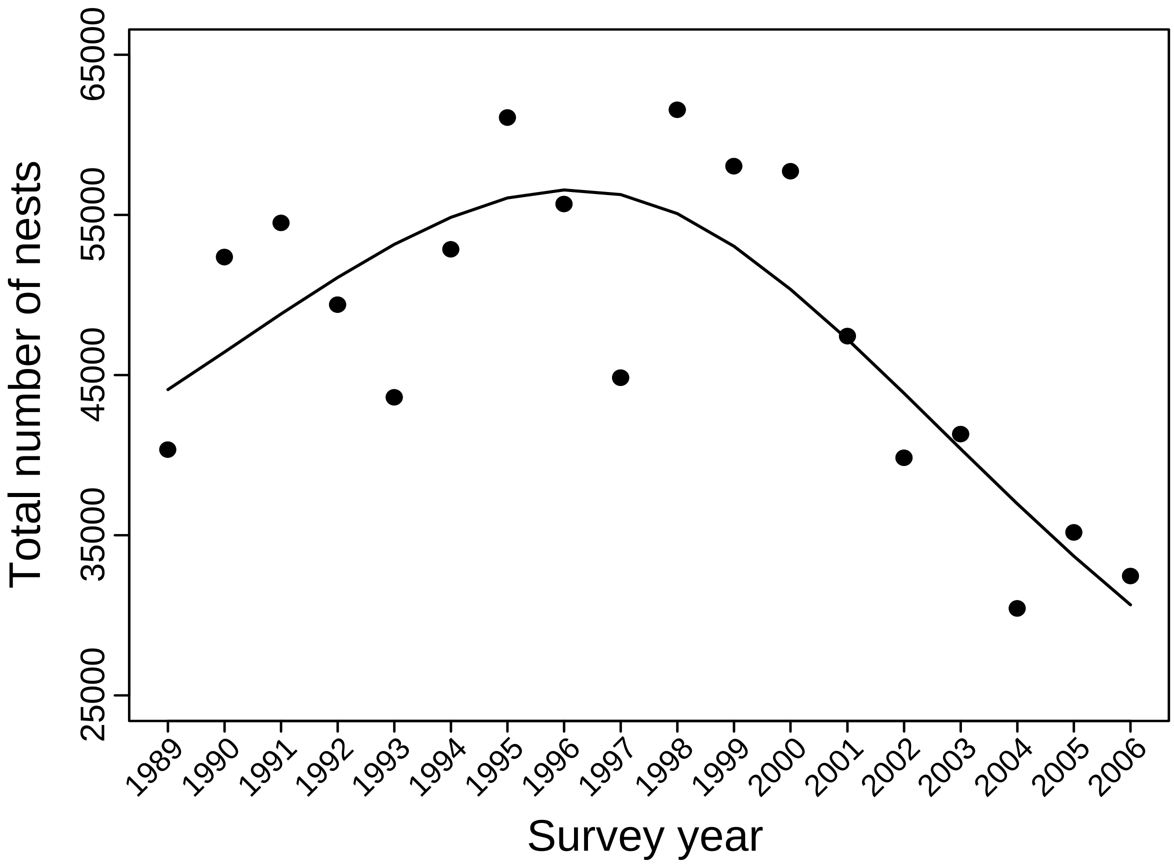

Figure 5. Annual total nest counts for loggerhead sea turtles on Florida Index beaches, 1989-2006. The trend line was estimated by fitting a 3-knot restricted cubic spline curve to the total counts via negative binomial regression (Witherington *et al*. in review). Note: Y-axis does not start at zero.

Northern Gulf Recovery Unit (NGRU)

The Northern Gulf Recovery Unit is the third largest nesting assemblage among the four U.S. recovery units. Nesting surveys conducted on approximately 300 km of beach within the Northern Gulf Recovery Unit (Alabama and Florida only) were undertaken between 1995 and 2006 (Alabama surveyed 2002-2006 only). The mean nest count during this 12-year period was 931 nests per year, which equates to about 227 females nesting per year (4.1 nests per female, Murphy and Hopkins 1984) (FFWCC, unpublished data).

Evaluation of long-term nesting trends for the Northern Gulf Recovery Unit is difficult because of changed and expanded beach coverage. However, there are 10 years of Florida index nesting beach survey (INBS) data for the Northern Gulf Recovery Unit (Figure 6, FFWCC, unpublished data). A log-linear regression showed a significant declining trend (P=0.005) of 6.3% annually. Preliminary nest counts from 2007 are low and are likely to steepen the estimated decline.

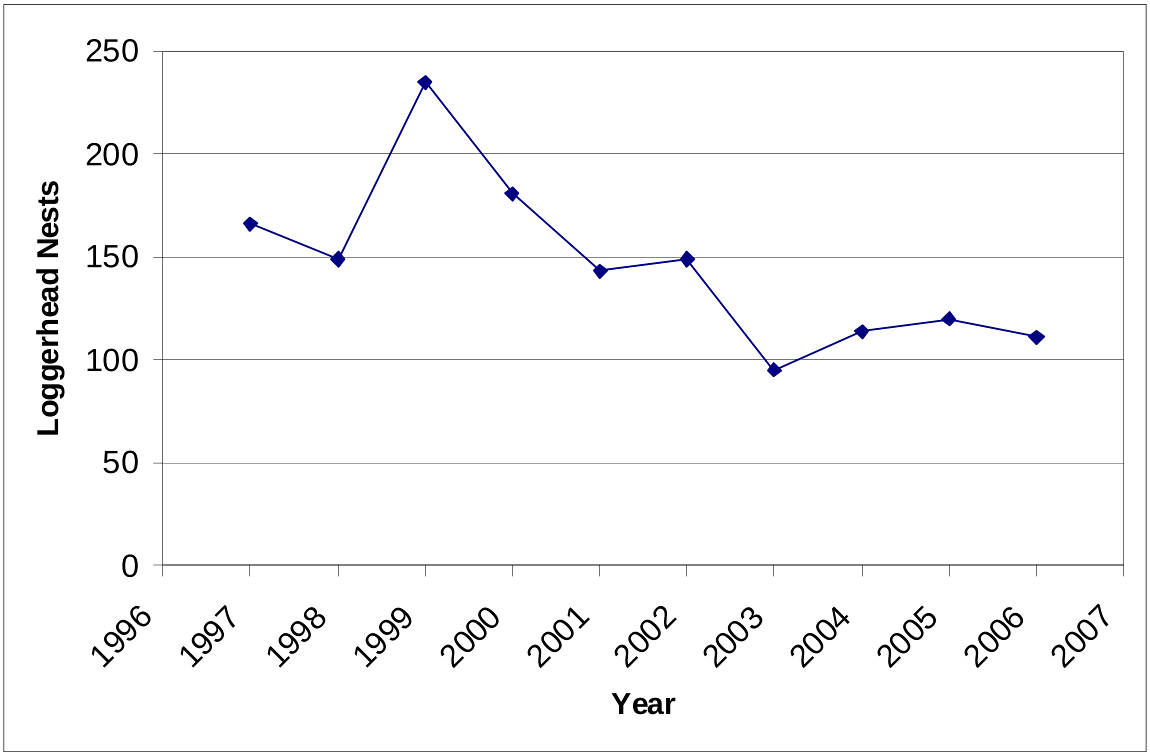

Figure 6. Summed annual loggerhead nest counts from three Northern Gulf Recovery Unit index beaches monitored consistently 1997-2006.

Dry Tortugas Recovery Unit (DTRU)

The Dry Tortugas Recovery Unit, located west of the Florida Keys, is the smallest of the identified recovery units. A near-complete census of the Dry Tortugas Recovery Unit undertaken from 1995 to 2004, excluding 2002, (9 years surveyed) reveals a mean of 246 nests per year, which equates to about 60 females nesting per year (4.1 nests per female, Murphy and Hopkins 1984) (FFWCC, unpublished data).

The nesting trend data for the Dry Tortugas Recovery Unit are from beaches that are not part of the INBS program but are part of the statewide nesting beach survey program. There are 9 years of data for this recovery unit (Figure 7). A simple linear regression accounting for temporal autocorrelation revealed no trend in nesting numbers. Because of the annual variability in nest totals, a longer time series is needed to detect a trend.

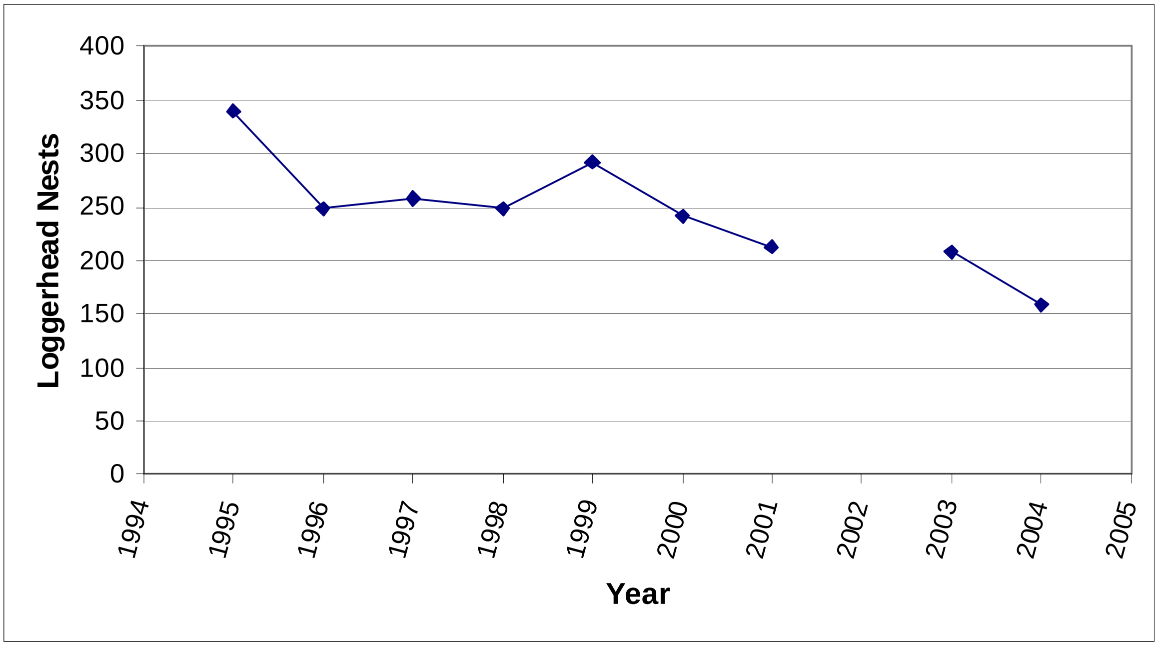

Figure 7. Summed annual loggerhead nest counts from beaches within the Dry Tortugas Recovery Unit (Monroe County west of Key West, including Woman Key, Boca Grande, Marquesas Keys, and islands of the Dry Tortugas) surveyed 1995-2004, excluding 2002.

Greater Caribbean Recovery Unit (GCRU)

The Greater Caribbean Recovery Unit is composed of all other nesting assemblages of loggerheads within the Greater Caribbean. Staticaslly valid analyses of long-term nesting trends for the GCRU are difficult because of the lack of long-term standardized surveys on loggerhead nesting beaches representative of the region, changing survey effort at monitored beaches, and scattered and low-level nesting by loggerheads at many locations. The most complete data are from Quintana Roo, Yucatan, Mexico, where an increasing trend was reported over a 15-year period from 1987-2001. However, nesting since 2001 has declined and the previously reported increasing trend appears to not have been sustained (J. Zurita, personal communcation, 2006).

E.2. IN-WATER POPULATIONS

In contrast to determining population size and trends on nesting beaches, determining population size and trends in the marine environment is logistically difficult and comparatively costly, in some cases prohibitively so. Short-term loggerhead population trends have been determined at a limited number of neritic sites in the U.S. (Table 1). However, extrapolation of these localized trends to the broader population and relating localized trends at neritic sites to population trends at nesting beaches is a problem of scale and requires the integration of many representative foraging grounds throughout the population range (Bjorndal *et al*. 2005).

Despite these problems, long-term in-water studies are needed in conjunction with surveys on nesting beaches to monitor population status and effectively track population changes, especially as recovery efforts are implemented and assessed. In addition to adding a vital component to monitoring trends in population numbers, in-water capture studies can provide information on sex ratios, population structure, genetic identities, health and occurrence of disease, and growth. All of these factors must be determined for accurate population modeling and assessment, and in-water studies provide a means of empirically deriving these important population parameters. In-water studies of sea turtles in the U.S. have focused on relatively few geographic areas and most have not monitored trends in population numbers. This section provides a summary of in-water studies where loggerheads are regularly captured, and where efforts have been made to provide local indices of abundance. Caution must be exercised in evaluating results from these studies given the relative short-term duration of most of the studies, noted difficulties in comparisons of trend data across disparate sampling periods, changes in sampling methodologies and equipment, small study areas, and uncontrolled variables such as weather, sea-state, migration patterns, and shifts in loggerhead distributions.

Table 1. Summary of loggerhead in-water population studies in the U.S. from which trend data have been reported.

Location	**Methodology**	**Study Period**[1]	**Trend Result**[2]	**Reference**
New York, inshore waters	Fishery Dependent (pound nets)	1987-2004	Declining	Morreale *et al*. 2005
Chesapeake Bay, VA	Aerial Survey	1982-2004	Declining	Mansfield 2006
Pamlico Sound, NC	Fishery Dependent (pound nets)	1995-2003	Increasing	SEFSC, unpublished data
Southeast U.S. Atlantic - SEAMAP	Trawl	1990-2000	No trend	NMFS 2001
Southeast U.S. Atlantic	Trawl	2000-2003	No trend	Maier *et al*. 2004
Mosquito Lagoon, FL	Tangle Net	1977-2005 1995-2005	Declining No trend	Jane Provancha, Dynamac Corporation, personal communication, 2006
Indian River Lagoon, FL	Tangle Net	1982-2005	No trend	Ehrhart *et al*. 2007
St. Lucie Nuclear Power Plant, FL	Power Plant Intake Structures	1977-2004	Increasing	FPL and Quantum Resources Inc. 2005
Florida Bay, FL	Sightings	2000-2006	No trend	Barbara Schroeder, NMFS, personal communication, 2006

[1] Study period does not imply continuous annual sampling, see project discussion for details.
[2] See project discussion for potential biases, caveats, and details.

New York

In-water studies of juvenile sea turtles in New York inshore waters (including Long Island Sound, Peconic Bay, Shinnecock Bay) were initiated in 1987 and continued through 1992. Turtles were collected from established pound nets throughout Long Island Sound. Research resumed in 2002 using a subset of the pound nets sampled during the earlier study period. Comparisons across the two study periods reveal a sharp decline in the percentage of turtle captures that were loggerheads from 59% of total captures from 1987-1992 to less than 4% of total captures during 2002-2004. In addition to the relative proportions of loggerheads changing dramatically between the two study periods, the absolute number of loggerheads captured in the latter study also changed dramatically - only two loggerheads were captured over the entire three-year period. Potential explanations for this decline include major shifts in loggerhead foraging areas and/or increased mortality in pelagic or early benthic stage/age classes (Morreale *et al*. 2005).

Chesapeake Bay, VA

The Chesapeake Bay is the largest estuary in the continental U.S. It lies adjacent to the Atlantic Ocean and is surrounded by Virginia and Maryland. The Chesapeake Bay's mainstem is 304 km long, extending from the Susquehanna River in the north to the Atlantic Ocean in the south. The Bay is 6.4 km wide at its narrowest point near Annapolis, Maryland, and 50 km wide at its widest point near the mouth of the Potomac River. The Bay hosts a seasonal population of loggerhead and Kemp's ridley sea turtles (*Lepidochelys kempii*), 95% of which is sub-adult/benthic juveniles. The Virginia Institute of Marine Science (VIMS) has maintained stranding and live mark-recapture datasets since 1979 and aerial abundance datasets spanning between 1982-1985, 1994, and 2001-2004 (Mansfield and Musick 2006). The mark-recapture program has tagged over 850 individual turtles to date from local fishing gears and live strandings. Up to 20-25% of individuals captured by pound net were subsequently recaptured in the same gear type indicating strong foraging site fidelity relative to these fixed gears (Mansfield 2006). Aerial surveys conducted from 2001-2004 indicated a 65% to 75% decline in the Chesapeake Bay sea turtle population since the 1980s (Mansfield 2006).

Available prey items (e.g., blue crab and horseshoe crab) have declined significantly within the Bay since the 1980s (Lipcius and Stockhausen 2002). Gut content analyses of Virginia strandings indicate a significant shift in diet among loggerhead sea turtles over time (1980-1994, 1997, and 2000-2002) from predominantly horseshoe crabs in the early to mid-1980s to blue crabs in the late 1980s and early 1990s, to mostly finfish in the late 1990s and early 2000s (Seney 2003; Seney and Musick 2007). These data suggest that turtles are foraging in greater numbers in or around fishing gears and on discarded bycatch (Seney 2003). The decline in observed sea turtle populations in the Bay may be related to this decline in prey with turtles redistributing outside of Bay waters. Replication of aerial surveys conducted in offshore areas by Keinath (1993) could provide additional information on observed declines in the Bay.

Pamlico-Albemarle Estuarine Complex

North Carolina's Pamlico-Albemarle Estuarine Complex is the largest estuarine system in the southeast U.S. and the third largest in North America (Gross 1972). The area encompasses several diverse estuarine habitats: open waters of the sounds, deeper central basins, embayments and tributary creeks, and shallow shelf areas containing seagrasses. This system is an important developmental habitat for loggerhead, green (*Chelonia mydas*), and Kemp's ridley sea turtles (Epperly *et al*. 1995b). Loggerheads, present in the sounds from April through December, are incidentally captured in pound nets. Population studies were initiated in 1995 to develop an index of sea turtle abundance and monitor long-term trends at this foraging site (Epperly *et al*. 2000). Catch rates of loggerheads in pound nets were derived for six sampling years (1995, 1996, 1997, 2001, 2002, 2003) from 1995 to 2003 (Epperly *et al*. 2000; SEFSC, unpublished data). Loggerhead catch rates increased significantly during the duration of the study (Sheryan Epperly, NMFS, personal communication, 2007).

In addition to the index of abundance surveys, pound nets in Pamlico and Core Sound have been systematically sampled several times per week for 6 months/year from May to December each year from 1998 to the present. Turtles are PIT and flipper tagged, measured, and blood and skin samples are collected from loggerheads to investigate growth rates (Braun-McNeill *et al*. 2002, NMFS 2001), sex ratios (Braun-McNeill *et al*. 2004, 2007a), stock structure (Bass *et al*. 1998), health status (Harms *et al*. 2002, 2006a, 2006b; Stamper *et al*. 2005; Valentine *et al*. 2007), tag retention (Braun-McNeill *et al*. 2002), survival (Sasso *et al*. 2006), abundance (Sasso *et al*. 2007), and site fidelity (Avens *et al*. 2003).

Southeast U.S. Atlantic

Maier *et al*. (2004) collected baseline data on sea turtle abundance along the southeast U.S. coast using bottom trawl gear (2-20 m nets; 16 cm stretch mesh) from 2000 through 2003. Between 602 and 709 stations were sampled annually from Georgetown, South Carolina, to St. Augustine, Florida, in water depths from 4.8 m to 14.9 m. No difference was found in loggerhead catch per unit effort among survey years (2000-2003). Loggerhead catch rates were also compared with fishery-dependent data collected on shrimp trawlers from 1979 through 1981 by Henwood and Stuntz (1987). Loggerhead capture rates were found to be approximately one order of magnitude higher in the present study than in the early 1980s. However, the authors warn that direct comparisons should be viewed with caution because net mesh size and tow speeds varied between studies. Both variables are known to influence capture rates. Despite these differences, the authors suggest that loggerheads were substantially more abundant during the study (2000-2003) than in the early 1980s (Maier *et al*. 2004).

The Southeast Area Monitoring and Assessment Program - South Atlantic Surveys (SEAMAP) program is an ongoing trawl survey conducted by SCDNR to assess the status of finfish, crab, shrimp, sea turtle, and squid populations in the coastal waters of the southeast U.S. Samples were taken from Cape Hatteras, North Carolina, to Cape Canaveral, Florida, using paired bottom trawls (2.0-22.9 m nets; 4.1 cm mesh) in depths ranging from 4 to 10 m. Between 78 and 102 stations were sampled annually from April through November. SEAMAP sea turtle capture data from 1990 to 2000 were analyzed by NMFS Southeast Fisheries Science Center (NMFS 2001).

Sea turtle capture rates were generally found to be low, and no significant trend was detected in loggerhead abundance during the study period. However, the authors caution that the power to detect a trend in loggerhead abundance was poor due to the short time series (11 years) and high variability in loggerhead capture rates.

Mosquito Lagoon, FL

Mosquito Lagoon, located in Brevard and Volusia Counties on the east-central coast of Florida, is an elongate shallow estuary 54 km long and 4 km wide at its widest point. The lagoon is bordered on the east by barrier islands and on the west by the Florida mainland. In the late 1970s, baseline data were collected on sea turtle life history, abundance, distribution, and behavior in the southern reaches of Mosquito Lagoon. Catch per unit effort (CPUE) derived for loggerheads over the 2-year study period (1977-1978) was 0.21 loggerheads per km-net hour (339 km-net hours) (Mendonca and Ehrhart 1992). In 1995, a new research project using the same capture methodology (large mesh tangle nets) and sampling locations was initiated to provide updated information on the life history, distribution, abundance, and movement of sea turtles within this estuarine ecosystem (Jane Provancha, Dynamac Corporation, personal communication, 2006). Captured turtles are measured, flipper and PIT (passive integrated transponder) tagged, blood sampled, externally examined, photographed, and released. Catch per unit effort is derived annually; CPUE for loggerheads over the 11-year study period was 0.07 loggerheads per km-net hour (311 km-net hours). A comparison of the CPUEs derived from these two studies indicates a decrease in the capture frequency of loggerheads from the late 1970s to the mid 1990s and early 2000s. However, caution must be exercised in directly comparing these results. Despite using similar capture techniques, the two studies, initiated almost 20 years apart, had very different total netting effort (i.e., the earlier study resulted in 339 km-net-hours over 2 years versus 328 km-net-hours over 12 years in the latter study). These differences could account for the observed CPUE decline between the two studies, or the decline may be real. There is no statistically significant trend in loggerhead CPUE over the 11-year sampling period in the more recent study (1995-2006) (Jane Provancha, Dynamac Corporation, personal communication, 2006).

Central Indian River Lagoon, FL

The Indian River Lagoon system extends 260 km along the Atlantic coast of Florida from Ponce de Leon Inlet in Volusia County to Jupiter Inlet in northern Palm Beach County. In 1982, the University of Central Florida Marine Turtle Research Group began a study of the life history, population structure, and relative abundance of sea turtle populations in the central region of the Indian River Lagoon within a large embayment 3 km south of Sebastian Inlet and within 1 km of the east shore in Indian River County. One of the primary purposes of the study is to monitor long-term trends in relative abundance of loggerheads using large-mesh tangle net capture methodologies. Annual CPUE is derived based on standard capture methodologies and similar year-to-year sampling effort. Captured turtles are measured, flipper and PIT tagged, photographed, blood sampled, assessed for signs of fibropapilloma tumors, and released. There was no statistically significant trend detected in loggerhead CPUE over the 23-year period from 1982-2005 (Ehrhart *et al*. 2007).

St. Lucie Power Plant, FL

The Florida Power and Light Company's St. Lucie Nuclear Power Plant, an electric generating station located on Hutchinson Island in St. Lucie County, Florida, has provided an opportunity to monitor loggerheads from waters adjacent to its cooling-canal intake. The power plant draws cooling water from the Atlantic Ocean adjacent to nearshore hardbottom, internesting habitat, and migratory routes. The water is drawn through large pipes (two with 3.7 m and one with 4.9 m diameter) at a moderate velocity (< 30 cm/sec) into a long intake canal. Loggerheads that swim beneath a velocity cap covering the intake are drawn into the intake canal where they are manually captured and returned to the ocean. Since the plant became operational in 1976, turtles trapped in the intake canal have been systematically captured, measured, weighed, tagged, examined for overall condition, and released. Since 1977, the first full year of plant operation, the number of loggerheads captured each year ranged from 62 in 1981 to 624 in 2004 (total captures = 6,482, 1976-2005). Loggerheads captured at the plant range in size from 39 to 112 cm minimum carapace length, which includes juveniles and adults that are foraging, migrating, or between nesting attempts at nearby nesting beaches. Total annual captures of loggerheads has been increasing (Florida Power and Light Company and Quantum Resources Inc. 2005), with high annual variation in captures. Biases associated with long-term capture trends include variable local habitat conditions, prey abundance and distribution, migration paths, condition of the intake pipes and caps, and power plant flow-rate changes.

Florida Bay, FL

Population studies of sea turtles in Florida Bay (southern terminus of the Florida peninsula) were initiated in 1990 in the central western portion of the Bay. Both juvenile and adult loggerheads are captured by hand during annual sampling events; approximately 750 individual loggerheads have been captured to date. Sampling methodologies introduced in 2000 were designed to monitor population trends within the study area using shipboard sightings per unit effort (SPUE) as an annual index of abundance. There was no significant difference in loggerhead SPUE over the 7-year period (2000-2006) (Barbara Schroeder, NMFS, personal communication, 2007).

F. LIFE HISTORY AND HABITAT

Loggerheads have a complex life history that encompasses terrestrial, nearshore, and open ocean habitats. Key life history characteristics are summarized in Tables 2 and 3.

Table 2. Key life history traits for loggerheads nesting in the U.S.

Life History Trait	**Data**
Clutch size	100-126 eggs[1]
Incubation duration (varies depending on time of year and latitude)	Range = 42-75 days[2,3]
Juvenile (<87 cm CCL) sex ratio	65-70% female[4]
Pivotal temperature (incubation temperature that produces an equal number of males and females)	29.0˚C[5]
Nest productivity (emerged hatchlings/total eggs) x 100 (varies depending on site specific factors)	Range = 45-70%[2,6]
Clutch frequency (number of nests/female/season)	3-4 nests[7]
Internesting interval (number of days between successive nests within a season)	12-15 days[8]
Remigration interval (number of years between successive nesting migrations)	2.5-3.7 years[9]
Nesting season	late April-early September
Hatching season	late June-early November
Age at sexual maturity	32-35 years[10]
Life span	>57 years[11]

1 Dodd 1988.
2 Dodd and Mackinnon (1999, 2000, 2001, 2002, 2003, 2004).
3 Blair Witherington, FFWCC, personal communication, 2006 (information based on nests monitored throughout Florida beaches in 2005, n=865).
4 National Marine Fisheries Service (2001); Allen Foley, FWC, personal communication, 2005.
5 Mrosovsky (1988); Marcovaldi *et al*. (1997).
6 Blair Witherington, FFWCC, personal communication, 2006 (information based on nests monitored throughout Florida beaches in 2005, n=1,680).
7 Murphy and Hopkins (1984); Frazer and Richardson (1985); Ehrhart, unpublished data.
8 Caldwell (1962), Dodd (1988).
9 Richardson *et al*. (1978); Bjorndal *et al*. (1983); Ehrhart, unpublished data.
10 Melissa Snover, NMFS, personal communication, 2005.
11 Dahlen *et al*. (2000).

Table 3. Reported size distributions, stage durations, annual survival probabilities, and growth rates for loggerheads nesting in the U.S. See citations for details regarding values reported.

Life Stage	Size	Stage Duration	Annual Survival Probabilities	Growth Rate
Hatchling	4 cm CCL[1]	1-5 days[2]	Year 1 = 0.7[3,6]	--
Post-hatchling	4-6 cm CCL[4]	<6 months[5]		10.8 cm/yr[5]
Oceanic juvenile	8.5-64 cm CCL[5,7]	7-11.5 years[8]	0.9[6,9]	2.9-5.4 cm/yr[10]
Neritic juvenile	46-87 cm CCL[11]	13-20 years[12]	0.7-0.8[13]	1.8-2.1 cm/yr[14]
Adult female	>87 cm CCL[1,15]	>25 years[16]	0.9[6,17]	0.6 cm/yr[18]
Adult male	>83 cm CCL[19]	--	--	0.1 cm/yr[20]

1 Ehrhart (1980).
2 Duration from hatching out of the egg until entering the water.
3 Hatchling and post-hatchling stages are combined because estimates of survival probabilities from stage-based models are based on annual rates; these two stages occur within the first year. Stage based survival estimates are based on similar size classes used in the matrix population models (Heppell *et al*. 2003b) and differ slightly with those presented in this table, which are based on empirical data.
4 Blair Witherington, FFWCC, personal communication, 2006.
5 Bjorndal *et al*. (2000).
6 Heppell *et al*. (2003b).
7 Bjorndal *et al*. (2003b).
8 Bjorndal *et al*. (2003a) (7 years: 8.5-46 cm CCL; 11.5 years: 8.5-64 cm CCL).
9 Bjorndal *et al*. (2003b) (estimated annual survivorship for years 2-6).
10 Snover (2002) (mean 2.9 cm SCL/yr); Bjorndal *et al*. (2003a) (mean 5.4 cm CCL/yr).
11 Bjorndal *et al*. (2001).
12 Bjorndal *et al*. (2001) (13 years: 64-87 cm CCL; 20 years: 46-87 cm CCL).
13 Heppell *et al*. (2003b).
14 Bjorndal *et al*. (2001) (mean = 1.8 cm CCL/yr (64-87 cm CCL); mean = 2.1 cm CCL/yr (46-87 cm CCL)); Snover (2002) (mean = 2.1 cm SCL/yr (45.1-80.6 cm SCL)).
15 Witherington (1986), Byrd *et al*. (2005).
16 Dahlen *et al*. (2000).
17 Hedges (2007).
18 Bjorndal *et al*. (1983).
19 Schroeder, unpublished data from Florida Bay (based on tail lengths >40 cm from plastron to tip of tail).
20 Schroeder, unpublished data from Florida Bay.

The three basic ecosystems in which loggerheads live are the:

1. Terrestrial zone (supralittoral) - the nesting beach where both oviposition (egg laying) and embryonic development and hatching occur.
2. Neritic zone - the inshore marine environment (from the surface to the sea floor) where water depths do not exceed 200 meters. The neritic zone generally includes the continental shelf, but in areas where the continental shelf is very narrow or nonexistent, the neritic zone conventionally extends to areas where water depths are less than 200 meters.
3. Oceanic zone - the vast open ocean environment (from the surface to the sea floor) where water depths are greater than 200 meters.

Within the two marine ecosystems:

- Organisms are pelagic if they occupy the water column, but not the sea floor, in either the neritic zone or oceanic zone. Organisms are epipelagic if they occupy the upper 200 meters in the oceanic zone.
- Organisms on the sea floor in either the neritic zone or oceanic zone are described as benthic or demersal.

Bolten (2003) reviews this terminology with respect to sea turtle life history; see Lalli and Parsons (1997) for review of basic oceanographic terminology.

The generalized life history of Atlantic loggerheads is shown in Figure 8 (from Bolten 2003). The life history stages are described in the following sections.

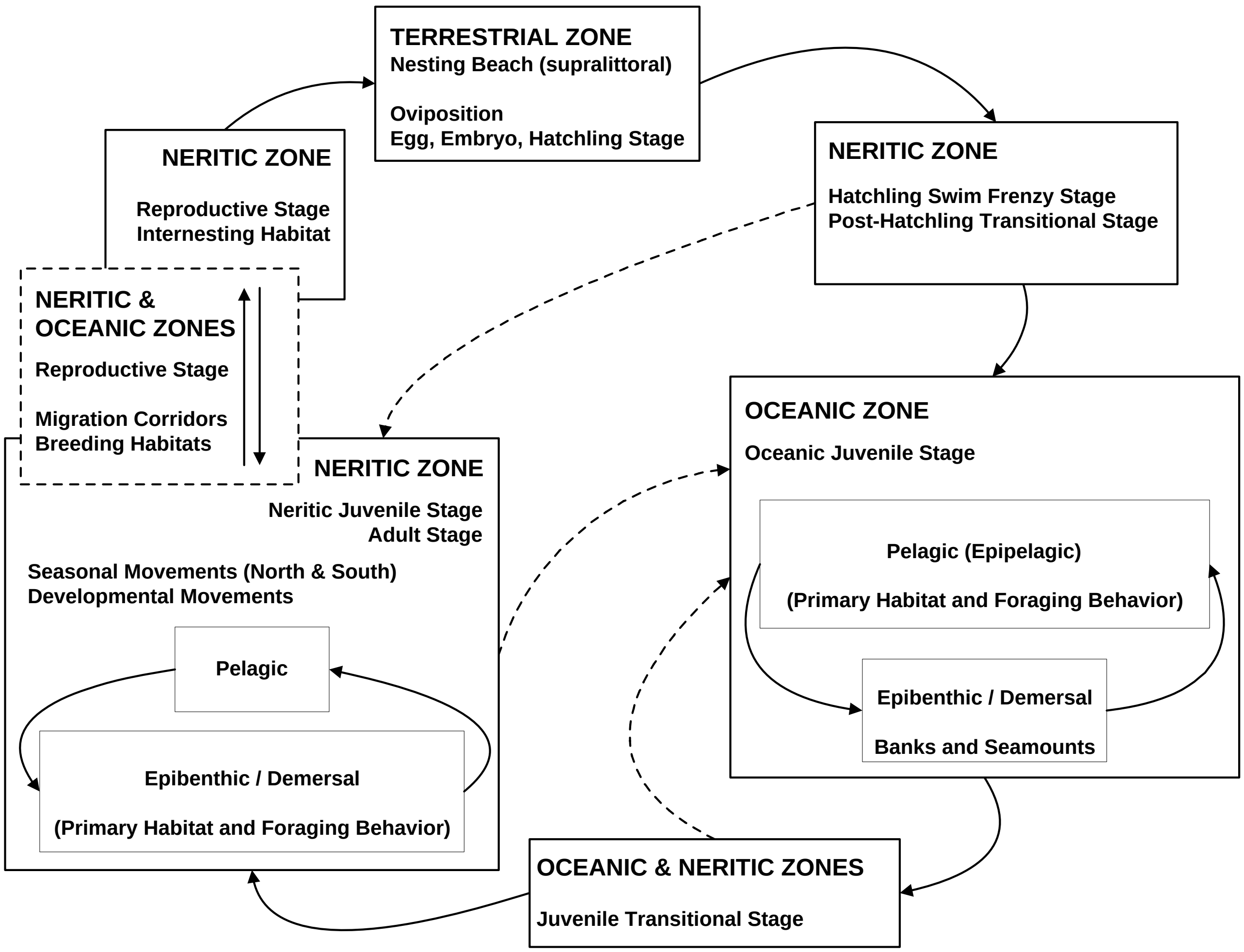

Figure 8. Generalized life history of North Atlantic loggerhead sea turtles (Bolten 2003).

F.1. TERRESTRIAL ZONE (NESTING BEACH)

Nesting Habitat

Loggerheads nest on ocean beaches and occasionally on estuarine shorelines with suitable sand. Nests are typically laid between the high tide line and the dune front (Routa 1968, Witherington 1986, Hailman and Elowson 1992). Wood and Bjorndal (2000) evaluated four environmental factors (slope, temperature, moisture, and salinity) and found that slope had the greatest influence on loggerhead nest-site selection. Loggerheads appear to prefer relatively narrow, steeply sloped, coarse-grained beaches, although nearshore contours may also play a role in nesting beach site selection (Provancha and Ehrhart 1987).

Nest Characteristics/Requirements

Sea turtle eggs require a high-humidity substrate that allows for sufficient gas exchange for development (Miller 1997, Miller *et al*. 2003). Mean clutch size varies from about 100 to 126 eggs along the southeast U.S. coast (Dodd 1988). Loggerhead nests incubate for variable periods of time. The length of the incubation period (commonly measured from the time of egg deposition to hatchling emergence) is inversely related to nest temperature, such that between $26^{o}C$ and $32^{o}C$, a change of $1^{o}C$ adds or subtracts approximately 5 days (Mrosovsky 1980).

The warmer the sand surrounding the egg chamber, the faster the embryos develop (Mrosovsky and Yntema 1980). Sediment temperatures prevailing during the middle third of the incubation period also determine the sex of hatchling sea turtles (Mrosovsky and Yntema 1980). Incubation temperatures near the upper end of the tolerable range produce only female hatchlings while incubation temperatures near the lower end of the tolerable range produce only male hatchlings. The pivotal temperature (i.e., the incubation temperature that produces equal numbers of males and females) in loggerheads is approximately $29^{o}C$ (Limpus *et al*. 1983, Mrosovsky 1988, Marcovaldi *et al*. 1997). However, clutches with the same average temperature may have different sex ratios depending on the fluctuation of temperature during incubation (Georges *et al*. 1994). Moisture conditions in the nest similarly influence incubation period, hatching success, and hatchling size (McGehee 1990, Carthy *et al*. 2003).

Hatchling Emergence Behavior

Loggerhead hatchlings pip and escape from their eggs over a 1- to 3-day interval and move upward and out of the nest over a 2- to 4-day interval (Christens 1990). The time from pipping to emergence ranges from 4 to 7 days with an average of 4.1 days (Godfrey and Mrosovsky 1997). Hatchlings emerge from their nests en masse almost exclusively at night, and presumably using decreasing sand temperature as a cue (Hendrickson 1958, Mrosovsky 1968, Witherington *et al*. 1990). Moran *et al*. (1999) concluded that a lowering of sand temperatures below a critical threshold, which most typically occurs after nightfall, is the most probable trigger for hatchling emergence from a nest. After an initial emergence, there may be secondary emergences on subsequent nights (Carr and Ogren 1960, Witherington 1986, Ernest and Martin 1993).

Hatchlings use a progression of orientation cues to guide their movement from the nest to the marine environments where they spend their early years (Lohmann and Lohmann 2003). Hatchlings first use light cues to find the ocean. On naturally lighted beaches without artificial lighting, ambient light from the open sky creates a relatively bright horizon compared to the dark silhouette of the dune and vegetation landward of the nest. This contrast guides the hatchlings to the ocean (Daniel and Smith 1947, Limpus 1971, Salmon *et al*. 1992, Witherington 1997, Witherington and Martin 1996).

F.2. NERITIC ZONE: HATCHLING SWIM FRENZY STAGE AND POST-HATCHLING TRANSITIONAL STAGE

Swim Frenzy

Immediately after hatchlings emerge from the nest, they begin a period of frenzied activity. During this active period, hatchlings move from their nest to the surf, swim and are swept through the surf zone, and continue swimming away from land for approximately 20 to 30 hours (Carr and Ogren 1960; Carr 1962, 1982; Wyneken and Salmon 1992; Witherington 1995). Orientation cues used by hatchlings as they crawl, swim through the surf, and migrate offshore are discussed in detail by Lohmann and Lohmann (2003). Mortality from fish predation was 5 of 74 hatchlings swimming within approximately 1 km from the beach and within 2 hours of entering the Atlantic at three Florida locations (Witherington and Salmon 1992). Predation over reefs and at hatcheries may be higher (Wyneken and Salmon 1996, Wyneken *et al*. 1998).

Observations of loggerheads swimming in a laboratory setting (Wyneken and Salmon 1992) and at sea (Witherington 1995) reveal a pronounced reduction in activity after 20 to 30 hours post-emergence, although oriented swimming continues for several days afterward. Five hatchlings released near midnight and observed constantly for 2 days during their movement from a Florida beach into the Atlantic swam with the powerstroke and dogpaddle pattern during the first 30 hours. After 30 hours (daylight of their second day at sea), they began to use a lower-energy rear-flipper kick-swimming pattern in addition to powerstroking. On the following night (42 hours post release), hatchlings became inactive and were commonly in a tuck position wherein flippers are held close to the body. Two hatchlings followed more than 3 days continued a diurnal swimming pattern like that observed in hatchlings swimming under natural photoperiods in the laboratory (Wyneken and Salmon 1992). In addition to swimming, hatchlings may stop briefly to move within the floating seaweeds in the genus *Sargassum* located in their path, assume a tuck position in response to subsurface predators, and make dives to 3 meters in response to aerial predators (Witherington and Salmon 1992, Witherington 1995). Hatchlings swimming from land rely on an approximately 5-day store of energy and nutrients within their retained yolk sac (Kraemer and Bennett 1981).

Post-hatchling Transition

Neonate loggerheads that have migrated away from land differ from swim frenzy stage hatchlings in that they are infrequently low-energy swimmers and they have begun to feed, no longer relying on their retained yolk (Witherington 2002). As post-hatchlings, loggerheads are pelagic and are best known from neritic waters along the continental shelf. This neritic post-hatchling stage is weeks or months long (Witherington 2002) and may be a transition to the oceanic stage that loggerheads enter as they grow and are carried within ocean currents (Bolten 2003).

Post-hatchling loggerheads inhabit areas where surface waters converge to form local downwellings (Witherington 2002). These areas are characterized by linear accumulations of floating material, especially *Sargassum*, and are common between the Gulf Stream and the southeast U.S. coast, and between the Loop Current and the Florida coast in the Gulf of Mexico. Post-hatchlings within this habitat are observed to be low-energy float-and-wait foragers that feed on a wide variety of floating items (Witherington 2002). Witherington (2002) found that small animals commonly associated with the *Sargassum* community, such as hydroids and copepods, were most commonly found in esophageal lavage samples. As post-hatchlings, loggerheads may linger for months in waters just off the nesting beach or become transported by ocean currents within the Gulf of Mexico and North Atlantic.

F.3. OCEANIC ZONE: JUVENILE STAGE

The biology of the oceanic juvenile stage (which will be referred to as the oceanic stage) has recently been reviewed by Bolten (2003).

Habitat Description

The oceanic stage begins when loggerheads enter the oceanic zone and, in the North Atlantic, has been primarily studied in the waters around the Azores and Madeira (Bolten 2003). Other populations exist (e.g., in the region of the Grand Banks off Newfoundland), but data on these populations are very limited. Turtle movements in this stage are both active and passive relative to surface and subsurface oceanic currents and winds; turtles may use bathymetric features for orientation (ACCSTR, unpublished data). These turtles are epipelagic, spending 75% of their time in the top 5 meters of the water column. Eighty percent of the dives are between 2 to 5 meters with the remainder of the dives distributed throughout the top 100 meters of the water column; occasionally dives are greater than 200 meters (ACCSTR, unpublished data). In the vicinity of seamounts, oceanic banks or ridges that come close to the surface, or around oceanic islands, loggerheads may become epibenthic/demersal by feeding or spending time on the bottom.

In Azorean waters, satellite telemetry data and flipper tag returns suggest a long period of residency (Bolten 2003), whereas turtles appear to be moving through Madeiran waters (Dellinger and Freitas 2000). This may not be surprising when one considers the physical oceanographic aspects of the regions. The Azorean region is characterized by a complexity of seamounts, banks, and the Mid-Atlantic Ridge, which results in a complexity of eddies and convergent zones – prime habitats for oceanic-stage loggerheads. Seamounts are less prevalent in the Madeiran region.

Diet

The diet of oceanic-stage loggerheads has been poorly studied. They are primarily carnivorous, although they do ingest some vegetation (Bjorndal 1997). Loggerheads in this life stage consume primarily coelenterates (e.g., sea jellies, hydroids) and salps, but also ingest a range of organisms including the pelagic snail *Janthina* spp., barnacles (*Lepas* spp.), and crabs (see Bjorndal 1997 for review).

Relationship of Oceanic Juvenile Populations to Rookery Sources

Carr (1986) and later Bolten *et al*. (1993) used the comparison of size frequency distributions to suggest that loggerheads found in the oceanic zone around the Azores were an earlier life stage of the larger turtles in the neritic waters of the western North Atlantic. The relationship between the little loggerheads in the oceanic zone and the larger-sized neritic loggerheads in the Northwest Atlantic was further supported by recaptures of turtles tagged in the oceanic zone and recaptured in the neritic zone of the Northwest Atlantic (Bolten 2003).

With the development of molecular genetic tools (e.g., mitochondrial DNA sequence analyses), the relative contributions of rookeries to mixed stocks of oceanic-stage loggerheads could be evaluated (Bowen 1995, 2003). After the Atlantic rookeries were genetically characterized by Encalada *et al*. (1998), Bolten *et al*. (1998) were able to demonstrate that the oceanic-stage loggerheads in the waters around the Azores and Madeira were primarily from rookeries in the southeast U.S. (90%) and Mexico (10%). Based on flipper tag returns (Bolten 2003, Bolten *et al*. 1992a) and on molecular genetic studies (Laurent *et al*. 1993, 1998), movement of little loggerheads from Northwest Atlantic rookeries and Azorean waters into the western Mediterranean is probably more common than originally thought. These loggerheads from the Northwest Atlantic apparently leave the Mediterranean before they mature and reproduce (Laurent *et al*. 1998).

Size Distribution

The size distribution of oceanic-stage loggerheads in the waters around the Azores ranges from 8.5 to 82 cm curved carapace length (CCL) with a mean and standard deviation of 34.5 ± 12.6 cm (Bolten 2003). Most turtles in this area (99.3% of the sample) range from 8.5 to 64 cm (n = 1,680, mean = 34.2, SD = 12.2; ACCSTR, unpublished data). This size distribution is not significantly different from another nearby oceanic-zone aggregation in the waters around Madeira (Bolten *et al*. 1993). For this recovery plan, the size range of the oceanic stage is defined as 8.5 to 64 cm CCL.

Growth Rates

Bjorndal *et al*. (2003a), using skeletochronology and longitudinal growth analyses, estimated a mean growth rate of 5.4 cm CCL per year (SD = 1.8 cm). The size-specific growth rate function from length-frequency analyses is consistent with growth rates calculated from recaptures of tagged turtles (summarized in Bjorndal *et al*. 2000). Zug *et al*. (1995) evaluated the somatic growth rates of oceanic-stage loggerheads in the Pacific using skeletochronology. The age-specific growth function for the Pacific was similar in shape but with a slower growth rate than those for the Atlantic (Bjorndal *et al*. 2003a).

Duration of the Oceanic Juvenile Stage

Length-frequency analyses (Bjorndal *et al*. 2000) and skeletochronology (Bjorndal *et al*. 2003a) were used to estimate the duration of the oceanic stage as 7 to 11.5 years depending on the size of the turtles when they leave the oceanic zone (46 to 64 cm CCL). Based on a skeletochronology study of neritic-stage loggerheads, Snover *et al*. (2000) concluded that loggerheads are approximately 52 cm SCL when they settle in the neritic zone off the U.S. Atlantic coast. This value of 52 cm SCL is similar to the value of 53 cm CCL at the intersection of the length frequency distributions of the oceanic stage and the neritic stage, which is equivalent to 8.2 years duration in the oceanic stage (Bjorndal *et al*. 2000).

Survival Probabilities

Survival probabilities for the oceanic stage have been generated as fitted values in demographic models rather than direct estimates (Chaloupka 2003, Heppell *et al*. 2003b). Bjorndal *et al*. (2003b) used catch-curve analyses to directly estimate survival probabilities of oceanic-stage loggerheads in the waters around the Azores. At ages before loggerheads begin to emigrate from the oceanic zone (2 to 6 years of age), the estimate of annual survival probability is 0.911. Turtles that are 2 to 6 years of age (18 to 44 cm CCL, Bjorndal *et al*. 2003b) are not generally caught in the longline fishery (Bolten 2003). After emigration begins at 7 years of age, the estimate of annual survival probability drops to 0.643, which is confounded by emigration but includes mortality from bycatch in longline fisheries (Bjorndal *et al*. 2003b). Using satellite telemetry, Sasso and Epperly (2007) calculated a survival rate of 0.81 for juvenile loggerheads (mean of 52 cm SCL) off the Grand Banks and Azores. Estimates of mortality prior to age 2 are not available, but mortality may be high during this stage both from natural predation and stochastic events that result in little loggerheads being passively swept into inappropriate habitats, such as the waters around Labrador or the waters around the British Isles (Carr 1986, Hays and Marsh 1997).

Juvenile Transition from Oceanic to Neritic Zone

The shift from the oceanic to the neritic zone is a dramatic one. As such, there is probably a period of transition, perhaps in both behavior and morphology. Kamezaki and Matsui (1997) discuss specific allometric relationships that change during the juvenile transitional stage, which are related to changes in foraging behavior (e.g., epipelagic versus benthic). The geographic regions where the transitional stages occur may be in regions where major oceanic currents approach or enter the neritic zone. The broad size range over which the turtles in the Atlantic leave the oceanic zone and enter the neritic zone (Bjorndal *et al*. 2000, 2001) may also suggest that this transitional stage is of variable duration. Factors that may drive this habitat shift (e.g., differential growth rates) are discussed in Bolten (2003). Size frequency distributions of populations that fall between the oceanic stage and the neritic juvenile stage may support the existence of this transitional stage. The mean size of 53 cm CCL of a population off the Atlantic coast of Morocco is the estimated mid-point of the size distributions for the juvenile transitional stage and suggests that this population may represent a transitional stage between the oceanic and neritic stages (Tiwari *et al*. 2002). A juvenile transitional stage for the Mediterranean populations has also been suggested (Laurent *et al*. 1998). As Figure 8 indicates, if the oceanic-neritic transition is not complete, loggerheads may return to the oceanic zone. For example, a 73 cm SCL loggerhead tagged along the Atlantic coast of Florida was recaptured in the Azores (Eckert and Martins 1989). Also, if juvenile loggerheads make multiple loops in the Atlantic gyre system rather than a single developmental loop, this could result in periodic movements between the oceanic and neritic zones (Witzell 2002, Bolten 2003).

F.4. NERITIC ZONE: JUVENILE STAGE

Habitat Description

Juvenile stage loggerheads in the North Atlantic inhabit continental shelf waters from Cape Cod Bay, Massachusetts, south through Florida, The Bahamas, Cuba, and the Gulf of Mexico. Estuarine waters, including areas such as Long Island Sound, Chesapeake Bay, Pamlico and Core Sounds, Mosquito and Indian River Lagoons, Biscayne Bay, Florida Bay, and numerous embayments fringing the Gulf of Mexico, comprise important inshore habitat (Musick and Limpus 1997, Murphy *et al*. 2003). Along the Atlantic and Gulf of Mexico shoreline, essentially all shelf waters are inhabited by loggerheads. Long-term in-water studies indicate that juvenile loggerheads reside in particular developmental foraging areas for many years. Seasonal movements of juvenile loggerheads along the Atlantic coast, from more northerly resident areas during warmer months to more southerly or offshore resident areas during colder months, have been well documented. Results from satellite telemetry have demonstrated that a small proportion of the juvenile stage may return to the oceanic zone particularly in the winter (McClellan and Read 2007, Mansfield 2006).

Diet

Juvenile stage loggerheads feed on a wide variety of organisms inhabiting the neritic zone. Diet studies focused on North Atlantic juvenile stage loggerheads indicate that benthic invertebrates, notably mollusks and benthic crabs, are the primary food items (Burke *et al*. 1993, Youngkin 2001, Seney 2003). In south Texas, sea pens (a colonial coral) were the most common prey item, followed by benthic crabs (Plotkin *et al*. 1993). Seasonal dietary shifts with changing prey abundance and/or geographic differences in prey selection have been documented (Plotkin *et al*. 1993, Ruckdeschel and Shoop 1988, Youngkin 2001). Youngkin (2001) found that discarded fish bycatch, from nearshore shrimp trawl fishing was commonly ingested by juvenile loggerheads. Gut content analyses of loggerheads in Chesapeake Bay, Virginia, by Seney and Musick (2007) documented a shift in loggerhead prey items from predominantly horseshoe crabs (*Limulus polyphemus*) during the early to mid-1980s, to predominantly blue crabs during the 1980s, to finfish discarded by fisheries in the mid-1990s and in 2000-2002.

Relationship of Neritic Juvenile Populations to Rookery Sources

The development of molecular genetic tools (e.g., mtDNA sequence analyses) has provided a basis for evaluating the relationship of neritic juvenile populations to rookery sources (see

Bowen *et al*. 2004 for a review). Two factors may explain the genetic composition of neritic juvenile foraging populations: population size of source rookeries and proximity to these rookeries. There is a significant correlation between the genetic composition of neritic juvenile populations and adjacent nesting populations that provides evidence for juvenile homing to natal regions (Bowen *et al*. 2004). Results from Bass *et al*. (2004) for a North Carolina foraging assemblage also support juvenile homing to natal regions. There have been new developments in statistical modeling of mixed foraging stocks (Bolker *et al*. 2003, 2007; Okuyama and Bolker 2005), as well as more complete rookery sampling (e.g., Cape Verde Islands and The Bahamas) (ACCSTR, unpublished data) and increased sampling of southeast U.S. rookeries (ACCSTR, unpublished data). These new statistical models and more complete rookery samples will provide a better basis for analyzing source rookeries for neritic juvenile populations.

Size Distribution

At about 46 cm CCL, oceanic juveniles begin to leave the oceanic habitat for the neritic habitat (Bjorndal *et al*. 2000, 2003a; Bolten 2003). By about 65 cm CCL, almost all of the juveniles have left the oceanic habitat. For the purposes of this recovery plan, the size range of the neritic juvenile stage is designated as 46-87 cm CCL. However, due to natural variations in the life history of the loggerhead, turtles smaller than 46 cm CCL may occur in the neritic habitat and turtles greater than 87 cm CCL may still not be sexually mature.

Growth Rates

Several studies have reported growth rates from juvenile loggerheads in neritic habitats (summarized in Bjorndal 2003, NMFS 2001). Published estimates for growth, based on carapace length for juvenile loggerheads in coastal waters of the U.S., are highly variable. Much of the variation is due to differences in body size and environment (e.g., water temperature). In addition, most studies suffer from very small sample sizes. Based on two studies with large sample sizes (Bjorndal *et al*. 2001 used length-frequency analyses; Snover 2002 used skeletochronology), the average growth rates for neritic juvenile turtles are 1.8 to 2.1 cm per year (see Table 3).

Duration of the Neritic Juvenile Stage

Several estimates of the duration of the neritic juvenile stage have been generated (summarized in Heppell *et al*. 2003a, NMFS 2001) employing a variety of techniques including mark-recapture, length frequency, and skeletochronology. These estimates are difficult to compare because they are based on different size ranges for the neritic juvenile stage. The duration from recruitment to 87 cm CCL is estimated as 13 to 20 years depending on whether loggerheads recruit to neritic habitats at a size of 64 or 46 cm CCL, respectively (Bjorndal *et al*. 2001). Loggerhead matrix models generated estimates of 14 to 24 years for neritic juvenile loggerheads ranging from 45 to 92 cm CCL (Heppell *et al*. 2003b).

Survival Probabilities

The first survival probabilities for neritic stage loggerheads were estimated by Frazer (1987) using a catch curve analysis. Survival probabilities have recently been updated using new size-at-age curves based on improved data from skeletochronology and mark-recapture (NMFS 2001). Annual survival probabilities for neritic juvenile loggerheads were estimated to be 0.7-0.8 (Heppell *et al*. 2003b). Using a mark recapture model, Sasso *et al*. (2006) estimated annual survival probability as 0.81 for loggerheads seasonally inhabiting Core Sound, North Carolina.

F.5. NERITIC ZONE: ADULT STAGE

Habitat Description

Habitat preferences of non-nesting adult loggerheads in the neritic zone differ from the juvenile stage in that relatively enclosed, shallow water estuarine habitats with limited ocean access are less frequently used. Areas such as Pamlico Sound and the Indian River Lagoon, regularly used by juveniles, are only occasionally frequented by adult loggerheads. Other estuarine areas, such as Chesapeake Bay in the northeast U.S., are more frequently used by adults during warmer seasons (John Musick, VIMS, personal communication, 2008). Shallow water habitats with large expanses of open ocean access, such as Florida Bay, provide year-round resident foraging areas for significant numbers of male and female adult loggerheads. Offshore, adults primarily inhabit continental shelf waters, from New York south through Florida, The Bahamas, Cuba, and the Gulf of Mexico (Schroeder *et al*. 2003). Seasonal use of mid-Atlantic shelf waters, especially offshore New Jersey, Delaware, and Virginia, during summer months and offshore shelf waters, such as Onslow Bay (off the North Carolina coast), during winter months has been documented for the Northern Recovery Unit (GDNR, unpublished data; SCDNR, unpublished data). Shelf waters along the west Florida coast, The Bahamas, Cuba, and the Yucatán Peninsula have been identified, using satellite telemetry, as important resident areas for Peninsular Florida Recovery Unit adult female loggerheads (Foley *et al*. in press).

Diet

Adult loggerheads feed on a wide variety of organisms inhabiting the neritic zone. The majority of diet studies of North Atlantic loggerheads have involved gut content analyses of stranded juveniles. However, Youngkin (2001) reported ontogenetic shifts in diet among loggerheads stranded in Georgia -- larger (presumably older) individuals consumed proportionally more mollusks than smaller, younger turtles. Proportionally more discarded shrimp trawl fishery bycatch was consumed by smaller turtles than by larger, older turtles. Limited studies of adult loggerheads indicate that mollusks and benthic crabs make up their primary diet, similar to the more thoroughly studied neritic juvenile stage.

Relationship of Neritic Adult Populations to Rookery Sources

The genetic population structure of adult loggerheads at their foraging areas is generally unknown. The vast majority of in-water studies target juvenile stage loggerheads. Reproductively mature female loggerheads tagged in Florida Bay are part of the Peninsular Florida Recovery Unit based on satellite telemetry results and tag returns (Schroeder, unpublished data).

Growth Rates

Growth data collected during mark-recapture studies of adult loggerheads indicate that growth rates (measured as curved carapace length) slow considerably as animals mature and reach their maximum size. Mean growth rates of adult female loggerheads nesting along the southeast U.S. coast was 0.57 cm/year (SCL) (Bjorndal *et al*. 1983). The growth rate (CCL) of adult male loggerheads (maturity assumed at >40 cm tail length, measured from plastron to tail tip) inhabiting inshore foraging areas in Florida Bay was essentially zero (Schroeder, unpublished data).

Duration of the Neritic Adult Stage

The duration of the adult stage in the neritic environment can be reasonably estimated for females from tag return data at nesting beaches. For the Northwest Atlantic nesting population, data from Little Cumberland Island, Georgia, show reproductive longevity, and hence duration of neritic adult female stage, as long as 25 years (Dahlen *et al*. 2000). This is likely an underestimate of the average reproductive life span given tag loss and incomplete surveys of nesting beaches at night. Comparable data for adult males do not exist.

Survival Probabilities

Adult females exhibit a strong degree of nest site fidelity, allowing for the possibility of "recapturing" the same turtle when she returns to nest. Therefore, most estimates of sea turtle survival rates are for adult females. An assumption of survival rates estimated from nesting females is that females that nest at the monitored beach will return to that beach to nest. It is known that nest site fidelity in sea turtles is not perfect (Miller 1997) and that females may try out one or more beaches before selecting a nesting beach to which she remains faithful. In analyses of nesting data, females that are tagged and never seen again are assumed dead, when they may have moved to another beach to nest. In most cases then, survival rates estimated from nesting data likely underestimate actual survival rates. Recent analysis of adult females from the NRU show an annual survival rate (0.85) slightly higher than used in the earlier loggerhead models (0.805) (Heppell *et al*. 2003b).

F.6. OCEANIC ZONE: ADULT STAGE

Based on stable isotope analyses and satellite telemetry, Hatase *et al*. (2002) demonstrated that some adult female loggerheads nesting in Japan inhabit oceanic habitats rather than neritic habitats. Satellite tagged adult loggerheads in western Africa have also been demonstrated to use oceanic foraging areas (Hawkes *et al*. 2006). Preliminary results from stable isotope analyses suggest that some loggerheads nesting in Florida may also inhabit oceanic habitats (Reich *et al*. 2007). In both Japan and Florida, the females inhabiting oceanic habitats were significantly smaller than those in neritic habitats. The extent to which adult loggerheads occupy oceanic habitats needs to be evaluated, and effects on survival probabilities and reproductive output should be assessed. If a substantial number of adult loggerheads are in oceanic habitats, the management and conservation implications are significant because of additional exposure to threats in these regions.

G. BIOLOGICAL CONSTRAINTS AND NEEDS

Loggerheads are long-lived, slow-growing animals that use multiple habitats across entire ocean basins throughout their life history. Maximum intrinsic growth rates of sea turtles are limited by the extremely long duration of the juvenile stage and fecundity. Loggerheads require high survival rates in the juvenile and adult stages, common constraints critical to maintaining long-lived, slow-growing species, to achieve positive or stable long-term population growth (Congdon *et al*. 1993; Heppell 1998; Crouse 1999; Heppell *et al*. 1999, 2003a; Musick 1999).

H. THREATS

This section provides descriptive information on each of the identified threats to the loggerhead. A comprehensive assessment of recovery plans indicated that the analysis of threats has received insufficient attention (Clark *et al*. 2002) and that this lack of knowledge regarding the nature of threats facing a species is likely to contribute to the failure of recovery plans (Lawler *et al*. 2002). In response to these assessments, the Loggerhead Recovery Team conducted a detailed analysis of threats to assist in prioritizing recovery actions. Appendix 1 describes the process the Recovery Team used to identify, categorize, quantify, and prioritize the threats to the Northwest Atlantic loggerhead population. The results of this threats analysis are presented in Appendix 2. Please refer to the threats tables in Appendix 2 to gain an understanding of the relative significance of each threat described below. Conservation efforts to address threats are primarily described in Section I; however, some references to conservation efforts are also included in this Section.

H.1. TERRESTRIAL ZONE (NESTING BEACH)

RESOURCE USE (NON-FISHERIES)

Illegal Harvest

In the U.S., killing of nesting loggerheads is infrequent. However, on some beaches, human poaching of turtle nests and clandestine markets for eggs has been a problem (Ehrhart and Witherington 1987; Mark Dodd, GDNR, personal communication, 2000; Jorge Picon, FWS, personal communication, 2002). 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 (Captain Jeff Ardelean, FFWCC, personal communication, 2002).

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.

In some areas, collected debris is buried directly on the beach, and this can lead to excavation and destruction of incubating egg clutches. Disposal of debris near the dune line or on the high beach can cover incubating egg clutches, hinder and entrap emergent hatchlings, and alter natural nest temperatures. Beach cleaning activities that occur prior to daily nesting surveys may harm turtles still attempting to nest in the early morning hours. Nesting females may be injured by direct contact with beach cleaning equipment or may abort nesting attempts as a result of disturbance. In addition, beach cleaning activities conducted prior to the completion of daily nesting surveys obscure crawls and make it difficult to determine if nests have been laid, which may lead to undercounting of nests and the loss of appropriate nest protection efforts (e.g., predator screening).

Human Presence

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).

Beachgoers, particularly children, have been reported digging into nests in search of eggs or hatchlings. Hatchlings may become trapped in holes dug on the beach. Research has shown that human footprints on the beach can interfere with the ability of hatchlings to reach the ocean (Hosier *et al*. 1981). 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).

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. Additionally, there are documented reports of nesting females being trapped under heavy wooden lounge chairs and cabanas, eggs being destroyed by equipment (e.g., beach umbrellas) penetrating the egg chamber, and hatchlings being hampered during emergence by equipment inadvertently placed on top of the nest (FFWCC, unpublished data).

Beach Vehicular Driving

Operating public vehicles on nesting beaches for recreational purposes or beach access is allowed on certain beaches in northeast Florida (Nassau, Duval, St. Johns, Flagler, and Volusia Counties), northwest Florida (Walton and Gulf Counties), Georgia (Cumberland, Little Cumberland, and Sapelo Islands), and North Carolina (Emerald Isle, Cape Lookout National Seashore, Cape Hatteras National Seashore, and Currituck Banks). Operating vehicles to conduct scientific research and management is generally allowed throughout the loggerhead's nesting range.

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 from predation, 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.

Research and Conservation Management Activities

Research and conservation management activities (e.g., nesting surveys, tagging of nesting females, nest manipulation) are tools to advance the recovery of the loggerhead; however, they have the potential to adversely affect nesting females, hatchlings, and developing embryos if not properly conducted. Research and conservation management activities should be carefully evaluated to determine their potential risks and conservation benefits. Under conditions where the conservation benefits (e.g., embryo survivorship, hatchling survivorship, conservation knowledge gained) are forecast to substantially outweigh the potential conservation risks, these activities can be beneficial to loggerhead recovery.

Most research and conservation management activities are likely to have minimal effects on nesting turtles, hatchlings, and developing embryos when conducted in accordance with established protocols designed to minimize disturbance and risk. On many beaches, surveyors use small 4-wheeled all-terrain vehicles with low-pressure (< 5 psi) tires that minimally impact nesting habitat. In addition, almost all surveys to count nests are conducted after sunrise when encounters with nesting turtles and emergent hatchlings are unlikely. Research activities, such as flipper and PIT tagging, blood sampling, skin sampling, satellite and radio transmitter attachment, and hatchling orientation surveys, have a minimal affect on individual turtles when conducted according to established guidelines (e.g., http://myfwc.com/seaturtle/Guidelines/MarineTurtleGuidelines.htm). Potential benefits from this research include important insight into our understanding of population structure, species health, habitat use, and other important aspects of loggerhead biology and ecology.

Nest relocation is a management technique for protecting nests that are predicted to be destroyed by environmental factors, such as erosion or repeated tidal inundation, or permitted human activities, such as beach nourishment during the nesting season. However, the unnecessary relocation of nests may result in negative impacts to eggs and hatchlings. Historically, the relocation of sea turtle nests to higher beach elevations or into hatcheries was a regularly recommended conservation management activity throughout the southeast U.S. However, advances in our knowledge of the incubation environment have provided important information to guide nest management practices. Nests located where there are threats from beachfront lighting, foot traffic, and mammalian predators can be effectively managed by addressing the threat directly or by protecting the nest in situ rather than by moving the nest. In situ protection, which addresses the root causes of egg and hatchling mortality, is in keeping with Frazer’s (1992) call to move away from “halfway technology.” Increased understanding of the potential adverse effects associated with nest relocation, restraint of hatchlings, and concentrated hatchling releases has resulted in less manipulative management strategies to protect nests and hatchlings. In Florida, the FFWCC’s sea turtle conservation guidelines consider nest relocation to be a management technique of last resort, but do not specify how nest relocation decisions should be made (http://myfwc.com/seaturtle/Guidelines/MarineTurtleGuidelines.htm). Recovery action 6111 describes development of protocols by which managers could identify threatened nests with greater precision, thereby minimizing the number of nests that are relocated.

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, and Eglin and Tyndall Air Force Bases in Florida) have the potential to increase non-nesting emergences of nesting females, run over nesting females and emerging hatchlings, and destroy nests. Periodic training exercises include such activities as beach landings of air cushioned landing craft, amphibious assault vehicles, and other craft; aerial bombing simulations over the beach; excavation of bunkers on the beach; testing missile defense systems; troops movements on the beach; and mission-related beach driving needs.

Beach Sand Placement

Beach sand placement refers to beach restoration, beach nourishment, and inlet maintenance projects carried out to provide a temporary remedy for beach erosion. Beach restoration is the placement of sand along the shoreline to rebuild a beach that has been totally lost to erosion. Beach nourishment is the periodic replenishment of a restored beach to maintain a desired beach width for protection of coastal structures. Beach nourishment often involves excavating large quantities of sand from one site and placing it on an existing, but eroding, section of coastline. Sand is most typically dredged from inlets or offshore, although inland sand sources may also be used. Inlet maintenance involves removing sand from an inlet for navigational purposes and often involves dredging and disposal of the material onto a nearby beach. Inlet sand bypass systems are engineered to allow sand that has been restricted from its normal movement pattern by a man-made structure (jetty or artificially deepened channel) to be placed on the downdrift beach. These systems usually consist of a large depression constructed near the end of a jetty or groin on the updrift side of an inlet. As sand migrates past the structure, it collects in the sink. When the sink is full, sand is pumped to the downdrift beach with a hydraulic dredge.

Beach sand placement is generally viewed as less harmful to sea turtles than armoring, but it too can affect sea turtle reproductive success in a variety of ways. Although placing sand on beaches may provide a greater quantity of nesting habitat, the quality of that habitat may be less suitable than pre-existing natural beaches. Sub-optimal nesting habitat may cause decreased nesting success, place an increased energy burden on nesting females, result in abnormal nest construction, and reduce the survivorship of eggs and hatchlings. Crain *et al*. (1995) provides a review of the potential effects of beach nourishment on sea turtles.

During the nesting and hatching season, construction impacts of sand placement projects can occur. Pipelines and heavy equipment can create barriers to nesting females, causing a higher incidence of non-nesting emergences. Increased human activity on the project beach at night may cause further disturbance to nesting females. Unmarked nests may be crushed by construction equipment or buried during sand placement. Nests relocated to a beach site outside the project area may experience reduced reproductive success (Limpus *et al*. 1979, Moody 1998). Project lighting along the beach and in the nearshore area of a borrow site may deter nesting females and misorient emergent hatchlings from adjacent non-project beaches.

Constructed beaches tend to differ from natural beaches in several important ways. They are typically wider, flatter, more compact, and the sediments are more moist than those on natural beaches (Nelson *et al*. 1987, Ackerman *et al*. 1991, Ernest and Martin 1999). On severely eroded sections of beach, where little or no suitable nesting habitat previously existed, sand placement can result in increased nesting (Ernest and Martin 1999). However, on most beaches, nesting success typically declines for the first year or two following construction, even though more nesting habitat is available for turtles (Trindell *et al*. 1998, Ernest and Martin 1999, Herren 1999). Reduced nesting success on constructed beaches has been attributed to increased sand compaction, escarpment formation, and changes in beach profile (Nelson *et al*. 1987, Crain *et al*. 1995, Lutcavage *et al*. 1997, Steinitz *et al*. 1998, Ernest and Martin 1999, Rumbold *et al*. 2001).

Compaction can inhibit nest construction or increase the amount of time it takes for turtles to construct nests, while escarpments often cause female turtles to return to the ocean without nesting or to deposit their nests seaward of the escarpment where they are more susceptible to frequent and prolonged tidal inundation.

Beach sand placement can affect the incubation environment of nests by altering the moisture content, gas exchange, and temperature of sediments (Ackerman *et al*. 1991, Ackerman 1997, Parkinson *et al*. 1999). The extent to which the incubation environment is altered is largely dependent on the similarity of the placed sands and the natural sediments they replace. Consequently, the results of studies assessing the effects of sand placement on reproductive success have varied among study sites.

Even though constructed beaches are wider, nests deposited there may experience higher rates of wash out than those on relatively narrow, steeply sloped beaches (Ernest and Martin 1999). This occurs because nests on constructed beaches are more broadly distributed than those on natural beaches, where they tend to be clustered near the base of the dune. Nests laid closest to the waterline on constructed beaches may be lost during the first year or two following construction as the beach undergoes an equilibration process during which seaward portions of the beach are lost to erosion.

Placing sand on highly eroded beaches, especially those with a complete absence of dry beach, can benefit nesting turtles if conducted properly. Sea turtle concerns must be considered in project planning to ensure the sand source is compatible with naturally occurring beach sediments in the area (in terms of grain size, shape, color, etc.) and that remediation measures are incorporated into the project to allow for successful nesting, nest incubation, and hatchling emergence. Beach and dune profiles that mimic the beaches nesting loggerheads prefer (narrow and steeply sloped with a prominent vegetated dune (Provancha and Ehrhart 1987)) are seldom the choice for sand placement projects. Rather, constructed beaches are commonly engineered to be wide and flat, traits that achieve the principal goals of upland property protection and increased area for human use.

Although inlet maintenance and sand bypassing efforts have the potential to reduce downdrift erosion effects, there may be effects on sea turtle reproduction that are similar to those from beach nourishment. For example, several researchers have evaluated the effects of an inlet maintenance program on sea turtle reproductive success at Sebastian Inlet on Florida's Atlantic coast. The first of those studies detected no significant differences in hatchling emerging success between the beach receiving bypassed sand and a control beach farther downdrift (Ryder 1993). However, in a study of a subsequent sand bypass effort, Herren (1999) found a significant reduction in hatchling emerging success on the nourished beaches compared to a control. Differences in results between studies probably relate to variability in the characteristics of sediments placed on the beach. In addition to reduced reproductive success, Herren (1999) also noted a decline in nesting success downdrift of the inlet during the first year or two following a sand bypass project, likely caused by the presence of escarpments that formed on the beach post-construction. Witherington *et al*. (2005) measured loggerhead nesting density over a 12-year period (1989 to 2000) within 6 km of Sebastian Inlet and found nesting decreased significantly with proximity to the inlet in both updrift and downdrift directions.

Beach Armoring

Armoring is any rigid structure placed parallel to the shoreline on the upper beach to prevent both landward retreat of the shoreline and inundation or loss of upland property by flooding and wave action (Kraus and McDougal 1996). Armoring includes bulkheads, seawalls, soil retaining walls, rock revetments, sandbags, and geotextile tubes. Schroeder and Mosier (2000) provide descriptions of these different structures. Although armoring structures may provide short-term protection to beachfront property, they do little to promote or maintain sandy beaches. These structures influence natural shoreline processes and the physical beach environment, but the effects are not well understood. It is clear that armoring structures prevent long-term recovery of the beach/dune system (i.e., building of the back beach) by physically prohibiting dune formation from wave uprush and wind-blown sand. Reported topographic effects seaward and adjacent to these structures vary between project sites (Kaufman and Pilkey 1979, Pilkey *et al*. 1984, Kraus 1988, Kraus and McDougal 1996).

Erosion of adjacent downdrift beaches can occur if an updrift armoring structure acts as a jetty and impounds sand (Kraus 1988, Tait and Griggs 1990). Additionally, these structures can cause wave reflection and scour, processes that accelerate erosion seaward of the structure and that steepen the offshore profile (Pilkey *et al*. 1984). Sand can move along shore past an armoring structure, but it is not clear whether the longshore sediment transport rate changes (Kraus and McDougal 1996). Pilkey *et al*. (1984) contend that the intensity of longshore currents increases in front of armoring structures and this hastens removal of beach sand. Most likely, the extent to which any of these potentially harmful effects may be realized is largely dependent upon a structure's physical position on the beach relative to the surf zone (Kraus 1988, Tait and Griggs 1990). The closer an armoring structure is to the surf zone, the greater its potential for altering shoreline processes.

Considerable anecdotal information suggests that permanent armoring structures can diminish the quality of sea turtle nesting habitat. However, there have been few experimental studies designed specifically to assess the impacts of these structures on sea turtle nesting. Mosier (1998) and Mosier and Witherington (2002) recorded the behavior of nesting turtles in front of seawalls and adjacent unarmored sections of beach. Mosier (1998) reported that fewer loggerheads made nesting attempts on beaches fronted by seawalls than on adjacent beaches where armoring structures were absent. Both studies found that when turtles did emerge in the presence of armoring structures, more returned to the water without nesting than those on non-armored beaches. Additionally, Mosier (1998) found that turtles on armored sections of beach tended to wander greater distances than those that emerged on adjacent natural beaches. It is unknown if this additional energy expenditure reduces reproductive output. Armoring structures can effectively eliminate a turtle's access to upper regions of the beach/dune system. Consequently, nests on armored beaches were generally found at lower elevations than those on non-walled beaches. Lower elevations subject nests to a greater risk of repeated tidal inundation and erosion and can potentially alter thermal regimes, an important factor in determining the sex ratio of hatchlings (Mrosovsky and Provancha 1989, Mrosovsky 1994, Ackerman 1997, Delpech and Foote 1998). The negative effects of armoring become more pronounced the closer the structures are to the surf zone. Thus, 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. There have also been reported incidents of nesting turtles and hatchlings getting caught in construction debris or trapped in excavations at construction sites (FFWCC, unpublished data). In addition, hatchlings have been trapped in holes or crevices of exposed riprap and geotextile tubes. Both nesting turtles and hatchlings have been entangled or entrapped in the debris of failed structures. There have also been reports of injuries and deaths of nesting turtles that have fallen from seawalls after crawling onto them from adjacent properties (FFWCC, unpublished data).

As the extent of armoring on beaches increases, the probability of a nesting turtle encountering a seawall or depositing a nest in sub-optimal habitat increases. The proportion of coastline that is armored is approximately 18% (239 km) in Florida (Clark 1992, Schroeder and Mosier 2000, Witherington *et al*. 2006), 9% (14 km) in Georgia (Mark Dodd, GDNR, personal communication, 2000), 12% (29 km) in South Carolina (Sally Murphy, SCDNR, personal communication, 2000), and 2% (9 km) in North Carolina (Sean McGuire, North Carolina Division of Coastal Management, personal communication, 2002). These assessments of armoring extent do not include structures that are a barrier to sea turtle nesting but that do not fit the definition of armoring, such as dune crossovers, cabanas, sand fences, and recreational equipment.

Other Shoreline Stabilizations

a. Groins and Jetties

Groins and jetties are shore-perpendicular structures that are designed to trap sand that would otherwise be transported by longshore currents. Jetties are defined as structures placed to keep sand from flowing into channels (Kaufman and Pilkey 1979, Komar 1983). In preventing normal sand transport, these structures accrete updrift beaches while causing accelerated beach erosion downdrift of the structures (Komar 1983, Pilkey *et al*. 1984, National Research Council 1987), a process that results in degradation of sea turtle nesting habitat. As sand fills the area updrift from the groin or jetty, some littoral drift and sand deposition on adjacent downdrift beaches may occur due to spillover. However, these structures often force the stream of sand into deeper offshore water where it is lost from the system (Kaufman and Pilkey 1979). The greatest changes in beach profile near groins and jetties are observed close to the structures, but effects eventually may extend many kilometers along the coast (Komar 1983).

Jetties are placed at ocean inlets to keep transported sand from closing the inlet channel. Together, jetties and inlets are known to have profound effects on adjacent beaches (Kaufman and Pilkey 1979). Witherington *et al*. (2005) found a significant negative relationship between loggerhead nesting density and distance from the nearest of 17 ocean inlets on the Atlantic coast of Florida. The effect of inlets in lowering nesting density was observed both updrift and downdrift of the inlets, leading researchers to propose that beach instability from both erosion and accretion may discourage loggerhead nesting.

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. Experimental mesh groins have been tested as a potential beach restoration system. The mesh groin system is a temporary set of groins composed of net "fences" set in the intertidal and subtidal zone that have the potential to entrap turtles and other marine life within the openings of the net or other parts of the structure.

Escarpments may develop on beaches between groins as the beaches equilibrate to their final profiles. These escarpments are known to prevent females from nesting on the upper beach and can cause them to choose unsuitable nesting areas, such as seaward of an escarpment. These nest sites commonly receive prolonged tidal inundation and erosion, which results in nest failure (Nelson and Blihovde 1998).

As groin structures fail and break apart, they spread debris on the beach, which may further impede nesting females from accessing suitable nesting sites and trap both hatchlings and nesting turtles. Geotextile tubes begin to disintegrate when exposed to ultraviolet light (life expectancy is approximately 5 to 10 years). This may result in pieces of geotextile material, a woven plastic-like substance, floating off or being washed up on the beach. Although painting the exposed portions of the geotextile tube to protect them from ultraviolet light will slow down the rate of disintegration, it will still occur. The material may be ingested by sea turtles or entangle them, either of which could result in death.

b. Offshore Breakwaters

Breakwaters are typically constructed from rock or concrete and are placed in nearshore waters to reduce wave energy (National Research Council 1990b). This reduction in wave energy modifies the longshore transport of sand and may result in an accumulation of sand and a reduction in erosion along the shoreline adjacent to the breakwater. However, the placement of breakwaters may result in the formation of a sand bar that connects the beach to the breakwater as sand accumulates. This creates a situation where the breakwater acts as a headland rather than an offshore feature. The breakwater then functions as a barrier to the longshore transport of material in a manner similar to a groin, resulting in downdrift erosion (National Research Council 1995) and degradation of downdrift sea turtle nesting habitat.

Breakwaters may be built with different top elevations. They may be built to project above the water's surface or they may be built as submerged structures that are designed to reduce the height of waves but not to absorb or reflect all wave energy (National Research Council 1989). Emergent breakwaters that are oriented parallel to the shoreline have the potential to interfere with the movement of adult females to and from the nesting beach; function as barriers to hatchlings during offshore migration; entrap hatchlings in the crevices of the structures or within eddies or other currents associated with the structures; and increase hatchling and adult female energy expenditure in their attempts to bypass the structures.

Sand Fences

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.

Stormwater Outfalls

Rainfall on dunes and beaches percolates rapidly into the permeable sands and produces little, if any, runoff. However, runoff from beachfront parking lots, building rooftops, roads, decks, and draining swimming pools adjacent to the beach is frequently discharged directly to the beach and dune either by sheet flow, through stormwater collection system outfalls, or through small diameter pipes. These outfalls are known to create localized erosion channels, prevent natural dune establishment, and wash out sea turtle nests (FFWCC, unpublished data). Stormwater runoff can result in beach erosion and prevent natural dune building in localized areas. Contaminants contained in stormwater, such as oils, grease, antifreeze, gasoline, metals, pesticides, chlorine, and nutrients, may affect sea turtle nests and other beach fauna when large amounts of stormwater are discharged onto the beach.

Coastal Construction

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. Most direct construction-related impacts can be avoided by requiring that non-emergency activities be performed outside of the nesting and hatching season. However, indirect effects can also result from the post-construction presence of structures on the beach. The presence of these structures may cause nesting turtles to return to the ocean without nesting, deposit their nests lower on the beach where they are more susceptible to frequent and prolonged tidal inundation, or select less suitable nesting sites where shading from the structures can influence incubation temperatures and potentially result in changes in hatchling sex ratios (Mrosovsky *et al*. 1995).

ECOSYSTEM ALTERATIONS

Beach Erosion and Accretion

Natural beach erosion events may influence the quality of nesting habitat. 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 the loggerhead 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. However, human activities along coastlines can accelerate erosion rates, interrupt natural shoreline migration, and reduce both the quantity and quality of available nesting habitat.

During erosion events, some nests may be uncovered or completely washed away. Nests that are not washed away may suffer reduced reproductive success as the result of frequent or prolonged tidal inundation. Eggs saturated with seawater are susceptible to embryonic mortality (Bustard and Greenham 1968, Milton *et al*. 1994, Martin 1996). However, in spite of the potential for reduced hatching success, loggerhead eggs can successfully survive periodic tidal inundation (Foley 1998, Foley *et al*. 2006). Similarly, Ernest and Martin (1993) found that although frequent or prolonged tidal inundation resulted in fewer emergent hatchlings, occasional overwash of nests appeared to have minimal effect on reproductive success. Accretion of sand above incubating nests may also result in egg and hatchling mortality. Ehrhart and Witherington (1987) found that accretion of sand over loggerhead clutches killed all embryos in affected nests, presumably from suffocation.

POLLUTION

Oil Pollution

Oil spills in the vicinity of nesting beaches just prior to or during the nesting season could place nesting females, incubating egg clutches, and hatchlings at significant risk (Fritts and McGehee 1982, Lutcavage *et al*. 1997, Witherington 1999). Fritts and McGehee (1982) conducted both field and laboratory studies to determine the effects of petroleum on the development and survival of sea turtle embryos. Their results suggest that an oil spill resulting in contamination of nesting beaches before the nesting season may affect nesting success for only a short period, if at all, but a spill resulting in the deposition of oil on eggs or on top of an incubating nest is likely to increase mortality and result in abnormal development of hatchlings. They concluded that the overall effect of oil spills on turtles was likely to be dependent on the timing of the spill and the age of the oil.

Two oil spills that occurred near loggerhead nesting beaches in Florida were observed to affect eggs, hatchlings, and nesting females. Approximately 350,000 gallons of fuel oil spilled in Tampa Bay in August 1993 and was carried onto nesting beaches in Pinellas County.

Approximately 212 hatchlings were killed and 2,177 eggs and hatchlings were injured (FDEP *et al*. 1997). Another spill near the beaches of Broward County in August 2000 involved approximately 15,000 gallons of oil and tar (NOAA and FDEP 2002). Models estimated that approximately 1,500 to 2,000 hatchlings and 0 to 1 adults were injured or killed.

Oil cleanup activities can also be harmful. Earth-moving equipment can dissuade females from nesting and destroy nests, containment booms can entrap hatchlings, and lighting from nighttime activities can misdirect turtles (Witherington 1999).

Lighting Pollution

Both nesting and hatchling sea turtles are adversely affected by the presence of artificial lighting on or near the beach (Witherington and Martin 1996). Experimental studies have shown that artificial lighting deters adult female turtles from emerging from the ocean to nest (Witherington 1992). 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 (FFWCC, unpublished data).

Hatchlings exhibit a robust sea-finding behavior guided by visual cues (Witherington and Bjorndal 1991, Salmon *et al*. 1992, Lohmann *et al*. 1997, Witherington and Martin 1996, Lohmann and Lohmann 2003), and direct and timely migration from the nest to sea is critical to their survivorship. Although the mechanism involved in sea-finding is complex, involving cues from both brightness and shape, it is clear that strong brightness stimuli can override other competing cues (Witherington and Martin 1996).

Hatchlings have a tendency to orient toward the brightest direction as integrated over a broad horizontal area. On natural undeveloped beaches, the brightest direction is commonly away from elevated shapes (e.g., dune, vegetation, etc.) and their silhouettes and toward the broad open horizon of the sea. On developed beaches, the brightest direction is often away from the ocean and toward lighted structures. Hatchlings unable to find the ocean, or delayed in reaching it, are likely to incur high mortality from dehydration, exhaustion, or predation (Carr and Ogren 1960, Ehrhart and Witherington 1987, Witherington and Martin 1996). Hatchlings lured into lighted parking lots or toward streetlights are often crushed by passing vehicles (McFarlane 1963, Philibosian 1976, Peters and Verhoeven 1994, Witherington and Martin 1996). Uncommonly intense artificial lighting can draw hatchlings back out of the surf (Daniel and Smith 1947, Carr and Ogren 1960, Ehrhart and Witherington 1987).

Although the attributes that can make a light source harmful to sea turtles are complex, a simple rule has proven useful in identifying lights that pose potential problems for sea turtles. Witherington and Martin (1996) propose that artificial light sources are "likely to cause problems for sea turtles if light from the source can be seen by an observer standing anywhere on the beach." This visible light can come directly from any glowing portion of a luminaire, including the lamp, globe, or reflector, or indirectly by reflection from buildings or trees that are visible from the beach. Bright or numerous light sources, especially those directed upward, will illuminate sea mist and low clouds, creating a distinct sky glow visible from the beach. Field research suggests hatchling orientation can be disrupted by the sky glow from heavily lighted coastal areas even when no direct lighting is visible (Witherington *et al*. 1994).

The ephemeral nature of evidence from hatchling disorientation and mortality makes it difficult to accurately assess how many hatchlings are misdirected and killed by artificial lighting. Reports of hatchling disorientation events in Florida describe several hundred nests each year and are likely to involve tens of thousands of hatchlings (Nelson *et al*. 2002). However, this number calculated from disorientation reports is likely a vast underestimate. Independent of these reports, Witherington *et al*. (1996) surveyed hatchling orientation at nests located at 23 representative beaches in six counties around Florida in 1993 and 1994 and found that, by county, approximately 10 to 30% of nests showed evidence of hatchlings disoriented by lighting. From this survey and from measures of hatchling production (FFWCC, unpublished data), the number of hatchlings disoriented by lighting in Florida is calculated in the range of hundreds of thousands per year.

Beach Debris

Hatchlings often must navigate through a variety of obstacles before reaching the ocean. These include natural and human-made debris. Debris on the beach may interfere with a hatchling's progress toward the ocean. Research has shown that travel times of hatchlings from the nest to the water may be extended when traversing areas of heavy foot traffic or vehicular ruts (Hosier *et al*. 1981); the same is true of debris on the beach. Hatchlings may be upended and spend both time and energy in righting themselves. Some beach debris may have the potential to trap hatchlings and prevent them from successfully reaching the ocean. In addition, debris over the tops of nests may impede or prevent hatchling emergence.

SPECIES INTERACTIONS

Predation

Predation of eggs and hatchlings by native and introduced species occurs on almost all nesting beaches. The most common predators in the southeast U.S. are ghost crabs (*Ocypode quadrata*), raccoons (*Procyon lotor*), feral hogs (*Sus scrofa*), foxes (*Urocyon cinereoargenteus* and *Vulpes vulpes*), coyotes (*Canis latrans*), armadillos (*Dasypus novemcinctus*), and red fire ants (*Solenopsis invicta*) (Dodd 1988, Stancyk 1982). In the absence of nest protection programs in a number of locations throughout the southeastern U.S., raccoons may depredate up to 96% of all nests deposited on a beach (Davis and Whiting 1977, Hopkins and Murphy 1980, Stancyk *et al*. 1980, Talbert *et al*. 1980, Schroeder 1981, Labisky *et al*. 1986). Prior to hog control efforts, up to 45% of all nests deposited at the Cape Canaveral Air Force Station, Florida, were depredated by feral hogs (FFWCC, unpublished data). In 1990, an estimated 70% of loggerhead nests were destroyed by feral hogs on Ossabaw Island, Georgia (GDNR, unpublished data). In addition to the destruction of eggs, predators may take considerable numbers of hatchlings prior to or upon emergence from the sand. Florida beaches report hatchlings being preyed upon by coyotes, foxes, raccoons, domestic dogs, red fire ants, and ghost crabs during emergence from the nest (FFWCC, unpublished data).

Although not considered a typical form of predation, roots of sea oats (*Uniola paniculata*), railroad vine (*Ipomoea pes-caprae*), and other dune plants sometimes invade the nest cavity and penetrate incubating eggs (Witherington 1986). This occurs primarily in nests laid high on the beach at or landward of the toe of the dune.

Exotic Dune and Beach Vegetation

Non-native vegetation has invaded many coastal areas and often outcompetes native species such as sea oats, railroad vine, sea grape (*Coccoloba uvifera*), bitter panicgrass (*Panicum amarum*), and seaside pennywort (*Hydrocotyle bonariensis*). The invasion of less stabilizing vegetation can lead to increased erosion and degradation of suitable nesting habitat. Exotic vegetation may also form impenetrable root mats that can prevent proper nest cavity excavation, invade and desiccate eggs, or trap hatchlings.

The Australian pine (*Casuarina equisetifolia*) is particularly harmful to sea turtles. Dense stands have taken over many coastal areas throughout central and south Florida. Australian pines cause excessive shading of the beach that would not otherwise occur. Studies in Florida suggest that nests laid in shaded areas are subjected to lower incubation temperatures, which may alter the natural hatchling sex ratio (Marcus and Maley 1987, Schmelz and Mezich 1988, Hanson *et al*. 1998). Fallen Australian pines limit access to suitable nest sites and can entrap nesting females (Austin 1978, Reardon and Mansfield 1997). The shallow root network of these pines can interfere with nest construction (Schmelz and Mezich 1988). Davis and Whiting (1977) reported that nesting activity declined in Everglades National Park where dense stands of Australian pine took over native dune vegetation on a remote nesting beach.

Beach vitex (*Vitex rotundifolia*) was introduced to the horticulture trade in the mid-1980s and is often sold as a "dune stabilizer." The plant is native to Japan, Korea, and Hawaii. Its presence on North Carolina and South Carolina beaches could have a negative effect on sea turtle nesting. This exotic plant is crowding out the native species, such as sea oats and bitter panicum, and can colonize large areas in just a few years.

Sisal, or century plant, (*Agave americana*) is native to arid regions of Mexico. The plant was widely grown in sandy soils around Florida in order to provide fiber for cordage. It has escaped cultivation in Florida and has been purposely planted on dunes. Although the effects of sisal on sea turtle nesting are uncertain, thickets with impenetrable sharp spines are occasionally found on developed beaches.

OTHER FACTORS

Climate Change

Climate change has the potential to greatly impact loggerhead turtles. Impacts from climate change, especially due to global warming, are likely to become more apparent in future years (Intergovernmental Panel on Climate Change (IPCC) 2007a). The global mean temperature has risen 0.76ºC over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (IPCC 2007a).

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. Climate change may also affect loggerhead sex ratios. Loggerhead turtles exhibit temperature-dependent sex determination. Rapidly increasing global temperatures may result in warmer incubation temperatures and highly female-biased sex ratios (e.g., Glen and Mrosovsky 2004).

Natural Catastrophes

Aperiodic, short-term weather-related erosion events (e.g., atmospheric fronts, northeasters, tropical storms, and hurricanes) are common phenomena throughout the loggerhead nesting range and may vary considerably from year to year. Milton *et al*. (1994) reported that 24.5% of all loggerhead nests laid on Deerfield Beach, Florida, in 1992 were lost or destroyed by Hurricane Andrew as a result of storm surge. Similarly, Martin (1996) reported a 22.7% loss of total loggerhead nest production on the southern portion of Hutchinson Island, Florida, during the passage of Hurricane Erin in 1995. Ehrhart and Witherington (1987) reported a 19% loss of loggerhead nests at Melbourne Beach, Florida, after a 5-day northeaster in 1985. In Georgia, 16% of loggerhead nests were lost to tropical storm systems in 2001 (Dodd and Mackinnon 2001); nest loss was particularly high on Sapelo (54%) and Little Cumberland Islands (28%). On Fisher Island in Florida, Milton *et al*. (1994) reported that hatchling emerging success decreased significantly following Hurricane Andrew in 1992. They found that hatchlings were unable to emerge from nests where sand had accreted in large quantities and that these hatchlings probably died from asphyxiation or exhaustion while struggling to emerge from the nests. 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.

H.2. NERITIC ZONE

RESOURCE USE (FISHERIES)

Trawl Fisheries

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 as 10 times greater than that of all other human-related factors combined. Most of these turtles were neritic juveniles and subadults, the life stages most critical to the stability and recovery of sea turtle populations (Crouse *et al*. 1987, Crowder *et al*. 1994).

In 1978, NMFS initiated the development of a net modification to allow captured turtles to escape from shrimp nets. The original modification, known as a turtle excluder device (TED), was a large cage-like design that was effective in excluding turtles, but proved unwieldy and potentially dangerous for fishermen. NMFS, in cooperation with commercial fishermen, developed several new lighter TED designs based on net modifications commonly used by shrimpers to reduce unwanted bycatch (e.g., cannonball jellyfish). These designs consisted of a metal-grid or webbing ramp that directed turtles to an escape opening cut in the top or bottom of the net. Because of the increasing number of new TED designs developed by fishermen, NMFS adopted standardized guidelines that required all approved TEDs to be 97% effective in excluding turtles (NMFS 1987, 52 FR 24244).

By 1986, lack of voluntary widespread use of TEDs by shrimpers resulted in Federal regulations requiring their implementation (Epperly 2003). NMFS published final regulations in June 1987; however, implementation was delayed as a result of legal and congressional action. This delay prompted several states, including South Carolina and Florida, to require the use of TEDs in waters under their jurisdiction. The use of TEDs for all offshore trawlers from North Carolina to Texas was implemented in September 1989. By December 1994, regulations requiring fishery-wide use of TEDs in shrimp trawls, including all inshore areas, were finalized or enacted (Epperly 2003).

The overall effectiveness of TEDs is difficult to assess. Crowder *et al*. (1995) found sea turtle strandings were reduced by 44% in South Carolina following the implementation of TEDs. Royle (2000) found strandings were reduced by 37% in Georgia over the period from 1980-1997. In contrast, Shoop *et al*. (1999) found no reduction in sea turtle strandings on Cumberland Island, Georgia, with increased TED use. In the Gulf of Mexico, Caillouet *et al*. (1996) found that TED regulations did not diminish the statistical correlation between stranding rates and commercial fishing intensity. Large-scale stranding events associated with shrimp fishing activity have been documented following the mandatory use of TEDs.

Although TEDs were found to reduce trawl related sea turtle mortality in some cases, the use of inefficient designs and small opening sizes has reduced their potential effectiveness. For example, NMFS approved several TED configurations (e.g., Morrison soft TED) that were later disallowed when additional testing found they captured and drowned turtles. Epperly and Teas (2002) found minimum TED opening sizes were too small to allow large subadult and adult loggerheads to escape from shrimp trawls. They estimated that 33 to 47% of the total loggerhead strandings measured on U.S. beaches from 1986 to 1999 were too large to fit through the minimum TED opening. Subsequent to this finding, the TED regulations were modified in 2004 to require openings large enough to exclude large subadult and adult loggerheads (NMFS 2003b, 68 FR 8456).

Several other shrimp-fishery related factors likely contribute to high loggerhead mortality rates. These factors include illegally modified TEDs (closed TED openings), high fishing densities (multiple capture of individual turtles), and high capture rates in sampling nets (trynets). Data are not currently available to assess the impacts of these factors on sea turtle mortality.

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. Loggerhead annual bycatch estimates in 2004 and 2005 in mid-Atlantic scallop trawl gear ranged from 81 to 191 turtles, depending on the estimation methodology used (Murray 2007). Estimated average annual bycatch of loggerheads in other mid-Atlantic federally managed bottom otter trawl fisheries during 1996-2004 was 616 turtles (Murray 2006). The harvest of *Sargassum* by trawlers can result in incidental capture of post-hatchlings and habitat destruction (Schwartz 1988, Witherington 2002).

Regulations regarding trawl fisheries under state jurisdiction are highly variable. Some states, including Virginia, Maryland, and Florida, maintain offshore areas permanently closed to trawling. The State of Georgia requires the use of NMFS-approved TEDs in all trawl fisheries operating in state waters. South Carolina uses a water-temperature trigger to ensure whelk trawling occurs when sea turtles are less abundant. With the exception of the shrimp fishery, TEDs are not required in most trawl fisheries operating in state waters.

Dredge Fisheries

Dredge fishing gear is the predominant gear used to harvest sea scallops off the mid- and northeastern Atlantic coast. 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. Total estimated bycatch of loggerhead turtles in the sea scallop dredge fishery operating in the mid-Atlantic region (New York to North Carolina) from June through November 2003 was 749 turtles (CV=0.28) (Murray 2004). Total estimated loggerhead bycatch in this region for the period June through November 2004 was 180 turtles (CV=0.37) (Murray 2005) and 0 turtles (CV=0.19) in 2005 (Murray 2007). Takes were observed in 2005; however, they occurred "off watch" and were therefore not used in developing the 2005 bycatch estimate. This apparent reduction in estimated annual bycatch must be viewed with caution as operation of the fishery changed in 2004. Specifically, scallop closures and rotations were implemented, and an unquantified number of vessels implemented voluntary use of a chain mat that prevents turtles (live and/or killed or injured by the dredge) from entering the bag and being observed, which likely affected the total observed bycatch of turtles. Scallop chain mats are now required in the sea scallop fishery in certain areas and at certain times; however, they are not expected to reduce the effects of the dredge on turtles encountered on the bottom. The interaction of the sea scallop dredge fishery on loggerheads in the Northwest Atlantic remains a serious concern.

A small dredge fishery for whelks has been pursued in inshore waters of Virginia. Occasional loggerhead takes have been reported in this fishery, but total bycatch is unknown (John Musick, VIMS, personal communication, 2005).

Longline Fisheries

The principal longline fishery affecting loggerheads in the neritic environment is the commercial bottom longline fishery for sharks, which operates in summer off the mid-Atlantic States and all year long off the south Atlantic and Gulf states. Estimated bycatch of loggerheads in shark bottom longline gear between 2004 and 2006 was 588 loggerheads caught in the Gulf of Mexico (176 dead) and 197 loggerheads caught in the southeast U.S. Atlantic (167 dead) (NMFS 2007, Richards 2007). The Gulf of Mexico reef fish and south Atlantic snapper-grouper commercial fisheries also have bottom longline components that impact loggerheads. These fisheries generally have shorter soak times, but sometimes deeper sets than the bottom longline fishery for sharks. NMFS estimates 85 loggerheads (42 dead) are caught in the Gulf of Mexico reef fish fishery and 22 (12 dead) are caught in the southeast U.S. Atlantic reef fish fishery every 3 years (NMFS 2005, 2006).

Other Hook and Line Fisheries

There are numerous Atlantic fisheries that use other types of hook-and-line gear (e.g., rod and reel, handline, bandit gear). The impact of these fisheries on loggerheads likely varies depending on the fishing practices used, the area fished, and the concentration of effort. For example, trolling, a common fishing practice for certain pelagic species, is not likely to adversely affect loggerheads. Captures are more likely when fishing from a stationary or slowly drifting vessel or from a pier and bottom fishing. The magnitude of sea turtle capture and mortality associated with these fisheries is not known. In addition to commercial fisheries, the recreational hook and line fishery is extensive, particularly in the Southeast, where loggerheads are susceptible to fishing impacts year-round. Turtle captures on recreational hook-and-line gear are not uncommon, but the overall level of take and percent mortality are unknown. It is assumed that most turtles captured in the commercial and recreational hook-and-line fisheries are released alive, but ingested hooks and entanglement in associated monofilament or steel line have been documented as the probable cause of death for some stranded turtles (NMFS, unpublished data). Most reports of sea turtle captures are from fishing off piers, but there are also reports of offshore captures from both commercial and recreational fishermen. Divers have reported seeing dead loggerheads entangled in monofilament line on artificial reefs and shipwrecks where fishing effort is often concentrated.

Gillnet (Demersal and Drift) Fisheries

Although a detailed summary of gillnet fisheries operating off the Atlantic and Gulf coasts of the U.S. was presented in TEWG (1998, 2000), the lack of sea turtle mortality data for these fisheries precluded a quantitative analysis of their impacts on loggerhead populations. Many states (South Carolina, Georgia, Florida, Louisiana, and Texas) have prohibited gillnets, but there remain active fisheries in other states and in Federal waters. Federal fisheries including the bluefish, monkfish, northeast multispecies, spiny dogfish, summer and southern flounder, Spanish and king mackerel, and shark fisheries all have gillnet components. The impact of some of these fisheries, particularly those using large mesh nets, could be significant. For example, in the spring of 2000, the monkfish fishery north of Cape Hatteras, North Carolina, was likely responsible for approximately 280 sea turtle strandings over a 2-week period (NMFS, unpublished data). In response to this event and other stranding events coinciding with increasing effort in offshore gillnetting, NMFS enacted seasonally adjusted restrictions to gillnetting in portions of the mid-Atlantic Exclusive Economic Zone (EEZ) in 2003 (NMFS 2002b, 67 FR 71895).

Pound Nets and Weirs

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). Nets with small mesh leader (less than 8 inches) usually do not present a threat to loggerheads (Mansfield *et al*. 2002a, Morreale and Standora 1998, Epperly *et al*. 2000). Chesapeake Bay appears to be the primary location where pound nets with large mesh leaders are used (NMFS 2001). In the early 1980s, 3 to 33% of all sea turtle mortalities in Virginia were attributed to large mesh leaders in the Bay (Bellmund *et al*. 1987). At that time, 173 such nets were fished. However, the fishery has declined since then and in 2000 only 20 large mesh nets remained in the Bay (Mansfield *et al*.

2002a). In 2002, NMFS prohibited, in certain areas and at certain times, pound nets with leaders having mesh greater than or equal to 12 inches and leaders with stringers.

Similar to pound nets, weirs consist of a maze of nets and poles to trap schooling fish such as scup, herring, mackerel, and squid as they migrate through shallow waters. NMFS has several records of turtles, including loggerheads, captured in weirs (Ellen Keane, NMFS, personal communication, 2008). The magnitude of bycatch and mortality in this gear is currently unknown.

Pots/Traps

Pots/traps are commonly used to target crabs, lobsters, and reef 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. Loggerheads may be particularly vulnerable to entanglement in vertical lines because of their attraction to, or attempts to feed on, baits and species caught in the traps and epibionts (living organisms) growing on traps, trap lines, and floats. Recently, a small number of loggerhead entanglements have been recorded in whelk pot bridles in the Mid-Atlantic States (Meredith Fagan, VIMS, personal communication, 2008).

Approximately 0.4% of stranded loggerheads (1997-2005 average) were found entangled in pot/trap line from Maine through Texas (NMFS, unpublished data). In addition, incidental captures have been reported from "fish traps" in Massachusetts, Rhode Island, New York, and Florida (fish traps and pound nets are very similar in construction, and the two terms have been used interchangeably in places) (NMFS 2001). See the previous section on pound nets.

Haul Seines and Channel Nets

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).

Purse Seines

Purse seines are used in the Gulf of Mexico and along the Atlantic coast to capture bluefin tuna and menhaden. The tuna fishery is confined to water over the continental shelf, and no sea turtle mortalities have been observed in this fishery (NMFS 2001). The menhaden fishery is pursued close to the coast and in large estuaries such as Chesapeake Bay. Thus, the potential for loggerhead interactions with this fishery may be higher than for the tuna fishery. Although no interactions were observed between sea turtles and purse seines in a study of finfish bycatch in Chesapeake Bay (Herbert Austin, VIMS, personal communication, 2000), sea turtles trapped in menhaden purse seines might be impinged on the grates of inlet pipes used to suck the catch into the hold; however, recent observations indicate these grates are regularly monitored and loggerheads are not likely to be injured (Sheryan Epperly, NMFS, personal communication, 2007).

RESOURCE USE (NON-FISHERIES)

Legal Harvest

Loggerhead turtles have been harvested in waters of the northwest Atlantic for centuries as a source of protein and for other domestic uses. Currently, 32 of the 47 (68%) countries/territories in the northwestern Atlantic legislate complete protection of loggerhead turtles in their territorial waters (Appendix 3). The ESA prohibits the harvest of loggerhead turtles in U.S. territorial waters. However, 14 of 28 (50%) Caribbean countries/territories allow harvest of loggerheads. The loggerhead harvest in the Caribbean is generally restricted to the non-nesting season with the exception of St. Kitts and Nevis and the Turks and Caicos Islands. Most countries/territories, with the exception of Haiti and Trinidad and Tobago, have size restrictions that favor harvest of large juveniles and adults, the most reproductively valuable members of the population. All Central and South American countries in the northwest Atlantic legislate complete protection of loggerheads in their territorial waters with the exception of Guyana. The North Atlantic islands of Bermuda, the Azores, Madeira, Cape Verde, and the Canary Islands have legislative prohibitions on the harvest of loggerhead turtles in territorial waters.

Illegal Harvest

Illegal directed harvest of juvenile and adult loggerhead turtles in the waters of the continental U.S. and U.S. Caribbean is uncommon, but no estimates of the level of take exist. Illegal harvest of sea turtles was documented in 9 of 10 Caribbean countries surveyed by Fleming (2001), although the level of exploitation of loggerheads was thought to be low as a result of the low overall abundance of loggerheads in the Caribbean region.

Oil and Gas Activities

Several activities associated with offshore oil and gas production, including oil spills, water quality (operational discharge), seismic surveys, explosive platform removal, platform lighting, and noise from drillships and production activities, are known to impact loggerheads. Currently, there are 3,443 federally regulated offshore platforms in the Gulf of Mexico dedicated to natural gas and oil production. Additional state-regulated platforms are located in state waters (Texas and Louisiana). As a result of newly developed floating and subsea production systems, oil production in the Gulf of Mexico is predicted to increase by 160% between 1995 and 2006 (MMS 2002). There are currently no active leases off the Atlantic coast.

All loggerhead life history stages are vulnerable to the harmful effects of oil through direct contact, degradation of food resources, and loss of habitat (MMS 2000). Vargo *et al*. (1986) reported that sea turtles would be at substantial risk if they encountered an oil spill or large amounts of tar in the environment. 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. Exposure to petroleum products can be fatal to all lifestages of loggerheads (Vargo *et al*. 1986). Physiological experiments showed that sea turtles exposed to petroleum products may suffer inflammatory dermatitis, ventilatory disturbance, salt gland dysfunction or failure, red blood cell disturbances, immune response, and digestive disorders (Vargo *et al*. 1986, Lutz and Lutcavage 1989, Lutcavage *et al*. 1995).

Operational discharge of produced waters, drill muds, and drill cuttings are routinely discharged in marine waters as a result of petroleum production activities (MMS 2000). Loggerheads may bioaccumulate heavy metals found in drill muds resulting in debilitation or death. Oil exploration and development on live bottom areas may disrupt foraging grounds by smothering benthic organisms with sediments and drilling muds (Coston-Clements and Hoss 1983).

The explosive removal of offshore oil and gas platforms is known to have impacts on loggerheads ranging from capillary damage, disorientation, loss of motor control, and mortality (National Research Council 1996). Klima *et al*. (1988) examined the effects of underwater explosions on sea turtles and found five of eight turtles exposed to explosions at distances varying between 229 m and 915 m were rendered unconscious. Loggerheads found closer to detonation sites would likely suffer fatal injuries. From 1987 to 2006, NMFS observers reported only one loggerhead mortality and three injured/stunned loggerheads during removal of approximately 1,700 offshore oil structures in the Gulf of Mexico (Gregg Gitschlag, NMFS, personal communication, 2007). The small number of sea turtles observed during platform removal may be a result of the inability of observers stationed at the surface to assess the impacts of explosions on submerged sea turtles.

Petroleum seismographic cannons produce intense noise at both high and low frequencies and have the potential to harm sea turtles. The effects of seismic survey activity have not been studied in sea turtles (Lutcavage *et al*. 1997). Drillships and production facilities produce sound at varying frequencies and intensities that may influence turtle behavior (MMS 2000). Although sea turtles can hear low frequency sounds, they are generally considered to have an insensitive ear. The minimum sound turtles can hear (hearing threshold) is about 132 to 140 decibels (Ridgway *et al*. 1960, Barthol *et al*. 1999). Information on their behavioral response to these decibel levels is limited. Captive loggerhead turtles exposed to brief, audio-frequency vibrations initially showed startle responses of slight head retraction and limb extension (Lenhardt *et al*. 1983). Sound-induced swimming has been observed for captive loggerheads (O'Hara and Wilcox 1990, Moein *et al*. 1993, Lenhardt1994); some loggerheads exposed to low-frequency sound responded by swimming toward the surface at the onset of the sound, presumably to lessen the effects of the transmissions (Lenhardt 1994).

The impacts of offshore lighted oil production platforms on loggerheads are unknown. Lighted platforms may attract hatchlings, making them more susceptible to predation (de Silva 1982). Neritic juveniles and adults may be attracted by high prey concentrations around the structures, making them more susceptible to ingestion of petroleum products.

Research and Conservation Management Activities

Research and conservation management activities involving loggerhead turtles are many and varied throughout their U.S. range. Activities include directed capture in marine habitats to obtain information about life stage, health status, diet, reproductive status, etc. These activities are carefully regulated under the ESA, which requires that all activities affecting loggerhead turtles, including those of a research and conservation management nature, be formally authorized. FWS and NMFS have implemented permitting regulations to ensure that proposed research and conservation activities are necessary for recovery, carried out by appropriately trained persons, non-duplicative, the least manipulative possible, and carried out in such a way to minimize chances of mortality. The vast majority of authorized take for research and conservation management is non-lethal take. Annually, a low level of lethal take is authorized by both agencies for research and conservation purposes, primarily to cover the very low level of lethal take that may occur when using certain capture techniques (e.g., large mesh gillnets, trawls) and to cover lethal take that may occur during bycatch reduction experiments in commercial fisheries.

Power Generation Activities

The entrainment and entrapment of loggerheads in saltwater cooling intake systems of coastal power plants has been documented in New Jersey, North Carolina, Florida, and Texas (Eggers 1989; National Research Council 1990a; Carolina Power and Light Company 2003; FPL and Quantum Resources, Inc. 2005; Progress Energy Florida, Inc. 2003). Average annual incidental capture rates for most coastal plants from which captures have been reported amount to several turtles per plant per year. One notable exception is the St. Lucie Nuclear Power Plant located on Hutchinson Island, Florida. During the first 15 years of operation (1977-1991), an average of 128 loggerheads per year was captured in the intake canal with a mortality rate of 6.4%. During 1991-2005, loggerhead captures more than doubled (average of 308 per year), while mortality rates decreased to 0.3% per year (FPL and Quantum Resources, Inc. 2005).

In recent years, alternative energy sources (i.e., wind, wave, tidal, current) have received widespread global attention. Numerous projects are under consideration in state and Federal waters off most states, and a growing number are operating as pilots or test facilities. Based on preliminary plans and state mandates for renewable energy portfolios, dozens of wind or hydrokinetic projects representing many hundreds of individual turbines could be operating by 2010. 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 loggerheads. The conversion of wave or tidal energy into power is cause for concern when these projects are located in loggerhead 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 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). Propeller wounds are greatest in southeast Florida (Palm Beach through Miami-Dade County); during some years, as many as 60% of the loggerhead strandings found in these areas had propeller wounds (FFWCC, unpublished data).

Human Presence

Human presence, especially in neritic habitats, can disturb both juvenile and adult loggerheads. 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 loggerheads. 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 loggerheads from preferred resting or foraging areas.

Military Activities

Military maneuvers involving explosives and/or low frequency sonar may potentially harm loggerheads in all life stages, but information on the scope and extent of the impacts is not well known. Although sea turtles can hear low frequency sounds, they are generally considered to have an insensitive ear. The minimum sound turtles can hear (hearing threshold) is about 132 to 140 decibels (Ridgway *et al*. 1969, Bartol *et al*. 1999). Information on their behavioral response to these decibel levels is limited. Captive loggerhead turtles exposed to brief, audio-frequency vibrations initially showed startle responses of slight head retraction and limb extension (Lenhardt *et al*. 1983). Sound-induced swimming has been observed for captive loggerheads (O'Hara and Wilcox 1990, Moein *et al*. 1994, Lenhardt 1994); some loggerheads exposed to low-frequency sound responded by swimming toward the surface at the onset of the sound, presumably to lessen the effects of the transmissions (Lenhardt 1994).

Salvage Operations

Efforts to salvage valuable artifacts from shipwrecks commonly entail extensive excavation of the sea floor. Because shipwreck sites are frequently located at reef and other hardbottom habitats, these excavations have the potential to detrimentally affect foraging and other habitats used by loggerheads. Excavation by salvers often entails redirected boat-prop wash to blow out sand and bottom materials in order to expose artifacts. This type of excavation may damage reefs, destroy benthic organisms, and increase local turbidity that may damage adjacent habitats.

CONSTRUCTION AND DEVELOPMENT

Dredging

Periodic dredging of sediments from navigational channels is necessary to provide for the passage of large commercial and military vessels. In addition, sand mining (dredging) for beach renourishment occurs along the Atlantic and Gulf of Mexico. 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).

Capture and mortality of sea turtles by hopper dredges was identified as a problem in the late 1970s. During a 3-month period in 1980, dredging operations in the Port of Canaveral, Florida, ship channel were responsible for killing at least 71 sea turtles (National Research Council 1990a). To minimize mortality associated with hopper dredging, Dickerson *et al*. (1995) conducted a study to determine the seasonal abundance of sea turtles in southeast U.S. ship channels. Loggerheads were rarely captured when water temperatures fell below 16°C. As a result, dredging activities in the southeast U.S. Atlantic were restricted to winter months when turtles are less abundant. Several other methods have been employed to reduce incidental capture and mortality of loggerheads in hopper dredges. The U.S. Army Corps of Engineers funded research to develop a plow-like deflector designed to push or move turtles away from the suction of the draghead (Nelson and Shafer 1996). In addition, shrimp trawlers have been employed to capture and relocate sea turtles prior to or during dredging operations. Most of the loggerheads taken during dredging operations are juveniles and subadults. Observations during dredging projects in Texas and Florida suggest that sea turtles may be captured and killed during pipeline or cutterhead dredging operations (NMFS, unpublished data). However, interactions between slow moving cutterhead dredges and sea turtles are thought to be rare. Clamshell dredges have not been implicated in the incidental take of sea turtles.

Channel and Bridge Blasting

Using explosives to remove existing bridge or piling structures and to create or deepen navigation channels can result in injury or death of loggerhead turtles inhabiting the area (Klima *et al*. 1988; Barbara Schroeder, NMFS, personal communication, 2005). Effects of the explosion(s), depending upon proximity of the turtle to the explosive source(s), can include immediate lethal injuries, serious injuries leading to delayed mortality, or reduced fitness (e.g., inability to avoid predators, inability to properly feed). The frequency of blasting to create or deepen channels is low, averaging one to two actions annually in the Atlantic and Gulf. The use of explosives to remove bridges occurs more frequently, but at a low level of approximately five actions annually in the Atlantic and Gulf.

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.

Offshore Breakwaters

The presence of breakwaters has the potential to attract and concentrate predatory fishes and provide perching spots for predatory birds, resulting in higher probabilities of hatchling predation as hatchlings begin their offshore migration. Hatchling predation in nearshore waters is variable and is observed to be considerably higher near submerged structures such as reefs (Witherington and Salmon 1992, Gyuris 1994, Wyneken and Salmon 1996). There are many documented occurrences of nearshore predators captured with hatchlings found in their digestive tracts (Stancyk 1982). During hatchling predation studies in Broward County, Florida, it was documented that predatory fish species targeted sea turtle hatchlings and learned where to concentrate foraging efforts (Glenn 1998, Wyneken *et al*. 1998).

ECOSYSTEM ALTERATIONS

Trophic Changes from Fishery Harvest

Anthropogenic disruptions of natural ecological interactions have been difficult to discern and few studies have been focused on the effects of these disruptions on loggerheads. Youngkin (2001) analyzed gut contents from hundreds of loggerheads stranded in Georgia over a 20-year period. His findings point to the probability of major effects on loggerhead diet from activities such as shrimp trawling and dredging. Lutcavage and Musick (1985) found that horseshoe crabs strongly dominated the diet of loggerheads in Chesapeake Bay in 1980-1981. Subsequently, fishermen began to harvest horseshoe crabs, primarily for use as bait in the eel and whelk pot fisheries, using several gear types. Atlantic coast horseshoe crab landings increased by an order of magnitude (0.5 to 6.0 million pounds) between 1980 and 1997, and in 1998 the Atlantic States Marine Fisheries Commission implemented a horseshoe crab fishery management plan to curtail catches (ASMFC 1998). The decline in horseshoe crab availability has apparently caused a diet shift in juvenile loggerheads, from predominantly horseshoe crabs in the early to mid-1980s to blue crabs in the late 1980s and early 1990s, to mostly finfish in the late 1990s and early 2000s (Seney 2003, Seney and Musick 2007). These data suggest that turtles are foraging in greater numbers in or around fishing gears and on discarded bycatch (Seney 2003). Studies on the effects of fishing activities on loggerhead prey and foraging ecology are urgently needed to assess the magnitude of this threat and to provide information for addressing it.

Trophic Changes from Benthic Habitat Alteration

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. 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.

Aquaculture

Aquaculture netting, particularly large mesh sizes, may entangle and drown sea turtles. The larger the mesh size, the greater the probability of entanglement (although even very small mesh can entangle a turtle, often wrapping around the nail on the rear or foreflippers). The more slack in the net, the greater the probability of entanglement. Such entanglement can result in a minor injury, or it can develop into a life-threatening condition (Moore and Wieting 2000). Studies have shown that sea turtle hatchlings (certain species in certain areas) migrate offshore after hatching and become associated (and dependent upon) floating rafts of seaweed (e.g., *Sargassum*) and other flotsam. Net pens and associated aquaculture structures, depending on their siting, may "collect" seaweed rafts or interfere with their natural passive movements and, therefore, may entangle, capture, or disrupt migratory movements of post-hatchling or pelagic-stage sea turtles.

Anthropogenic lighting has been well documented to misorient hatchling turtles during their transit from nest to sea (see above section on Lighting Pollution under H.1. Pollution) and has also been documented to misorient hatchlings after their entry into the sea. Studies have also shown that nesting female turtles can be deterred from nesting and/or misoriented at the nesting beach by artificial lights. Artificial lighting at aquaculture facilities, depending on their siting, may misorient hatchlings and/or adult females in the proximity of nesting beaches. No studies have been conducted on the effects of artificial lighting offshore of nesting beaches, but such studies must be a component of any thorough investigation into the impacts of aquaculture on sea turtles.

The location of aquaculture facilities should take into consideration proximity of nesting beaches, foraging habitat, and migratory pathways of sea turtles. Only certain of these are identifiable at this time. Additional research will be needed as aquaculture sites are selected or considered. Vessel strikes are a significant threat to sea turtles in certain areas of high vessel traffic. Increases in vessel traffic that result from aquaculture operations must be evaluated with respect to effects on resident or migratory sea turtle populations. Documentation and characterization of the effects of aquaculture on disease, predation, and alteration of behavior of sea turtles is needed.

Eutrophication

Eutrophication is a condition in aquatic ecosystems where high nutrient concentrations can stimulate harmful algal blooms. Human activities can greatly accelerate eutrophication by increasing the rate at which nutrients and organic substances enter aquatic ecosystems from surrounding watersheds. Agricultural runoff, urban runoff, leaking septic systems, sewage discharges, and similar sources can increase the flow of nutrients and organic substances into aquatic systems. Eutrophication caused by excessive nutrient pollution in coastal waters can affect sea turtles both directly and indirectly (Milton and Lutz 2003).

Algal blooms cloud the water and block sunlight, causing underwater seagrasses to die. Secondly, when algae die and decompose, oxygen is used up. This is a concern because dissolved oxygen in the water is essential to most organisms living in the water, including fish and crabs, which are prey items for loggerheads. The presence of harmful algal blooms also can result in increased levels of ammonia and toxins, including tumor promoters and immunosuppressants (Osborne *et al*. 2001). The effects of large-scale eutrophication on resident sea turtle populations currently are unknown because of the lack of in-water population studies in affected areas (Milton and Lutz 2003).

POLLUTION

Marine Debris Entanglement

Loggerheads 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; NMFS, unpublished data). From 1997 to 2005, 1.6% of stranded loggerheads found on Atlantic and Gulf of Mexico beaches were entangled in fishing gear. Monofilament line appears to be the principal source of entanglement for loggerheads in U.S. waters (0.9%; 1997-2005 average), followed by pot/trap line (0.4%; 1997-2005 average) and fishing net (0.3%; 1997-2005 average). Less than 1% of stranded sea turtles in 2005 were found entangled in other marine debris (NMFS, unpublished data). From 1991 through 2005, the annual percent occurrence of entanglement for Florida sea turtle strandings ranged from 2.8 to 7.6% (mean=4.7%, SD=1.18%) (FFWCC, unpublished data). Records from Florida indicate that some entanglements result from netting and monofilament line that has accumulated on both artificial and natural reefs. These areas are often heavily fished, resulting in snagging of hooks and discarding of lines. Turtles foraging and/or resting in these areas can become entangled and drown (FFWCC, unpublished data). 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 1987a, Witherington 2002).

Marine Debris Ingestion

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. 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*. 1994b).

Epipelagic (open surface waters) convergence lines 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 loggerheads ingest this debris at a high frequency and incur mortality from its effects. Witherington and Hirama (2006) reported that of 83 post-hatchling loggerheads stranded in east Florida, 83.1% had ingested plastics and 33.7% had ingested tar.

Oil Pollution

The deleterious effects of oil pollution on sea turtles have been well documented (Lutcavage *et al*. 1997). Turtles in oil slicks experience prolonged physical contact with floating oil. This contact can cause significant changes in respiration, diving patterns, energy metabolism, and blood chemistry. The turtle salt glands appear particularly sensitive to oil pollution. Prolonged salt gland failure interferes with water balance and ion regulation and may be fatal (Lutcavage *et al*. 1997). Annually about 1% of all sea turtle strandings along the U.S. east coast have been associated with oil, but higher rates of 3 to 6% have been observed in South Florida and Texas (Teas 1994, Rabalais and Rabalais 1980, Plotkin and Amos 1990).

Toxins

Pollution sources other than oil that may affect sea turtles include persistent chlorinated hydrocarbons and heavy metals. Long-lived carnivorous species, such as loggerheads, would tend to bioaccumulate these compounds (Rybitski *et al*. 1995, Lutcavage *et al*. 1997). However, organochlorine concentrations found in sea turtles have been much lower than those found in marine mammals and birds (George 1997), probably due to the much lower metabolic rates of sea turtles. The impacts of these compounds have been shown to have deleterious effects on loggerheads (Keller *et al*. 2004, 2006). Keller *et al*. (2004) found that widespread and persistent organochlorine contaminants, such as polychlorinated biphenyls (PCBs) and pesticides, may be affecting the health of loggerheads even though sea turtles accumulate lower concentrations of organochlorine contaminants compared with other wildlife. Keller *et al*. (2004) found significant correlations for a wide variety of biological functions, suggesting, for example, changes in the immune system, possible liver damage, and possible alterations in protein and carbohydrate regulation. However, the authors cautioned that the correlations suggest, but do not prove, a cause and effect link. Researchers have also collected baseline information on heavy metal contamination in loggerhead populations at several locations throughout the southeast U.S.

Noise Pollution

Noise pollution from a number of sources including shipping and military activities may have negative non-lethal effects (e.g., alteration of migration routes, avoidance of foraging areas) on neritic loggerheads. Samuel *et al*. (2005) recorded underwater sound in the Peconic Bay Estuary system in Long Island Sound, New York, during a period that coincided with the sea turtle activity season and suggested that continued exposure to high levels of noise and any increase could affect sea turtle behavior and ecology. No estimates on the extent of this threat are available.

Thermal Pollution

Coastal power plants use estuarine or ocean water as a cooling source and result in the discharge of heated water to nearshore habitats. Alteration of natural temperature regimes within the discharge area can lower dissolved oxygen content and alter habitats by altering the composition of species, including loggerhead prey items. Loggerheads may avoid or be attracted to these heated waters, depending on ambient water temperatures in surrounding areas.

Desalinization Plant Pollution

Little is known about the potential impacts of desalinization plant discharges on sea turtles and their habitats. At a minimum, discharges should be placed to ensure that effluent does not directly impact seagrass beds, live coral reef, or other important sea turtle habitats.

SPECIES INTERACTIONS

Predation

Large sharks may prey upon neritic stage loggerheads. 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). Predation by white sharks (*Carcharodon carcharias*) has also been reported (Fergusson *et al*. 2000). The magnitude of loggerhead mortality caused by sharks in the Northwest Atlantic is unknown. A study that took place in Western Australia showed that loggerheads incurred shark-bite injuries at a greater frequency than green turtles (Heithaus *et al*. 2002).

Disease and Parasites

Loggerheads are affected by a variety of health problems, although relatively few diseases have been documented in wild populations. At least two bacterial diseases have been described in wild loggerhead populations, including bacterial encephalitis and ulcerative stomatitis/obstructive rhinitis/pneumonia (George 1997). There are few reports of fungal infections in wild loggerhead populations. Homer *et al*. (2000) documented systemic fungal infections in stranded loggerheads in Florida. Both bacterial and fungal infections are common in captive sea turtles (Herbst and Jacobson 1995, George 1997).

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. An exception is Florida Bay where approximately 9.5% of the loggerheads captured exhibit fibropapilloma-like external lesions (Barbara Schroeder, NMFS, personal communication, 2006).

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).

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 loggerhead populations is not known (Herbst and Jacobson 1995). Several researchers have initiated health assessments to study health problems in free-ranging turtle populations. Sampling methods for these assessments have included capturing sea turtles with modified shrimp nets (Segars *et al*. 2005), capturing turtles in commercial pound nets (Harms *et al*. 2006a, 2006b; Kelly *et al*. in press), and sampling adult females on nesting beaches (Deem *et al*. 2003). To date, these assessments have focused on establishing normal baseline blood chemistry values and conducting physical exams. As more assays become available, researchers hope to assess the prevalence of infectious diseases in wild loggerhead populations.

Red Tide

A red tide is a higher-than-normal concentration of microscopic algae. In Florida, the species that causes most red tides is *Karenia brevis*, a type of microalgae known as a dinoflagellate (Florida Marine Research Institute 2003). This organism produces a toxin that has been documented as a mortality factor in birds and marine mammals and is a suspected mortality factor in sea turtles. During four red tide events along the west coast of Florida, sea turtle stranding trends indicated that these events were acting as an additional mortality factor (Redlow *et al*. 2003). Sea turtles that washed ashore alive during these red tide events displayed symptoms that were consistent with acute brevitoxicosis (e.g., uncoordinated and lethargic but otherwise robust and healthy in appearance) and completely recovered within days of being removed from the area of the red tide. The concentration of brevitoxin in the livers of eight turtles, including one loggerhead, that were found dead during red tides ranged from 10-330 nanograms per gram. These concentrations were similar to the concentrations of brevitoxin found in Florida manatees (*Trichechus manatus latirostris*) that were determined to have died from brevitoxicosis. Concentrations of brevitoxin in the livers of two dead loggerheads that did not strand during red tides were less than 0.05 nanograms per gram (Redlow *et al*. 2003).

Although the organism that causes Florida's red tide is found almost exclusively in the Gulf of Mexico, blooms have been found off the Atlantic coast of Florida, and a bloom was detected off the coast of North Carolina in 1987. Scientists believe the Florida Current and Gulf Stream Current carried *Karenia brevis* out of the Gulf of Mexico, around south Florida, and up to the Carolina coast. Other types of microorganisms cause different kinds of red tides (now called harmful algal blooms) in other parts of the world as well (Florida Marine Research Institute 2003).

OTHER FACTORS

Climate Change

Impacts from climate change, especially due to global warming, are likely to become more apparent in future years (IPCC 2007a). The global mean temperature has risen 0.76ºC over the last 150 years, and the linear trend over the last 50 years is nearly twice that for the last 100 years (IPCC 2007a). There is a high confidence, based on substantial new evidence, that observed changes in marine systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation. These changes include shifts in ranges and changes in algal, plankton, and fish abundance (IPCC 2007b), which could affect loggerhead prey distribution and abundance.

Natural Catastrophes

Storm events causing turbulence and currents during the nesting season can wash post-hatchling turtles up on the beach with algae and flotsam (Carr and Meylan 1980). Post-hatchlings, or washback hatchlings, are turtles that have left nesting beaches, spent weeks or months at sea, and are then washed back onto the beach with seaweed during storm events. Storm systems may also result in benthic habitat alterations influencing the abundance and diversity of prey species for loggerheads. Similarly, prolonged drought conditions may influence estuarine ecosystems and reduce the abundance of important food resources, such as blue crabs.

Cold Water

Loggerheads are susceptible to cold stunning, a phenomenon in which turtles become incapacitated as a result of rapidly dropping water temperatures (Witherington and Ehrhart 1989, Morreale *et al*. 1992). As temperatures fall below 8-10^{o}C, turtles may lose their ability to swim and dive, often floating to the surface. It appears to be the rate of cooling that precipitates cold stunning rather than the water temperature itself (Milton and Lutz 2003). Sea turtles that overwinter in inshore waters are most susceptible to cold stunning, because temperature changes are most rapid in shallow water (Witherington and Ehrhart 1989).

H.3. OCEANIC ZONE

RESOURCE USE (FISHERIES)

A major threat to the survival of loggerheads during the oceanic stage is the risk of incidental capture in commercial fisheries. Indirect take in fisheries, whether it is the high seas drift nets, longlines, or other fisheries, is a very serious problem for juvenile turtles (National Research Council 1990a, Wetherall *et al*. 1993, Balazs and Pooley 1994, Witzell 1999, Bolten *et al*. 2000).

Gillnet (Drift) Fisheries

Prior to the United Nations General Assembly (UNGA) resolution prohibiting large-scale high-seas drift-net fishing, bycatch of oceanic juvenile turtles was significant and well documented, at least in the Pacific (Wetherall *et al*. 1993). UNGA Resolution 44/225, adopted in 1990, called for a moratorium on the use of drift-net fishing gear on the high seas by June 30, 1992. This Resolution was supplanted by UNGA Resolution 46/215, which delayed the effective date of the moratorium until December 31, 1992.

Longline Fisheries

Incidental take of oceanic-stage loggerheads in swordfish pelagic longline fisheries has recently received a lot of attention (Balazs and Pooley 1994; Bolten *et al*. 1994, 2000; Aguilar *et al*. 1995; Laurent *et al*. 1998; Long and Schroeder 2004; Watson *et al*. 2005). The mean size CCL (± standard deviation) for loggerheads captured in the swordfish fishery in the Azores during an experiment conducted in 2000 was 49.8 ± 6.2 cm CCL (n = 224; ACCSTR, unpublished data), which is significantly larger ($p < 0.001$, Kolmogorov-Smirnov test, ks = 0.6528) than the mean of the overall oceanic-stage population, 34.5 ± 12.6 cm CCL (n = 1692, Bolten 2003). The largest size classes in the oceanic stage are the size classes impacted by the swordfish longline fishery (Bolten 2003). Earlier studies in Azorean waters documenting swordfish longline captures show similar size classes impacted by that fishery (Bolten *et al*. 1994, Ferreira *et al*. 2001). There are no estimates of mortality of turtles caught and released in the swordfish fishery in the Azores. The demographic consequences relative to population recovery of the increased mortality of these size classes have been discussed (Crouse *et al*. 1987; see also Heppell *et al*. 2003b and Chaloupka 2003).

Similar size classes of loggerheads are impacted by longline fisheries in other regions. In the western Mediterranean, the mean size of loggerheads caught in drifting longline fisheries was 47.4 ± 10.4 cm CCL (n = 62) and 45.9 ± 7.5 cm CCL (n = 53) in the eastern Mediterranean (Laurent *et al*. 1998). Witzell (1999) reported a mean size of 55.9 ± 6.5 cm CCL (n = 98) for loggerheads caught in the longline fishery from the Northwest Atlantic, primarily the Grand Banks, Newfoundland, Canada. More recently, Watson *et al*. (2005) reported a similar size for loggerheads caught during a longline bycatch reduction experiment conducted in the Northwest Atlantic (range = 32.4-68.0 cm SCL, mean 56.8 cm SCL, n = 93). In the Pacific, the mean size of loggerheads caught by longlines is 57.7 ± 11.5 cm SCL (n = 163; Balazs and Parker, unpublished data).

Results from satellite telemetry with satellite-linked time-depth recorders have demonstrated the potential negative impacts of longline hooking on dive behavior and movement patterns of oceanic juveniles. Following release, hooked turtles have significantly reduced diving behavior (e.g., shallower dive depths) and their movements appear to be influenced to a greater extent by ocean currents (i.e., the turtles are less active swimmers and drift with the current) (ACCSTR, unpublished data).

Numerous other fisheries impact oceanic-stage loggerhead populations, and new ones continue to emerge. For example, the fishery for black scabbard (*Aphanopus carbo*) in Madeira has significant bycatch of oceanic-stage loggerheads (Dellinger and Encarnacao 2000). This fishery is currently under investigation for development in the Azores.

RESOURCE USE (NON-FISHERIES)

Legal Harvest and Illegal Harvest

Directed take of loggerheads in the oceanic zone is for both food and the souvenir trade in polished shells or whole stuffed turtles. The once-popular souvenir trade in Madeira, Portugal, combined with harvest for meat, accounted for between 1,000 and 4,000 loggerhead deaths annually (Brongersma 1982). Turtle harvest is now illegal in Madeira, but still exists in other regions. The extent of legal and illegal take of loggerheads needs to be quantified (e.g., Fleming 2001, Nada 2001).

Vessel Strikes

Increased tourism into sensitive sea turtle habitats (e.g., whale watching and sport/recreational fishing) may increase the frequency of boat collisions. There are currently no data available to evaluate this threat.

Oil and Gas Activities

Loggerheads in oceanic habitats can be at a considerable risk from toxic effects of oil spills and, to a lesser extent, boat collisions during transport (Lutcavage *et al*. 1997). Stranded loggerhead carcasses in the Canary Islands had esophageal impactions and lesions associated with ingestion of crude oil (Orós *et al*. 2004).

Research and Conservation Management Activities

Research and conservation management activities involving loggerhead turtles are many and varied throughout their U.S. range. Activities include directed capture in marine habitats to obtain information about life stage, health status, diet, reproductive status, etc. These activities are carefully regulated under the ESA, which requires that all activities affecting loggerhead turtles, including those of a research and conservation management nature, be formally authorized. NMFS has implemented permitting regulations to ensure that proposed research and conservation activities are necessary for recovery, carried out by appropriately trained persons, non-duplicative, the least manipulative possible, and carried out in such a way to minimize chances of mortality. The vast majority of authorized take for research and conservation management is non-lethal take. Annually, a low level of lethal take is authorized by NMFS for research and conservation purposes, primarily to cover the very low level of lethal take that may occur when using certain capture techniques (e.g., large mesh gillnets) and to cover lethal take that may occur during bycatch reduction experiments in commercial fisheries.

Military Activities

For a discussion of the effects of military activities on the marine environment, see the section on Military Activities under H.2. Neritic Zone.

ECOSYSTEM ALTERATIONS

Trophic Changes from Fishery Harvest and Habitat Alteration

Oceanic ecosystems are changing as a result of overfishing and pollution. Selective, and usually intense, harvest of species in fisheries will result in changes to the suite of species interactions in this ecosystem (e.g., predator-prey interactions, trophic dynamics and food webs; see Bjorndal 2003). Changes in trophic dynamics may have a major impact on sea turtles; however, data are lacking to quantify these impacts. Changes to trophic interactions may affect availability of prey for loggerheads, and loggerheads may become prey to a new suite of predators following food-web alterations. Decreasing food resources for loggerheads could result in sublethal effects in the form of decreased growth rates and reproductive output (Bjorndal 2003). Such sublethal effects will be difficult to discern because our knowledge of rates of food intake and rates of growth is poor (Bjorndal 2003). Similar changes to trophic dynamics in this ecosystem can occur from the toxic effects of pollution.

SPECIES INTERACTIONS

Predation

Oceanic-stage loggerheads are preyed upon by sharks, killer whales (*Orcinus orca*), and probably any large carnivorous fish or mammals in this habitat (Bjorndal 2003). There are no estimates of predation of loggerheads in this life stage.

Disease

There are no definitive reports of sea turtle fibropapilloma disease for oceanic-stage loggerheads.

POLLUTION

Oil Pollution and Toxins

Toxic effects of pollution (e.g., oil, gas, heavy metals) can have direct effects on turtles (Lutcavage *et al*. 1997) or can alter the habitat by affecting trophic dynamics.

Noise Pollution

Noise pollution from a number of sources, including shipping and military activities, may have negative non-lethal effects (e.g., alteration of migration routes, avoidance of foraging areas) on oceanic loggerheads. No estimates on the extent of this threat are available.

Marine Debris Ingestion and Entanglement

The lethal and sublethal effects of debris ingestion and entanglement are also major concerns (Balazs 1985, Carr 1987a, McCauley and Bjorndal 1999, Witherington 2002). The open ocean is full of debris, and little loggerheads frequently ingest plastics, tar, styrofoam, and monofilament

(Carr 1987a, Witherington 2002). This ingestion, as well as entanglement, can be lethal. The sublethal effects from marine debris ingestion may also have severe consequences, but are difficult to quantify. During laboratory feeding trials, post-hatchling loggerheads were not able to adjust their intakes to counter nutrient dilute diets similar to what turtles would experience when ingesting debris (McCauley and Bjorndal 1999). However, the authors suggest that with increasing size, turtles may be better able to adjust their intakes.

OTHER FACTORS

Climate Change

For a discussion of the effects of climate change on the marine environment, see the section on Climate Change under H.2. Neritic Zone.

Natural Catastrophes

Hurricanes and other major storm events can have significant short-term effects on trophic dynamics (see above section on Trophic Changes from Fishery Harvest and Habitat Alteration under H.3. Ecosystems Alterations).

Cold Water

Oceanic-stage juvenile loggerheads can be carried by currents into waters with temperatures below their lethal minimum (Hays and Marsh 1997) resulting in mortality. Cold water can also result in sub-lethal effects (Schwartz 1978).

I. MAJOR CONSERVATION EFFORTS

The following section summarizes the major conservation efforts intended to reduce or remove threats to the loggerhead. These efforts have been conducted by Federal, state, and local agencies, private organizations, academia, and individuals. This section is not intended to be an exhaustive list of every conservation action undertaken.

I.1. TERRESTRIAL ZONE (NESTING BEACH)

In the southeast U.S., major nest and beach habitat protection efforts are underway for most of the significant nesting areas, and progress has been made in reducing mortality from human-related impacts on the nesting beach.

Efforts to Acquire Nesting Habitat

The Archie Carr National Wildlife Refuge (NWR), located in Brevard and Indian River Counties, Florida, represents the United States' most significant land acquisition effort to protect the loggerhead. The acquisition plan for the refuge set a goal for purchase of 15.0 km (9.3 miles) of beach within a 32.7-km (20.3-mile) stretch where nesting densities often exceed 600 nests per km (1,000 nests per mile). The establishment of the Archie Carr refuge was made possible by a multi-agency land acquisition effort. Partners in this effort include the FWS, FDEP, Brevard County, Indian River County, Richard King Mellon Foundation, The Conservation Fund, and The Nature Conservancy. Over 60% of the available beachfront acquisitions for the Refuge have been completed. FWS has 14 additional refuges in the Southeast where loggerheads regularly nest and are provided protection. Numerous coastal national seashores, military installations, and state parks in the Southeast also provide protection for loggerheads on their lands.

Efforts to Minimize Effects of Beach Nourishment

During ESA section 7 consultations for beach nourishment projects, FWS places conditions on projects to minimize impacts to sea turtles. Minimization measures include nest relocation to non-project areas when nourishment cannot be conducted outside the nesting season, use of beach quality sand, sand compaction and escarpment monitoring and remediation, and management of project lighting.

Efforts to Reduce Light Pollution on Nesting Beaches

Effects of light pollution on sea turtles are most extensive in Florida due to dense coastal development. FFWCC advertises the State of Florida's Model Lighting Ordinance [http://myfwc.com/seaturtle] as an example for local governments to follow. As of November 2007, there were 19 counties and 57 municipalities with lighting ordinances [http://myfwc.com/seaturtle/Lighting/Light_Ordinance.htm]. Enforcement of mandatory lighting ordinances has increased, and Florida counties with the highest loggerhead nesting (Brevard through Palm Beach) appear to have the best compliance. In addition, FFWCC, working in close coordination with FWS, has developed a sea turtle lighting certification program that involves conducting workshops to educate all interested parties about the affects of lighting on sea turtles, the best lighting options to use near sea turtle nesting beaches, and the wide variety of light fixtures and bulbs available to manage lighting on their properties without negatively impacting sea turtles.

A significant number of beaches outside of Florida have lighting ordinances designed to reduce the effects of artificial lighting on sea turtles. All developed beaches in South Carolina and Georgia have lighting ordinances with the exception of Horry County, South Carolina (excluding Waties Island). In North Carolina, five municipalities have adopted lighting ordinances to protect sea turtles. However, judging by reports of hatchling disorientation, the NGRU suffers the greatest effects from light pollution relative to the number of turtles nesting there (FFWCC, unpublished data).

Efforts to Elucidate Effects of Barriers to Sea Turtle Nesting

During 2001 and 2002, FFWCC sampled stretches of beach in Florida to measure the extent of barriers (e.g., armoring, sand fences, recreational beach equipment, etc.) to sea turtle nesting. This information will provide a baseline to study spatial and temporal changes in this measure of nesting habitat suitability.

Efforts to Reduce Nest Predation

The most longstanding beach management program has been to reduce the destruction of nests by natural and introduced predators. Most major nesting beaches in the southeast U.S. employ some type of lethal (trapping, hunting) or nonlethal (screen, cage) control of mammalian predators to reduce nest loss. In 2002, over 90% of known loggerhead nests in North Carolina and Georgia were protected with a wire or plastic screen or cage (GDNR, unpublished data; NCWRC, unpublished data). In Florida and South Carolina, screens or cages were employed on 47% and 57% of nests, respectively (FFWCC, unpublished data; SCDNR, unpublished data). Predator removal (trapping, hunting) was used to reduce feral hog, raccoon, and fox depredation on approximately 10% of beaches in North Carolina, South Carolina, and Florida. In Georgia, 42% of nest protection projects used trapping and hunting to reduce feral hog populations. Throughout the southeast U.S., lethal methods were more commonly employed on undeveloped beaches where mammalian depredation is high. Overall, nest protection activities have substantially reduced loggerhead nest depredations, although the magnitude of the reduction has not been quantified.

Efforts to Reduce Effects of Beach Cleaning on Nesting Beaches

Beach cleaning is an activity most common in southern Florida; 16 urban counties have received beach-cleaning permits from FDEP. FDEP and FFWCC have set beach cleaning permit conditions pursuant to Rule 62B-33.005(11) of the Florida Administrative Code that restrict the timing and nature of beach cleaning.

Efforts to Reduce Effects of Beach Vehicular Driving

In 1996, Volusia County, Florida, developed a habitat conservation plan (HCP) to minimize and mitigate the impacts of County-regulated driving on 57.3 km (35.6 miles) of beaches. A HCP is a statutory component of an incidental take permit application under section 10 of the ESA. The Volusia County HCP limits the potential for sea turtle-vehicle interactions through four basic mechanisms: (1) public access is limited to daylight hours, and public safety vehicles that operate at night must follow specific guidelines; (2) public driving is limited primarily to those areas where nest densities are lowest; (3) in those areas where public driving is permitted, all driving and parking must occur outside a marked Conservation Zone near the dune, where the majority of nests are typically deposited; and (4) all nests are conspicuously marked so they can be avoided. Mitigation measures to offset unavoidable take have included development and implementation of a beach lighting management plan and rehabilitation of stranded sea turtles. Similar programs are being considered by other counties in Florida where beach driving is still allowed.

Efforts to Eradicate Exotic Plants on Nesting Beaches

Numerous efforts have been undertaken in Florida to remove exotic plants, such as Australian pine trees and Brazilian pepper trees (*Schinus terebinthifolius*), from sea turtle nesting beaches. For example, on Loggerhead Key, Dry Tortugas National Park, the National Park Service has eliminated Australian pines from the island in an effort to restore and enhance sea turtle nesting habitat. Similar efforts have been undertaken at St. Lucie State Park, Hobe Sound NWR, and the Archie Carr NWR, as well as others. In North and South Carolina, the Carolina Beach Vitex Task Force was established to document and eradicate beach vitex from loggerhead nesting beaches.

Efforts to Standardize and Improve Monitoring of Nest and Hatchling Production

FFWCC advertises sea turtle conservation guidelines [http://myfwc.com/seaturtle/Guidelines/MarineTurtleGuidelines.htm] in an attempt to standardize monitoring of nest and hatchling production. Annual training workshops are conducted in Florida within several coastal regions to reinforce standardized methods for marking and inventorying nests to measure hatching success.

I.2. NERITIC ZONE

Managing threats to sea turtles in the water lags behind efforts on the beach due to limited access to turtles, lack of information on habitat use by different life history stages, and cost. Therefore, most efforts to preserve marine and estuarine habitats are regulatory in nature.

Efforts to Reduce Bycatch in Commercial Fisheries

Mortality resulting from commercial fisheries operations, both domestically and in international waters, ranks among the most significant threats to the species. A variety of gears is used in commercial fisheries, including gillnets, trawls, hook and line (e.g., longlines), seines, dredges, and various types of pots/traps. Among these, gillnets, longlines, and trawl gear collectively result in tens of thousands of loggerhead deaths annually throughout their range in the Atlantic Ocean and Gulf of Mexico (see for example, Lewison *et al*. 2004; NMFS 2002a, 2004b).

Considerable effort has been expended since the 1980s to document and address these serious mortality factors. NMFS has implemented observer programs in many federally managed fisheries to collect turtle bycatch data. The most effective observer programs have been implemented in the longline fishery, nearshore gillnet fisheries, and trawl fisheries. Along with academic partners, NMFS has been evaluating alternative methods of observing fisheries, especially those fisheries that employ small vessels, making it impractical or unsafe to carry observers. NMFS has successfully deployed observers on alternative platform vessels and observed haulbacks or directly observed stationary nets to document turtle bycatch. Efforts are also underway to use acoustic technologies to visualize stationary gear in the water column and to determine whether turtles are present as bycatch (e.g., side scan sonar).

Efforts to reduce bycatch and mortality of loggerheads in fishing operations have focused on several areas. NMFS, along with partners, has reduced bycatch by developing technological solutions to prevent capture or to allow turtles to escape without harm (e.g., TEDs), by implementing time and area closures to prevent interactions from occurring (e.g., prohibitions on gillnet fishing along the mid-Atlantic coast during the critical time of northward migration of loggerheads), and/or by modifying gear (e.g., requirements to reduce mesh size in the leaders of pound nets to prevent entanglement).

NMFS recently adopted one of the most significant conservation actions -- a coastwide strategy to reduce bycatch of sea turtles in state and Federal fisheries. This approach will enable NMFS to look comprehensively at turtle bycatch in various fisheries on a gear-type basis. In other words, NMFS will evaluate turtle bycatch across gear types, such as gillnet or trawl, as opposed to a fishery-by-fishery basis, such as monkfish gillnet or flounder trawl. This will allow for a more comprehensive and ordered approach to address the most problematic gear and develop coastwide solutions for reducing bycatch inshore, nearshore, and offshore.

Trawl Fisheries: The development and implementation of TEDs in the shrimp trawl fishery is arguably the most significant conservation accomplishment in the marine environment since loggerheads were listed under the ESA. Although implementing TEDs has been a protracted and difficult process, the reduction of loggerhead mortality in shrimp trawl fisheries of the U.S. and in other countries as a result of TED use has been significant. In the southeast U.S. and Gulf of Mexico, TEDs have been mandatory in shrimp and flounder trawls for over a decade. NMFS has implemented various improvements in the design and function of TEDs to improve turtle exclusion and/or shrimp retention. Most notably, in 2003, NMFS implemented new requirements for TEDs in the shrimp trawl fishery to ensure that large loggerheads could escape through TED openings. An evaluation of turtle strandings by Epperly and Teas (2002) clearly demonstrated that approved TED openings were not large enough to exclude large loggerheads. Despite these improvements, TEDs are not required in all trawl fisheries, and significant loggerhead mortality still occurs in some trawl fisheries. In addition, enforcement of TED regulations is limited by available funding, and illegal or improperly installed TEDs are common in some areas.

Gillnet Fisheries: Gillnets of various mesh sizes are used extensively to harvest fish in the Atlantic Ocean and Gulf of Mexico. Gillnets can be anchored or drifting, and are fished at varying depths and configurations depending on the target species. With few exceptions, gillnets entangle loggerheads wherever the two co-occur. All size classes of loggerheads in coastal waters are prone to entanglement in gillnets, and, generally, the larger the mesh size the more likely that turtles will become entangled. State resource agencies and NMFS have been addressing this issue on several fronts. In the southeast U.S., gillnets are prohibited in the state waters of South Carolina, Georgia, Florida, and Texas and are restricted to fishing for pompano and mullet in saltwater areas of Louisiana. While these prohibitions were enacted primarily to recover fish stocks and prevent bycatch of various species in addition to turtles, they have contributed to loggerhead recovery. Addressing bycatch of loggerheads in the remaining state and federally regulated gillnet fisheries of the U.S. Atlantic and Gulf of Mexico has been difficult. NMFS has addressed the issue for several federally managed fisheries, such as the large-mesh gillnet fishery (primarily for monkfish) along the Atlantic coast, where gillnets larger than 8-inch stretched mesh are now regulated in North Carolina and Virginia through rolling closures timed to match the northward migration of loggerheads along the mid-Atlantic coast in late spring and early summer. The state of North Carolina, working with NMFS through the ESA section 10 process, has been making significant progress in reducing bycatch of loggerheads in gillnet fisheries operating in Pamlico Sound. The large mesh driftnet fishery for sharks off the Atlantic coast of Florida and Georgia remains a concern, despite observer requirements and the implementation of temporary emergency regulations when turtle bycatch has been documented.

Longline Fisheries: Observer programs have documented significant bycatch of loggerheads in the U.S. longline fishery operating in the Atlantic Ocean and Gulf of Mexico. In recent years, NMFS has dedicated significant funding and effort to address this bycatch issue. In partnership with academia and industry, NMFS has funded and conducted field experiments in the northwest Atlantic Ocean to develop gear modifications that eliminate or significantly reduce loggerhead bycatch. The experiments found that using large circle hooks in combination with finfish bait, as opposed to using "J" hooks and squid bait, significantly reduce loggerhead bycatch. NMFS required the use of circle hooks fleet wide and circle hooks in combination with whole finfish bait in the Northeast Distant area (NMFS 2004a, 69 FR 40734). In addition, NMFS is conducting research on the sensory biology of loggerheads to examine if sight, smell, and sound may be used to reduce bycatch (Swimmer and Wang 2007).

The incidental capture and mortality of loggerheads by international longline fleets operating in the North Atlantic Ocean and Mediterranean Sea is of great concern. NMFS is focusing attention to recognize and address the problem on a multi-lateral level. For example, NMFS is collaborating with foreign governments to conduct similar research to that undertaken in the U.S. fleet. The U.S. is also working through Regional Fisheries Management Organizations, such as the International Commission for the Conservation of Atlantic Tunas (ICCAT), to encourage member nations to adopt gear modifications (e.g., large circle hooks) that have been shown to significantly reduce loggerhead bycatch.

Pound net Fisheries: Pound nets are used in the mid-Atlantic and North Carolina to capture a variety of finfish. Loggerheads can become entangled in or impinged on the mesh leaders that funnel fish toward the pound, where turtles may also become entrapped. Entanglement in the large mesh leaders often leads to death, especially in areas of strong currents. NMFS has promulgated regulations restricting the use of pound net leaders in certain areas of the Chesapeake Bay and regulations to require a modified pound net leader to minimize loggerhead bycatch (NMFS 2006b, 71 FR 36024).

Pot/Trap Fisheries: NMFS is working with industry to better understand the interaction of loggerheads with pot and trap fisheries along the mid-Atlantic and northeast U.S. coast. While a solution has not yet been identified, gear experts are focusing on developing a technical solution to reduce bycatch in pot/trap fisheries. NMFS has established a Sea Turtle Disentanglement Network to respond to reports of entangled turtles.

Efforts to Reduce the Effects of Dredging

Dredging activities to deepen or widen navigation channels and harbors, or to provide sand for artificial beach nourishment activities, have been demonstrated to capture and kill loggerheads. Under the provisions of section 7 of the ESA, the COE has implemented monitoring and conservation actions to reduce or eliminate bycatch of turtles. Seasonal restrictions to prevent the use of hopper dredges in certain areas where turtles are abundant have been implemented through regulation in the southeast U.S. Deflector devices are required on hopper dredges at all times to help prevent turtles from being taken during hopper dredging activities and observers are also required to monitor whether turtles are being taken in certain times and areas, depending on turtle abundance. In certain areas and at certain times, turtles are captured by trawl and relocated out of dredging areas.

Efforts to Conduct In-water Monitoring

NMFS convened a workshop to evaluate methods for assessing abundance and trends in in-water populations using mark-recapture, capture-effort, and transect methodologies (Bjorndal and Bolten 2000). Workshop participants developed recommendations for selection of study populations, experimental design, and analysis. Trends in neritic foraging ground populations must be integrated over a large geographic area in order to forecast trends successfully in nesting populations (Bjorndal *et al*. 2005).

SCDNR initiated a large-scale 4-year study in 2000 designed to document species diversity and provide an index of abundance of sea turtles in the coastal waters of South Carolina, Georgia, and northeast Florida (Maier *et al*. 2004). During spring and summer (May-August), sea turtles were captured using shrimp trawlers with large-mesh nets (8-inch stretch) from Georgetown, South Carolina, to St. Augustine, Florida. Sampling was conducted in waters ranging from 15 to 40 feet in depth. This study has yielded valuable information on the species composition and habitat use of juvenile and adult loggerheads in the coastal waters of the southeast U.S. The sea turtle abundance index established during this study provides a baseline for assessing future population trends. Eaton *et al*. (in press) provide a comprehensive overview of historical and current research and monitoring projects concerning the occurrence, distribution, abundance, and representation of life stages of sea turtles in Florida waters. They identified 25 active and 17 inactive in-water sea turtle research projects in Florida, with the majority taking place on the Atlantic coast. Studies are also underway in North Carolina waters to gather information on trends in abundance, survival estimates, sex ratios, health status, population structure, and behavior (Avens 2003; Bass *et al* 2004; Braun-McNeill *et al* 2007a, 2007b; Epperly *et al* 2007; Stamper *et al* 2005). In-water studies in Chesapeake Bay and Long Island Sound have also provided important information on habitat use and behavior of loggerheads in these habitats (Byles 1988, Morreale and Standora 1998, Mansfield 2006).

Efforts to Coordinate a Stranding Network

Since 1980, NMFS, in close cooperation and with coastal states in the Atlantic and Gulf of Mexico, has coordinated a regional effort to document sea turtle mortality. The Sea Turtle Stranding and Salvage Network (STSSN) documents dead or injured sea turtles along the U.S. coast from Maine to Texas (Shaver and Teas 1999). Currently, 26 of the 44 statistical zones receive systematic surveys. Each stranding is identified to species, measured, and assessed for obvious wounds, injuries, or abnormalities. Data are recorded on standardized forms and submitted to the STSSN coordinator at NMFS. Stranding summaries are available on the NMFS Southeast Fisheries Science Center web page [http://www.sefsc.noaa.gov/seaturtleSTSSN.jsp]. Analysis of stranding data has been important in assessing regulations designed to protect sea turtles from fishery-related mortality. For example, a recent analysis of sea turtle stranding data suggested that the minimum TED openings were too small to allow large juvenile and adult loggerheads to escape from shrimp nets (Epperly and Teas 2002), which prompted NMFS to revise TED regulations to include larger minimum TED openings.

Efforts to Rehabilitate and Release Stranded Turtles

There are approximately 25 rehabilitation facilities along the Atlantic and Gulf of Mexico coasts that take in sick or injured sea turtles on a regular basis and release healthy turtles back into the wild. Several hundred live loggerheads are brought to these facilities through the STSSN annually.

Efforts to Reduce the Effects of Military Activities

Consultation under section 7 of the ESA is the primary avenue for evaluating potential adverse effects of military activities on loggerheads, and for developing alternatives and solutions to minimize these effects. NMFS and FWS consult with the Department of Defense on military activities, including training exercises near nesting beaches, shipshock testing of submarines in migration and foraging habitats, and bombing training exercises in resting, migration, and foraging habitats. Efforts to minimize the effects of these activities have focused on adjusting timing to minimize encounters with loggerheads and/or adjusting locations of activities to reduce overlap with sea turtle habitats.

Efforts to Reduce the Effects of Oil and Gas Activities

Oil and gas exploration and production activities have been documented to adversely affect loggerheads, either through direct effects (e.g., explosive removal of aging oil platforms) or indirectly through degradation of marine habitats (e.g., oil spills). MMS, the Federal agency responsible for regulating oil and gas activities, regularly consults with NMFS (through ESA section 7) on the effects of these actions on sea turtles. The most significant conservation accomplishment in this arena is the implementation of required monitoring programs prior to all oil and gas platform removals to reduce the likelihood that turtles will be in the vicinity when the detonation occurs.

Efforts to Reduce Vessel Strikes

The seriousness of the threat caused by vessel strikes to loggerheads in the Atlantic and Gulf of Mexico cannot be overstated. This growing problem is particularly difficult to address. In some cases, NMFS, through section 7 of the ESA, has worked with the U.S. Coast Guard (USCG) in an attempt to reduce the probability of vessel strikes during permitted offshore race events. Most races now require a protected species watch program including observers to monitor for sea turtles in the area. Continuous aerial surveys are usually required 1 hour prior to and throughout the event or practice sessions. If sea turtles are located within the designated race area, the event is postponed. However, most vessel strikes occur outside of these venues and the growing number of licensed vessels, especially inshore and nearshore, exacerbates the conflict. Slow speed zones, implemented for manatee protection, may provide some benefits to turtles, although this has not been quantified.

Efforts to Conduct Health Assessments

Researchers have conducted health assessments of loggerheads in several locations along the southeast Atlantic coast. Maier *et al*. (2004) conducted general physical exams and assessed the blood chemistry of 946 loggerheads captured in standardized trawls from 2000-2003 in the coastal waters of South Carolina, Georgia, and northeast Florida. Stamper *et al*. (2005) assessed epibiota and blood chemistry of resident and migratory loggerheads captured in pound nets in North Carolina. Researchers and managers have also evaluated epizootic events such as the mass stranding of loggerheads with clinical signs of a neurological disorder in south Florida during 2000 (Jacobson *et al*. 2006).

In addition, researchers have collected baseline information on pesticide and heavy metal contamination in loggerhead populations at several locations throughout the southeast U.S. Until recently, the majority of studies have focused on contaminant levels in turtle eggs (Pugh and Becker 2001). However, several ongoing studies are examining pesticide and heavy metal contamination in benthic juveniles and adults. For example, SCDNR has documented mercury contamination in loggerheads caught during standardized sea turtle abundance surveys in coastal waters of South Carolina, Georgia, and north Florida (Day 2005). Keller *et al*. (2004) documented polychlorinated biphenyl and organochlorine pesticide levels in juvenile loggerheads in coastal North Carolina. Further research suggested that organochlorine pesticide exposure may suppress innate immunity (Keller *et al*. 2006). Results from these research efforts are critical for assessing current and future impacts of environmental contamination on loggerhead populations.

I.3. OCEANIC ZONE

Efforts to Reduce Bycatch in Commercial Fisheries

<u>Driftnet Fisheries</u>: In 1991, the United Nations banned the use of large-scale high seas driftnets over 2.5 km long. Prior to the U.N. driftnet ban, these nets were of enormous proportions reaching lengths of 40 to 60 km. The U.S. supported this ban and continues to support efforts to ensure compliance. NMFS and the international conservation community are actively working with ICCAT to adopt mandatory measures to minimize loggerhead bycatch in swordfish and tuna fisheries operating in the Atlantic and Mediterranean.

<u>Longline Fisheries</u>: For a discussion of longline fisheries, refer to the Neritic section.

Efforts to Reduce Marine Debris

The MARPOL Convention (International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978) is the main international convention that addresses prevention of pollution (including oil, chemicals, harmful substances in packaged form, sewage, and garbage) of the marine environment by ships from operational or accidental causes.

I.4. OTHER

Efforts to Increase Public Education and Awareness

Public Turtle Walks - guided, interpretive sea turtle nesting-beach tours guided by state-permitted organizations. The purpose of turtle walks is to provide the public with opportunities to see a nesting loggerhead and to learn about the biology of sea turtles and about threats to their survival. On its website, FFWCC has guidelines for Florida turtle walks [http://myfwc.com/seaturtle/Guidelines/MarineTurtleGuidelines.htm (see Section 7 -- Educational Activities)] and contact information for permitted organizations that conduct turtle walks [http://myfwc.com/seaturtle/Education/2006_Watches_List.htm].

Websites - links to numerous websites with sea turtle information for the general public are listed at seaturtle.org [http://www.seaturtle.org/links].

Sea Grant Teacher Training Program - a teaching exercise to instruct children (K-12) about loggerhead demographics and mortality has been developed and made available at national marine educators training sessions and on the VIMS Sea Grant Website "The Bridge" [http://www.vims.edu/bridge].

Efforts to Improve Communication and Access to Information

CTURTLE - a listserv discussion network for sea turtle biology and conservation managed by the ACCSTR [http://accstr.ufl.edu/cturtle.html].

Marine Turtle Newsletter - a quarterly publication that is distributed free of charge [http://www.seaturtle.org/mtn]. The Marine Turtle Newsletter aims to provide a forum for exchange of information about all aspects of marine turtle biology and conservation, and to alert interested people to particular threats to marine turtles.

International Sea Turtle Society - an organization that convenes annual symposia to promote the exchange of information that advances the global knowledge of sea turtle biology and conservation [http://www.seaturtle.org/ists].

Chelonian Conservation and Biology - an international journal of turtle and tortoise research that publishes papers on the conservation and biology of sea turtles [http://www.chelonian.org/ccb].

Seaturtle.org - a website that provides a wealth of sea turtle information, including links to numerous additional websites with sea turtle information [http://www.seaturtle.org/links].

Sea Turtle Online Bibliography - a website managed by the ACCSTR that includes references on all aspects of sea turtle biology, conservation, and management [http://accstr.ufl.edu/biblio.html]. Citations are from recognized bibliographic sources as well as "grey literature."

Bibliography of the Loggerhead Sea Turtle - a bibliography developed and maintained by C. Kenneth Dodd, Jr. [http://www.flmnh.ufl.edu/natsci/herpetology/caretta/Caretta.htm].

Online Publications - full-text documents, including the Proceedings from the Annual Symposia on Sea Turtle Biology and Conservation, are available on the NMFS Office of Protected Resources website [http://www.nmfs.noaa.gov/pr/species/turtles/publications.htm].

Efforts to Address Research and Management Needs

Significant advances in our understanding of loggerhead biology and ecology have occurred since the publication of the 1993 recovery plan for Atlantic loggerheads. These advances have greatly improved conservation and management strategies. Advances in our knowledge span topics including anatomy and physiology, age to maturity and survival, incubation environment and egg development, temperature-dependent sex determination, sex ratios, nest site selection and nesting activity/patterns, hatchling emergence and orientation, reproductive strategies, population structure, foraging ecology and habitat use, movement, and principal threats. Advances in these various fields are detailed in other sources (e.g., Bolten and Witherington 2003, Lutz and Musick 1997, Lutz *et al*. 2003).

Efforts to Address International Needs

International Agreements: Several international agreements have been developed that provide legal protection for sea turtles. The following are the main instruments, and Hykle (2002) has reviewed their advantages and disadvantages.

- Convention on Biological Diversity (190 Parties; in force since 1993) - an international treaty that focuses on "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources . . ."

- Convention on the Conservation of European Wildlife and Natural Habitats (45 European and African States and the European Union; in force since 1982; also known as the Bern Convention) - designed "to conserve wild flora and fauna and their natural habitats, especially those species and habitats whose conservation requires the cooperation of several States, and to promote such co-operation."

- Convention on the Conservation of Migratory Species of Wild Animals (101 member states as of January 2007; also known as the Bonn Convention) - an international treaty that focuses on the conservation of migratory species and their habitats.

- Convention on International Trade in Endangered Species of Wild Fauna and Flora (169 Parties; in force since 1975) - designed to regulate international trade in a wide range of wild animals and plants.

- Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (21 Parties; in force since 1986; also known as the Cartagena Convention) with its Protocol Concerning Specially Protected Areas and Wildlife (SPAW) (12 Parties; in force since 2000) - designed to encourage Parties "to take all appropriate measures to protect and preserve rare or fragile ecosystems, as well as the habitat of depleted, threatened or endangered species, in the Convention area." The SPAW Protocol provides specifically for protection of marine turtles.

- Inter-American Convention for the Protection and Conservation of Sea Turtles (11 Parties; in force since 2001) - an independent, regional treaty that focuses on the protection of marine turtles and their habitats. The treaty is open to all nations in North, Central, and South America, and the Caribbean.

- Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (in force since 1999, under the Barcelona Convention for the Protection of the Mediterranean Sea against Pollution) - has general provisions to protect the Mediterranean marine environment, including sea turtles and their habitats.

Technology Transfer: The U.S. has undertaken significant efforts to transfer sea turtle bycatch reduction technologies to foreign nations using similar gear and fishing in areas where sea turtles are present. Most notable is the TED technology transfer program, administered by NMFS. Workshops and hands-on training onboard commercial vessels have been conducted throughout the world where shrimp fishing occurs. More recently, efforts have also focused on reducing bycatch and mortality of loggerheads in global longline fisheries. These efforts include information dissemination and training on the use of circle hooks, release protocols, and dehookers.

Capacity Building: Federal and state biologists, as well as biologists from academia, the private sector, and the conservation community, have undertaken efforts to build management, research, and enforcement capacity in other nations within the range of the Atlantic loggerhead. Workshops and manuals on topics such as operating stranding and salvage networks, conducting necropsies, establishing nesting beach surveys, and conducting enforcement operations have been developed and conducted in the region. These opportunities provide excellent venues for galvanizing support and capacity for conservation actions both within and outside foreign governments.

Improved Communication: Improved communication is critical for addressing international conservation and management needs. See above [section I.4 "Other" subsection "Efforts to Improve Communication and Access to Information"] for descriptions of currently available resources for improved international communication.

PART II. RECOVERY STRATEGY

This Recovery Strategy section presents and justifies the recommended recovery program for the Northwest Atlantic population of the loggerhead based on the information presented in the Background section. This section provides a concise summary of the species' status and the recommended recovery approach.

A. OVERVIEW

Loggerheads have a complex life history that spans terrestrial, neritic, and oceanic habitats (see Part I). In addition, loggerheads have slow growth rates and are long lived with late sexual maturity – traits requiring high annual juvenile survival. These life history complexities, both geographic and demographic, provide both constraints and opportunities for recovery that necessitate a diverse and comprehensive recovery strategy.

The life history and basic biology of the loggerhead were reviewed in Part I. As pointed out in a number of sections, there are several significant data deficiencies with respect to our knowledge of loggerhead basic biology, demography, distributions, and movements. To comprehensively conserve and recover loggerhead turtles in the Atlantic, these data gaps need to be addressed.

From the beginning of standardized surveys in 1989 until 1998, the Peninsular Florida Recovery Unit, the largest nesting assemblage in the Atlantic by an order of magnitude, had a significant increase in the number of nests. However, since 1998 there has been a decrease of 39.9% in annual nest counts (Witherington *et al*. in review). This dramatic change in status for the Peninsular Florida Recovery Unit is a serious concern and requires immediate attention to determine the cause(s) for this change in population trajectory and the actions needed to reverse it. The Northern Recovery Unit has been declining since standardized surveys were implemented in 1983. The Northern Gulf Recovery Unit has shown a significant declining trend of 6.8% annually since index nesting beach surveys were initiated in 1997. No statistical trends in nesting abundance can be determined for the Dry Tortugas Recovery Unit because of the lack of long-term data. Similarly, no statistical trends in abundance can be determined for the Greater Caribbean Recovery Unit because of the lack of long-term standardized surveys on loggerhead nesting beaches representative of the region, changing survey effort at monitored beaches, and scattered and low-level nesting by loggerheads at many locations.

A quantitative analysis of threats to Atlantic loggerhead populations is presented in Appendix 1. Bycatch in commercial fisheries (particularly longline, bottom trawl, and gillnet fisheries) is the most significant anthropogenic threat to the conservation of Atlantic loggerhead populations. A comprehensive set of recovery actions has been developed to address the problem of bycatch. Other significant threats to Atlantic loggerhead populations include light pollution on nesting beaches; coastal development, which leads to coastal armoring and other erosion control measures that impact nesting habitat; and nest predation. Recovery actions that address these threats are identified later in this section.

In Part II of the Recovery Plan, we present the geographic and genetic basis for designating recovery units for the Northwest Atlantic loggerhead population. Recovery goals and objectives are discussed and demographic and threats-based recovery criteria are identified. In Part III, we present an implementation schedule for recovery.

B. RECOVERY UNITS

Recovery units are subunits of the listed species that are geographically or otherwise identifiable and essential to the recovery of the species. Recovery units are individually necessary to conserve genetic robustness, demographic robustness, important life history stages, or some other feature necessary for long-term sustainability of the species. Establishing recovery units is a useful management tool for species occurring across wide ranges with multiple populations, varying ecological pressures, or different threats in different parts of their range. Recovery units are primarily delineated on a biological basis; however, boundaries may be modified to reflect differing management regimes. Recovery units are not necessarily self-sustaining viable units on their own, but instead need to be collectively recovered to ensure recovery of the entire listed entity.

The loggerhead sea turtle is listed worldwide at the species level. Therefore, the full species is the listed entity. However, in this recovery plan, we have identified recovery units for the Northwest Atlantic loggerhead population. At this time, the Northwest Atlantic loggerhead population is only a "potential" distinct population segment (DPS) and cannot be considered for delisting separately from the listed entity (i.e., the entire species) until it meets both the recovery criteria for each recovery unit and has completed a formal DPS evaluation and designation, which would involve a proposed rulemaking, public review and comment, and a final rulemaking. (In 1996, FWS and NMFS published a joint policy defining the phrase “distinct population segment” (FWS and NMFS 1996, 61 FR 4722). Three elements are considered in a decision regarding the listing, delisting, or reclassification of a DPS as endangered or threatened under the ESA: discreteness of the population segment in relation to the remainder of the species, significance of the population segment to the species, and conservation status.) In early 2008, NMFS established a Loggerhead Biological Review Team to assess the loggerhead population structure globally to determine whether DPSs exist and, if so, to assess the status of each DPS. The Loggerhead Biological Review Team will review and synthesize information, render expert opinion, and prepare a written report (status review) by mid-2008. With this in mind, we have identified recovery units for the Northwest Atlantic loggerhead population as follows.

Five nesting subpopulations of loggerheads in the Northwest Atlantic have been previously identified based on mtDNA haplotype frequencies (Encalada *et al*. 1998, Pearce 2001). However, recent increases in sample sizes and more complete sampling of rookeries along the Atlantic coast of Florida (i.e., Canaveral National Seashore (n=263), Archie Carr NWR (n=351), Juno Beach beaches (n=97), and Broward County beaches (n=48)) now suggest that there is continuous spatial variation for each of the two primary haplotypes (Figure 9; ACCSTR, unpublished data). Analyses using these new data indicate that there is no genetic difference between loggerheads nesting on adjacent beaches along the Florida Peninsula (north to south: Volusia County beaches, Canaveral National Seashore, Archie Carr NWR, Juno Beach beaches, Broward County beaches, and Dry Tortugas). This lack of genetic structure makes it difficult to designate specific boundaries for the subpopulations based on genetic differences alone. Therefore, we used a combination of geographic distribution of nesting densities, geographic separation, and geopolitical boundaries, in addition to genetic differences, to reassess the designation of subpopulations within the U.S. to identify recovery units for use in this recovery plan.

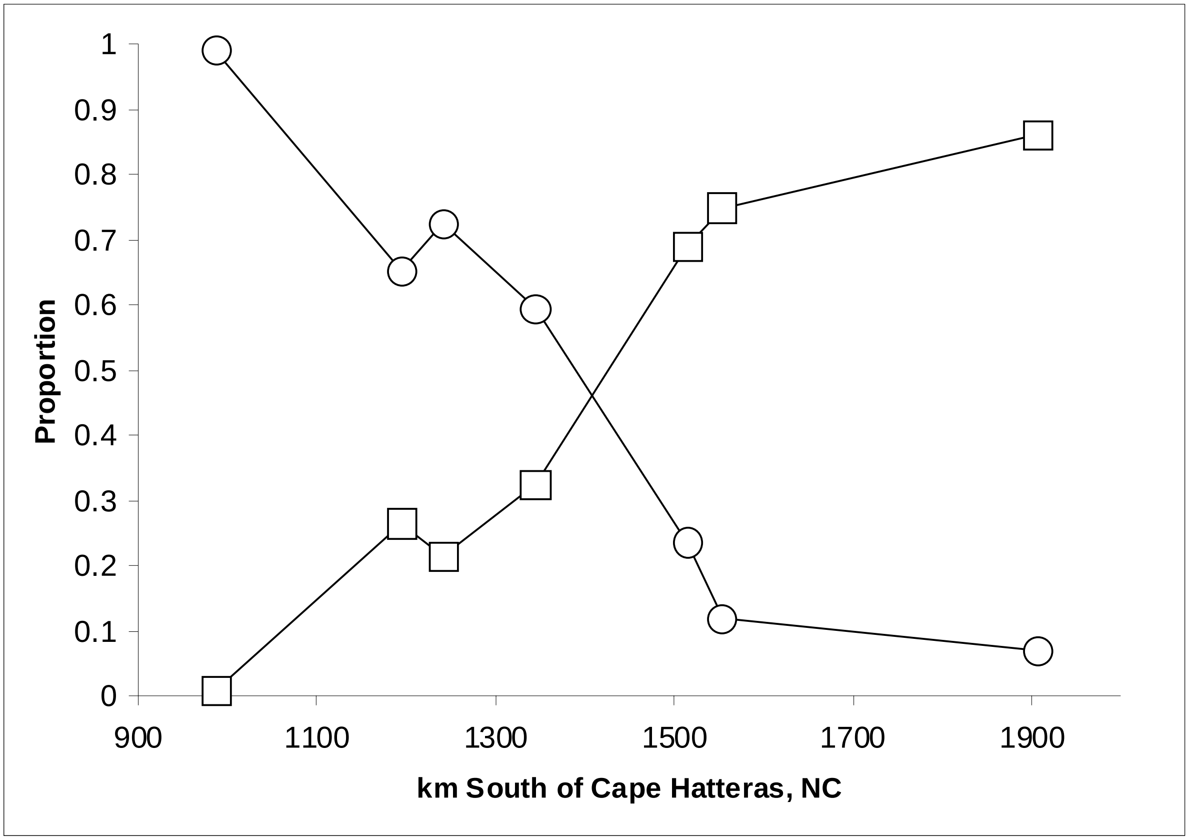

Figure 9. The frequency of haplotypes CC-A1 (open circles) and CC-A2 (open squares) are plotted for each of the seven nesting locations (north to south: NRU, Volusia County beaches, Canaveral National Seashore, Archie Carr NWR, Juno Beach beaches, Broward County beaches, and Dry Tortugas). Haplotypes CC-A1 and CC-A2 are the most frequent haplotypes, and combined vary from 88 to 100% for each nesting beach (ACCSTR, unpublished data).

Our reassessment involved examining loggerhead nesting densities along the U.S. Atlantic and Gulf coasts to define peaks and gaps in nesting. We qualitatively identified five nesting peaks based on both nesting density and geographic separation (Figure 10). The five nesting peaks are: 1) Cape Romain, South Carolina; 2) southeast Florida (Brevard County through Palm Beach County); 3) Dry Tortugas, Florida; 4) Sarasota County, Florida; and 5) St. Joseph Peninsula (Gulf County), Florida. In addition to being geographically separated, nesting females from each of these five areas are genetically distinct based on mtDNA haplotype frequencies (when the neighboring nesting beaches from Brevard County through Palm Beach County are combined), with the exception of females nesting at southeast Florida, which are indistinguishable from those at Sarasota County (southwest Florida) (Encalada *et al*. 1998; Pearce 2001; ACCSTR, unpublished data). Therefore, we designated four recovery units within the U.S. loggerhead nesting range based on a combination of geographic distribution of nesting densities and geographic separation in addition to genetic differences. The boundaries of these four recovery units were delineated based on geographic isolation and geopolitical boundaries (Figure 11).

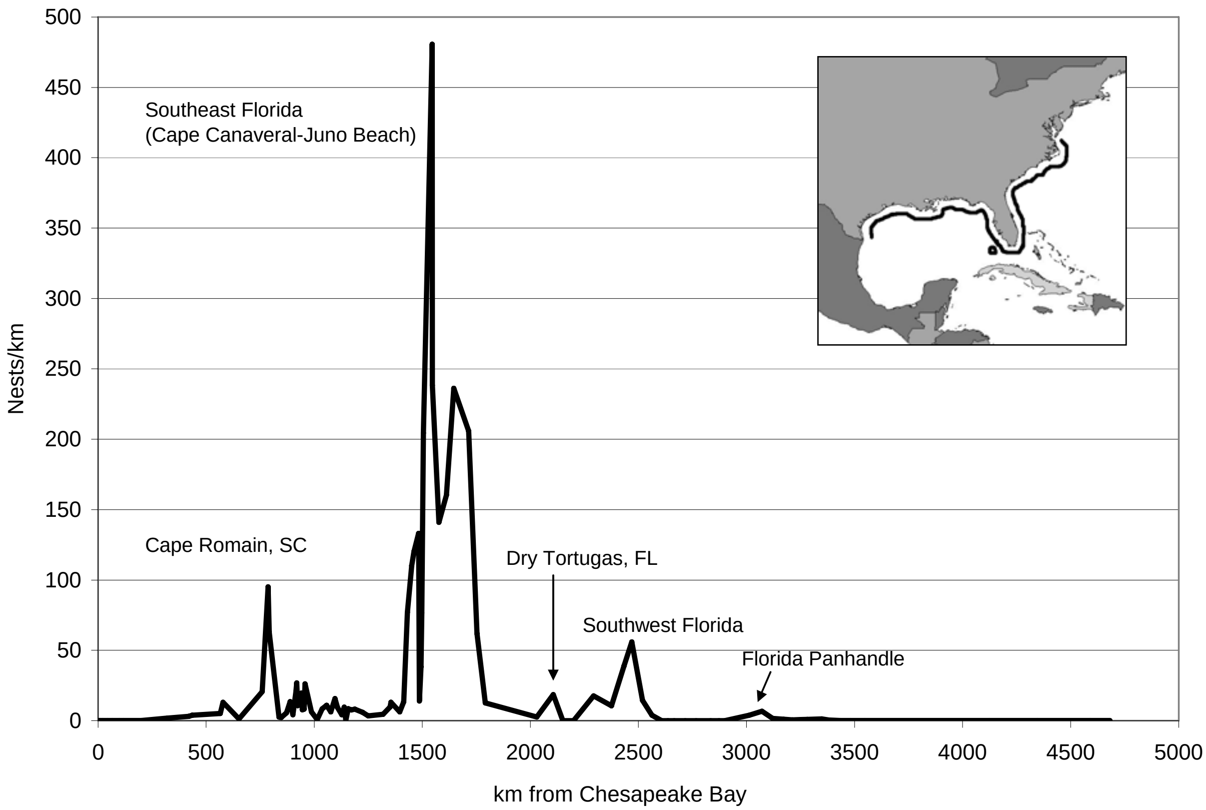

Figure 10. Mean loggerhead nesting densities from southern Virginia to the U.S.-Mexico border (1999-2003).

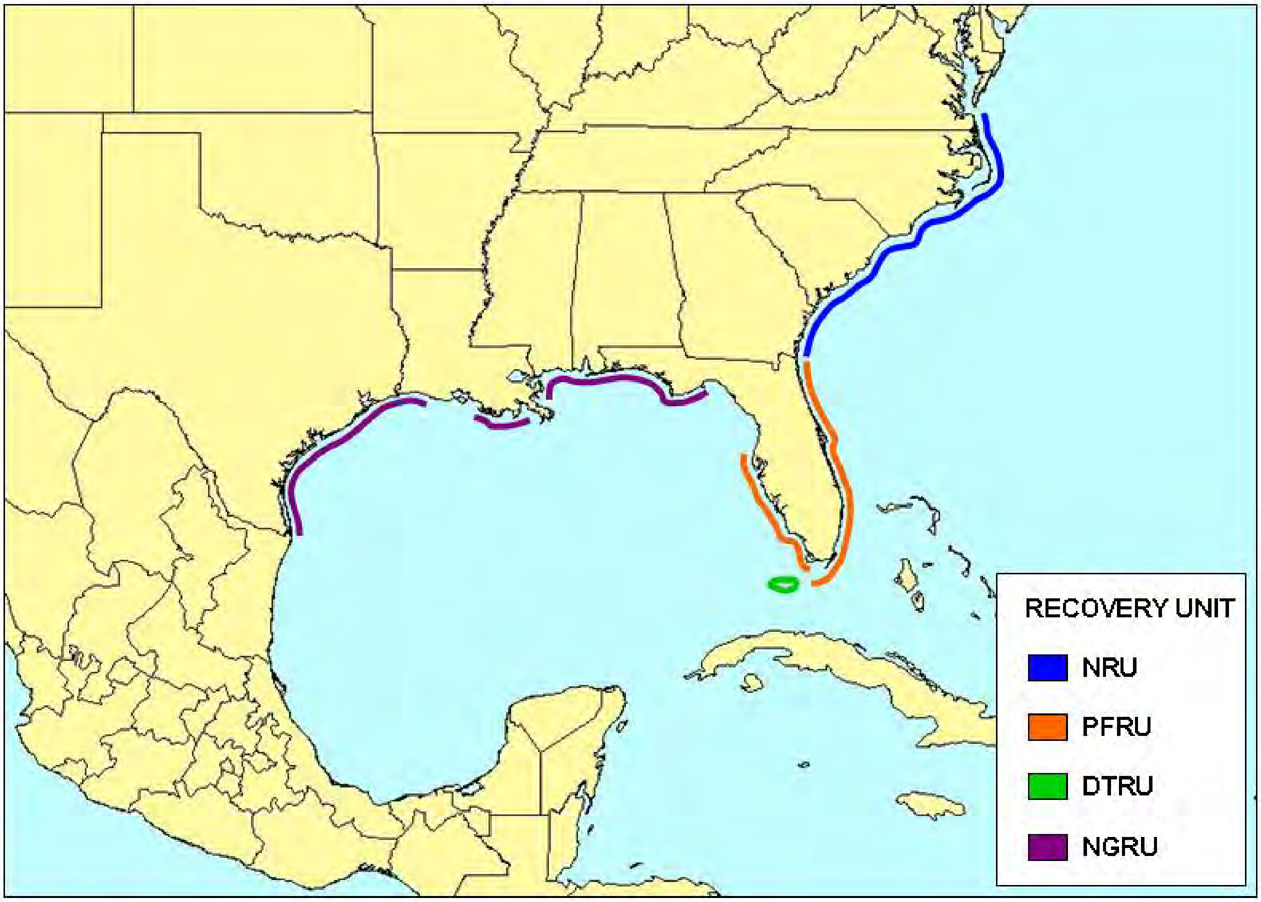

Figure 11. Location of the four identified recovery units in the U.S. (NRU = Northern Recovery Unit, PFRU = Peninsular Florida Recovery Unit, DTRU = Dry Tortugas Recovery Unit, NGRU = Northern Gulf Recovery Unit).

The first four recovery units represent nesting assemblages in the southeast U.S. The fifth recovery unit is a combination of all other nesting assemblages of turtles that nest outside the U.S., but occur within U.S. waters during some portion of their lives.

<u>Northern Recovery Unit</u>: The Northern Recovery Unit is defined as loggerheads originating from nesting beaches from the Florida-Georgia border through southern Virginia (the northern extent of the nesting range). Because we could not precisely define the southern boundary based on genetics, we selected the Florida-Georgia border as the southern boundary of this recovery unit.

<u>Peninsular Florida Recovery Unit</u>: The Peninsular Florida Recovery Unit is defined as loggerheads originating from nesting beaches from the Florida-Georgia border through Pinellas County on the west coast of Florida, excluding the islands west of Key West, Florida. Pinellas County, Florida, was selected as the northern Gulf coast boundary of this recovery unit because the Big Bend area between Pinellas and Franklin Counties is largely composed of salt marsh that separates this recovery unit from the Northern Gulf Recovery Unit.

Northern Gulf Recovery Unit: The Northern Gulf Recovery Unit is defined as loggerheads originating from nesting beaches from Franklin County on the northwest Gulf coast of Florida through Texas (the western extent of U.S. nesting range). Franklin County, Florida, was selected as the eastern boundary of this recovery unit because the Big Bend area between Franklin and Pinellas Counties is largely composed of salt marsh that separates this recovery unit from the Peninsular Florida Recovery Unit. The Texas-Mexico border was chosen as the western boundary of this recovery unit.

Dry Tortugas Recovery Unit: The Dry Tortugas Recovery Unit is defined as loggerheads originating from nesting beaches throughout the islands located west of Key West, Florida, because these islands are geographically separated from other recovery units.

Greater Caribbean Recovery Unit: The Greater Caribbean Recovery Unit is composed of loggerheads originating from all other nesting assemblages within the Greater Caribbean (Mexico through Venezuela, The Bahamas, Lesser Antilles, and Greater Antilles).

C. RECOVERY GOAL

The goal of this revised recovery plan is to ensure that each recovery unit meets its Recovery Criteria alleviating threats to the species so that protections under the ESA are no longer necessary and so that the Northwest Atlantic population of the loggerhead sea turtle can be removed from the List of Endangered and Threatened Wildlife.

D. RECOVERY OBJECTIVES

The Recovery Goal can be subdivided into discrete component objectives that, collectively, describe the conditions necessary for achieving the Recovery Goal. It is appropriate to identify Recovery Objectives in terms of demographic parameters, reduction or elimination of threats to the species (the five listing factors), and any other particular vulnerability or biological needs inherent to the species. The objectives of this recovery plan are to:

1. Ensure the number of nests in each recovery unit is increasing and this increase corresponds to an increase in the number of nesting females.
2. Ensure the in-water abundance of juveniles in both neritic and oceanic habitats is increasing and is increasing at a greater rate than strandings of similar age classes.
3. Manage sufficient nesting beach habitat to ensure successful nesting.
4. Manage sufficient feeding, migratory, and internesting marine habitats to ensure successful growth and reproduction.
5. Minimize legal harvest.
6. Implement scientifically based nest management plans.
7. Minimize nest predation.
8. Recognize and respond to mass/unusual mortality or disease events appropriately.
9. Develop and implement local, state, Federal, and international legislation to ensure long-term protection of loggerheads and their terrestrial and marine habitats.
10. Minimize bycatch in domestic and international commercial and artisanal fisheries.
11. Minimize trophic changes from fishery harvest and habitat alteration.

12. Minimize marine debris ingestion and entanglement.
13. Minimize boat strike mortality.

E. RECOVERY CRITERIA

Section 4(f) of the ESA directs the Secretaries of the Department of the Interior and the Department of Commerce to develop and implement recovery plans. These plans must contain, to the maximum extent practicable, objective, measurable Recovery Criteria which, when met, would result in a determination that the species be removed from the List of Endangered and Threatened Wildlife. Recovery Criteria can be viewed as targets, or values, by which progress toward achievement of Recovery Objectives can be measured. Recovery Criteria may include such things as population numbers and sizes, management or elimination of threats by specific mechanisms, and specific habitat conditions. As a result, there is a need to frame Recovery Criteria in terms of both population parameters (Demographic Recovery Criteria, Section E.1.) and the five listing factors (Listing Factor Recovery Criteria, Section E.2.). The nesting beach Demographic Recovery Criteria (E.1.1) are specific to recovery units. The remaining Criteria cannot be delineated by recovery unit because individuals in the recovery units mix in the marine environment; therefore, these Criteria are applicable to all recovery units.

E.1. DEMOGRAPHIC RECOVERY CRITERIA

The Demographic Criteria evaluate trends and numbers of nests and nesting females, trends in abundance on foraging grounds, and trends in strandings. In developing the Demographic Criteria for nests and nesting females, pre-listing nesting population data were not used as a baseline either because they were not available or because uncertainties existed with data collection methodologies. However, post-listing nesting population data, which were available and sufficient to establish a baseline, were used to establish Demographic Criteria. The Demographic Criteria for nests and nesting females were based on a time frame of one generation -- defined as 50 years. One generation is estimated as age to maturity (34 years) plus one half of reproductive life span (12.5 years based on Little Cumberland Island, Georgia, tag return data showing 25-year returns) (Dahlen *et al*. 2000). The resulting value (46.5 years) was rounded to 50 years to account for imprecision in the age to maturity estimate and a likely underestimate of reproductive lifespan (from tag loss and anthropogenic mortality). To be considered for delisting, each recovery unit will have recovered to a viable level (based on population viability analyses or similar type analyses) and each recovery unit will have increased for at least one generation. The rate of increase used for each recovery unit was dependent upon the level of vulnerability of each recovery unit. The minimum statistical level of detection (based on annual variability in nest counts over a generation time of 50 years) of 1% per year was used for the least vulnerable recovery unit (Peninsular Florida). A higher rate of increase of 3% per year[1] was used for the most vulnerable recovery units (Dry Tortugas and Northern Gulf). A rate of increase of 2% per year was used for a moderately vulnerable recovery unit (Northern).

Sufficient data do not exist to develop detailed, stochastic life-history models for Northwest Atlantic loggerheads. Therefore, the Demographic Criteria for nests and nesting females were assessed using diffusion approximation analysis (Holmes 2001, 2004). This method was used because it can be applied to the sort of nesting counts that are available for sea turtle populations.

This approach allowed quantitative population viability analysis based on a time series of nest counts to estimate the probability of crossing extinction thresholds. This method was used to examine the population viability of the Northern and Peninsular Florida Recovery Units. This method was not applied to the Dry Tortugas and Northern Gulf Recovery Units due to a limited time series of nest counts for both of these recovery units.

A fundamental problem with restricting population trend analyses to nesting beach surveys is that they are unlikely to reflect changes in the entire population. This is because of the long time lag to maturity and the relatively small proportion of females that are reproducing for the first time on a nesting beach, at least in populations with high adult survival rates. A decrease in oceanic juvenile or neritic juvenile survival rates may be masked by the natural variability in nesting female numbers and the slow response of adult abundance to changes in recruitment to the adult population (Chaloupka and Limpus 2001). In light of this, two additional Demographic Criteria were developed to ensure a more representative measure of population status was achieved. The first of these additional Demographic Criteria assesses trends in abundance on foraging grounds, and the other assesses age-specific trends in strandings relative to age-specific trends in abundance on foraging grounds. These latter two demographic criteria are not specific to recovery units because progeny from the various recovery units mix on the foraging grounds. As a result, in-water trends were not developed for the individual recovery units.

1. Number of Nests and Number of Nesting Females

a. Northern Recovery Unit (a 2% annual rate of increase was used to develop the Demographic Criteria because this recovery unit is between 1,000 and 10,000 nests per year, currently declining, and moderately vulnerable to extinction from stochastic events)

(1) There is statistical confidence (95%) that the annual rate of increase over a generation time of 50 years is 2% or greater and the total annual number of nests has increased to 14,012 or greater for this recovery unit (approximate distribution of nests is NC=14% [1,963], SC=65% [9,141], and GA=21% [2,908])[2].

(2) This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

b. Peninsular Florida Recovery Unit (a 1% minimal detectable annual rate of increase was used to develop the demographic criteria because this recovery unit is greater than 10,000 nests per year and determined least vulnerable to extinction from stochastic events)

(1) There is statistical confidence (95%) that the annual rate of increase over a generation time of 50 years is statistically detectable (1%) and the total annual number of nests has increased to 107,940 or greater for this recovery unit[3].

(2) This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

c. Dry Tortugas Recovery Unit (a 3% annual rate of increase was used to develop the demographic criteria because this recovery unit is less than 1,000 nests per year and highly vulnerable to extinction from stochastic events)

(1) There is statistical confidence (95%) that the annual rate of increase over a generation time of 50 years is 3% or greater and the total annual number of nests has increased to 1,074 or greater for this recovery unit[4].

(2) This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

d. Northern Gulf Recovery Unit (a 3% annual rate of increase was used to develop the demographic criteria because this recovery unit is less than 1,000 nests per year and highly vulnerable to extinction from stochastic events)

(1) There is statistical confidence (95%) that the annual rate of increase over a generation time of 50 years is 3% or greater and the total annual number of nests has increased to 3,988 or greater for this recovery unit (approximate distribution of nests (2002-2006) is FL= 93% [3,778] and AL=7% [260])[5].

(2) This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

e. Greater Caribbean Recovery Unit

(1) The total annual number of nests at a minimum of three nesting assemblages, each averaging greater than 100 nests annually (e.g., Yucatan, Mexico; Cay Sal Bank, Bahamas), are increasing over a generation time of 50 years.

2. Trends in Abundance on Foraging Grounds

A network of in-water sites, both oceanic and neritic, distributed across the foraging range is established and monitoring is implemented to measure abundance. There is statistical confidence (95%) that a composite estimate of relative abundance from these sites is increasing for at least one generation.

3. Trends in Strandings Relative to In-water Abundance

Stranding trends are not increasing at a rate greater than the trends in in-water relative abundance for similar age classes for at least one generation.

Footnotes to Explain Methods Used to Determine Demographic Criteria:

[1] A statistically significant rate of annual increase was 3% at a composite of Florida beaches (Hutchinson Island, MacArthur Beach State Park, and South Brevard) for which a minimum of 21 years (1985-2005) of standardized data were available (FFWCC, unpublished data).

[2] Power analysis indicates that 2% exceeds the minimum detectable annual increase (see Table 4(b), 1983-2006; CV=0.28), alpha=0.05, beta=0.10, duration in years=50, two-tailed significance test, exponential rate of change (TRENDS software per Gerrodette 1993). The target of 14,012 nests per year is based on a 2% annual increase over 50 years from a baseline of 5,206 nests per year (1990-2006 average total nests per year for the NRU). Diffusion approximation analysis indicates that this rate of increase and resulting number of nests would result in the NRU having a less than 1% chance of extinction over 100 years. The recovery criterion rate of increase shall be calculated based on annual nest counts from nesting beaches that meet standardized daily survey criteria, see Table 4.

[3] Power analysis indicates that the minimum detectable annual increase is approximately 1% (see Table 5(b), 1989-2006; CV=0.20), alpha=0.05, beta=0.10, duration in years=50, two-tailed significance test, exponential rate of change (TRENDS software per Gerrodette 1993). The target of 107,940 nests per year is based on a 1% annual increase over 50 years from a baseline of 65,631 nests per year (1989-2006 average total nests per year for the PFRU). Diffusion approximation analysis indicates that this rate of increase and resulting number of nests would result in the PFRU having a less than 1% chance of extinction over 100 years. The recovery criterion rate of increase shall be calculated based on standardized annual nest counts from index nesting beaches, see Table 5.

[4] For recovery units that do not exceed 1,000 nests annually, the maximum possible rate of increase (3%, see Footnote 2) observed on a composite of Florida beaches was adopted to minimize the risk of extinction due to stochastic events. Power analysis indicates that 3% exceeds the minimum detectable annual increase (see Table 6(b), 1995-2004; CV=0.21), alpha=0.05, beta=0.10, duration in years=50, two-tailed significance test, exponential rate of change (TRENDS software per Gerrodette 1993). The average number of nests per year for 1995-2004 is 246 and a 3% annual increase results in a total of 1,074 nests for this recovery unit. The recovery criterion rate of increase is to be calculated based on annual nest counts from index nesting beaches, see Table 6. Diffusion approximation analysis was not calculated due to a limited data series.

[5] For recovery units that do not exceed 1,000 nests annually, the maximum possible rate of increase (3%, see Footnote 2) observed on a composite of Florida beaches was adopted to minimize the risk of extinction due to stochastic events. Power analysis indicates that 3% exceeds the minimum detectable annual increase (see Table 7(b), 1997-2006; CV=0.28), alpha=0.05, beta=0.10, duration in years=50, two-tailed significance test, exponential rate of change (TRENDS software per Gerrodette 1993). The average number of nests per year for 1995-2006 is 910 and a 3% annual increase results in a total of 3,988 nests for this recovery unit. The recovery criterion rate of increase is to be calculated based on annual nest counts from index nesting beaches, see Table 7. Diffusion approximation analysis was not calculated due to a limited data series.

Table 4. Summary of data used to calculate Northern Recovery Unit nest trends and the minimum detectable trend for recovery criteria.

(a) Beaches used in the analysis. Standardized daily surveys were conducted on all beaches from 1983 to 2006.

Beach	State	Survey Length (km)
Hammocks Beach SP	NC	6.4
Onslow Beach	NC	11.3
Bald Head Island	NC	14.5
Cape Island	SC	13.0
Edisto Beach SP	SC	2.3
Edisto Beach	SC	7.6
Fripp Island	SC	4.8
Pritchard's Island	SC	4.0
Wassaw Island	GA	10.7
Blackbeard Island	GA	11.0
Little Cumberland Island	GA	4.7

(b) Loggerhead annual nest totals from selected beaches (see Table 4(a)) used to calculate a coefficient of variation (CV) for the power analysis.

Year	Loggerhead Nests
1983	1,509
1984	2,247
1985	1,778
1986	2,430
1987	1,380
1988	1,729
1989	1,421
1990	2,466
1991	2,127
1992	1,844
1993	931
1994	2,207
1995	1,484
1996	1,969
1997	1,100
1998	1,812
1999	2,173
2000	1,475
2001	1,242
2002	1,543
2003	1,998
2004	549
2005	1,766
2006	1,745

(c) Loggerhead annual nest totals for all surveyed beaches used to determine the baseline annual number of nests. Statewide nest estimates are not available for all years in South Carolina. The years used are those for which statewide aerial surveys were conducted in South Carolina.

Statewide Loggerhead Nest Totals

Year*	**North Carolina**	**Georgia**	**South Carolina**	**Northern Recovery Unit Nest Total**
1990	806	1,091	4,155	6,052
1991	931	1,213	3,542	5,686
1992	729	1,057	3,944	5,730
1995	662	1,036	2,905	4,603
1996	776	1,116	3,807	5,699
1997	568	816	2,238	3,622
2000	757	1,073	3,387	5,217
2001	659	851	2,808	4,318
2002	694	1,034	2,660	4,388
2005	647	1,200	4,233	6,080
2006	794	1,396	3,679	5,869
	8,023	11,883	37,358	Average=5,206

* Complete surveys were available for a limited sample of years.

Table 5. Summary of data used to calculate Peninsular Florida Recovery Unit nest trends and the minimum detectable trend for recovery criteria.

(a) Core index nesting beaches within the Peninsular Florida Recovery Unit. Surveys on these beaches have been established to have consistent and uniform effort among years, have been monitored since 1989, and are suitable for the assessment of temporal trends in nesting.

Beach	County	Survey Length (km)	Notes
Fort Clinch SP	Nassau	3.68	
Amelia Island	Nassau	20.80	
Little Talbot Island SP	Duval	8.00	
Atlantic-Jax Beach	Duval	12.80	
Guana River SP	St. Johns	6.72	
Ft. Matanzas NM	St. Johns	7.68	
Canaveral NS	Volusia/Brevard	38.00	
Merritt Island NWR	Brevard	9.92	
Canaveral AF Station	Brevard	21.00	
Patrick AF Base	Brevard	7.04	
South Brevard County	Brevard	40.50	
Sebastian Inlet SRA	Brevard/Indian River	4.80	
Wabasso Beach	Indian River	8.00	
Ft. Pierce Inlet SRA	St. Lucie	9.60	
Hutchinson Island	St. Lucie/Martin	36.90	
St. Lucie Inlet SP	Martin	4.30	
Hobe Sound NWR	Martin	5.60	
Jupiter Island	Martin	12.00	
Juno Beach	Palm Beach	8.40	excludes zones J&K (10&11)
Boca Raton	Palm Beach	8.00	
J.D. MacArthur SP	Palm Beach	2.88	
John U. Lloyd SRA	Broward	3.36	excludes zone E (5)
Miami Beaches	Dade	20.00	
Sanibel Island	Lee	5.60	
Wiggins Pass SRA	Collier	6.40	
Keewaydin Island	Collier	6.88	

(b) Loggerhead annual nest totals from selected beaches (=core index nesting beaches, see Table 5(a)) used to calculate a coefficient of variation for the power analysis.

Year	Loggerhead Nests
1989	39,083
1990	50,266
1991	52,802
1992	47,567
1993	41,808
1994	51,168
1995	57,843
1996	52,811
1997	43,156
1998	59,918
1999	56,471
2000	56,277
2001	45,941
2002	38,101
2003	40,726
2004	29,547
2005	34,310
2006	31,329

(c) Loggerhead annual nest totals for all surveyed beaches used to determine the baseline annual number of nests. Survey effort was not constant among years.

Year	Loggerhead Nests
1989	49,309
1990	66,511
1991	68,327
1992	64,623
1993	55,261
1994	70,887
1995	79,546
1996	75,528
1997	63,914
1998	84,552
1999	79,468
2000	83,027
2001	68,587
2002	62,188
2003	62,406
2004	46,262
2005	51,833
2006	49,137

Table 6. Summary of data used to calculate the Dry Tortugas Recovery Unit nest trends and the minimum detectable trend for recovery criteria.

(a) Beaches used in the analysis. Surveys on these beaches have consistent and uniform effort among years, have been monitored since 1995, and are suitable for the assessment of temporal trends in nesting. Beach length is reported for 2004 (the latest year during which all islands were surveyed).

Beach	County	Survey Length (km)
East Key	Monroe	0.6
Loggerhead Key	Monroe	2.4
Miscellaneous Keys	Monroe	3.2

(b) Loggerhead annual nest totals from selected beaches (see Table 6(a)) used to calculate a coefficient of variation for the power analysis and to determine the baseline annual number of nests. Survey effort was not constant among years.

Year	Loggerhead Nests
1995	340
1996	249
1997	258
1998	249
1999	292
2000	242
2001	213
2002	*
2003	208
2004	159
2005	*

* Incomplete surveys were conducted during these years; therefore, an annual nest total could not be calculated.

Table 7. Summary of data used to calculate the Northern Gulf Recovery Unit nest trends and the minimum detectable trend for recovery criteria.

(a) Beaches used in the analysis. Surveys on these beaches have consistent and uniform effort between years, have been monitored since 1997, and are suitable for the assessment of temporal trends in nesting.

Beach	County	Survey Length (km)
Santa Rosa Island	Walton	19.3
Panama City	Bay	28.2
St. Joseph Peninsula SP	Gulf	14.5

(b) Loggerhead annual nest totals from selected beaches (see Table 7(a)) used to calculate a coefficient of variation for the power analysis.

Year	Loggerhead Nests
1997	166
1998	149
1999	235
2000	181
2001	143
2002	149
2003	95
2004	114
2005	120
2006	111

(c) Loggerhead annual nest totals for all surveyed beaches used to determine the baseline annual number of nests. Survey effort was not constant among years.

Year	Loggerhead Nests
1989	113 *
1990	174 *
1991	287 *
1992	351 *
1993	565 *
1994	772 *
1995	928
1996	891
1997	1,133
1998	1,187
1999	1,285
2000	1,118
2001	857
2002	754 **
2003	894 **
2004	805 **
2005	657 **
2006	668 **

* Only partial surveys were conducted during these years.

** Years with nest counts made for Alabama beaches. All other years are represented by Florida only.

E.2. LISTING FACTOR RECOVERY CRITERIA

1. <u>Present or Threatened Destruction, Modification, or Curtailment of a Species Habitat or Range</u>

a. Terrestrial

(1) Beach armoring, shoreline stabilization structures, and all other barriers to nesting are categorized and inventoried for areas under U.S. jurisdiction. A peer-reviewed strategy is developed and implemented to ensure that the percentage of nesting beach free of barriers to nesting is stable or increasing relative to baseline levels.

(2) Beach sand placement projects conducted in areas under U.S. jurisdiction are in compliance with state and FWS criteria and are conducted in a manner that accommodates loggerhead needs and does not degrade or eliminate nesting habitat.

(3) At least 1,581 km of loggerhead nesting beaches and adjacent uplands (current amount as identified in Appendix 4) under U.S. jurisdiction are maintained within conservation lands in public (Federal, state, or local) or private (NGO and private conservation lands) ownership that are managed in a manner compatible with sea turtle nesting.

(4) A peer-reviewed model is developed that describes the effects of sea level rise on the nesting range of loggerheads, and steps have been taken to mitigate such effects.

(5) Nesting beaches outside U.S. jurisdiction are managed for compatibility with loggerhead nesting.

b. Marine (estuarine, neritic, and oceanic)

A peer-reviewed, comprehensive strategy is developed and implemented to identify, prioritize, and protect marine habitats (e.g., feeding, migratory, inter-nesting) important to loggerheads.

2. <u>Overutilization for Commercial, Recreational, Scientific, or Educational Purposes</u>

a. Legal harvest (both commercial and subsistence) in the Caribbean, Atlantic, and Mediterranean is identified and quantified. A strategy is developed and implemented to minimize legal harvest through international agreements.

b. A scientifically based nest management plan outlining strategies for protecting nests (under U.S. jurisdiction) from natural and manmade impacts is developed and implemented.

3. <u>Disease or Predation</u>

a. Ecologically sound predator control programs are implemented to ensure that the annual rate of mammalian predation on nests (under U.S. jurisdiction) is 10% or below within each recovery unit based on standardized surveys[1].

b. A peer-reviewed strategy is developed to recognize, respond to, and investigate mass/unusual mortality or disease events.

4. <u>Inadequacy of Existing Regulatory Mechanisms</u>

a. Light management plans, which meet minimum standards identified in the Model Lighting Ordinance (Witherington and Martin 2000), are developed, fully implemented, and effectively enforced on nesting beaches under U.S. jurisdiction. Annual percentage of total nests with hatchlings disoriented or misoriented by artificial lighting does not exceed 10% based on standardized surveys[2].
b. Specific and comprehensive Federal legislation is developed, promulgated, implemented, and enforced to ensure long-term protection of loggerheads and their terrestrial and marine habitats post-delisting, including protection from fishery interactions.
c. State and local legislation is developed and/or maintained, promulgated, implemented, and enforced to ensure long-term (including post-delisting) protection of loggerheads and their terrestrial and marine habitats, including protection from fishery interactions.
d. Foreign nations with significant loggerhead foraging or migratory habitat have implemented national legislation and have acceded to international and multi-lateral agreements to ensure long-term protection of loggerheads and their habitats. Nations that have important foraging or migratory habitat include Canada, Mexico, Cuba, The Bahamas, Turks and Caicos Islands, Panama, Spain, Portugal, Morocco, and Cape Verde Islands.
e. Nations that conduct activities affecting loggerheads in foraging or migratory habitats in the North Atlantic Basin and the western Mediterranean have implemented national legislation and have acceded to international and multi-lateral agreements to ensure long-term protection of loggerheads and their habitats throughout the high seas and in foreign EEZs.

5. Other Natural or Manmade Factors Affecting Its Continued Existence

a. A peer-reviewed strategy is developed and fully implemented to minimize fishery interactions and mortality for each domestic commercial fishing gear type that has loggerhead bycatch.
b. A peer-reviewed strategy is developed and fully implemented in cooperation with relevant nations to minimize fishery interactions and mortality of loggerheads in foreign EEZs and on the high seas.
c. A peer-reviewed strategy is developed and fully implemented to quantify, monitor, and minimize effects of trophic changes on loggerheads (e.g., diet, growth rate, fecundity) from fishery harvests and habitat alterations.
d. A peer-reviewed strategy is developed and fully implemented to quantify, monitor, and minimize the effects of marine debris ingestion and entanglement in the U.S. EEZ, foreign EEZs, and the high seas.
e. A peer-reviewed strategy is developed and fully implemented to minimize boat strike mortality in the U.S. EEZ.

Footnotes for Listing Factor Criteria:

[1] A 10% rate has been achievable at beaches where predator control efforts have been made and where predation rates were formerly greater than 80% (Merritt Island NWR and Canaveral National Seashore; Witherington, unpublished data).

[2] A 10% rate, excluding outliers, has been measured at developed beaches where light management efforts have been made (Witherington *et al*. 1996).

F. RECOVERY PROGRAM

This section describes the recovery actions necessary to achieve the goal and objectives of the plan and the monitoring necessary to track the status of the species and the effectiveness of recovery actions. This section includes a Recovery Action Outline, which lists the recovery actions without the accompanying descriptions. This section also includes the Recovery Action Narrative, which describes the actions necessary to achieve full recovery of the species.

F.1. RECOVERY ACTION OUTLINE

1. Determine demographic parameters, refine population genetic structure, and monitor distribution, abundance, and trends.
   - 11. Monitor and refine population genetic structure.
     - 111. Refine geographic boundaries of recovery units.
     - 112. Monitor population genetic structure on foraging grounds.
     - 113. Develop new techniques for refining population genetic structure.
   - 12. Monitor nesting abundance and trends by recovery unit.
     - 121. Maintain and/or adopt standardized criteria for on-the-ground nesting surveys.
     - 122. Continue to monitor trends in nesting and non-nesting emergences on index/standardized beaches.
     - 123. Incorporate index/standardized nesting survey protocols on additional beaches to fully represent recovery units.
     - 124. Monitor annual nesting and non-nesting emergences on non-index/non-standardized beaches as extensively as possible.
     - 125. Conduct periodic censuses of recovery units to obtain total nest counts and geographic distribution of nesting.
   - 13. Monitor in-water population abundance and trends.
     - 131. Establish a network of index in-water study sites across the range of all habitats (neritic and oceanic) and develop sampling protocols to estimate indices of abundance and determine trends.
     - 132. Evaluate, improve, maintain, and expand in-water surveys at index sites to estimate indices of abundance and determine trends.
     - 133. Develop sampling protocols for conducting large-scale in-water surveys to estimate indices of abundance and determine trends.
     - 134. Implement large-scale in-water surveys to estimate indices of abundance and determine trends.
   - 14. Determine geographic distribution patterns of in-water populations.
     - 141. Develop and maintain a comprehensive GIS database of distribution and abundance.
     - 142. Determine migratory pathways for all life history stages.
   - 15. Determine and monitor female reproductive output by recovery unit.
     - 151. Adopt standardized hatchling production assessment criteria.
     - 152. Implement annual assessments of hatchling production using standardized criteria.
     - 153. Determine and monitor clutch frequency.
     - 154. Determine and monitor remigration interval.

155. Determine female reproductive lifespan.

16. Determine and monitor demographic parameters at index in-water sites.
    161. Develop sampling and data collection protocols for demographic parameters.
        1611. Refine and develop techniques for determining sex ratios.
        1612. Refine and develop aging techniques.
        1613. Determine somatic growth rates and evaluate sources of variation.
        1614. Determine age-specific survival probabilities.
        1615. Determine age at sexual maturity for females.
        1616. Determine age at sexual maturity, reproductive frequency, and reproductive lifespan for males.
    162. Implement sampling and data collection protocols at index in-water sites.
17. Maintain and improve the Sea Turtle Stranding and Salvage Network.
    171. Maintain the Sea Turtle Stranding and Salvage Network.
    172. Implement improvements to the Sea Turtle Stranding and Salvage Network.
18. Maintain and enhance centralized administration and coordination of tagging programs.

2. Assess, monitor, and protect habitats.
    21. Ensure beach sand placement projects are conducted in a manner that accommodates loggerhead needs and does not degrade or eliminate nesting habitat.
        211. Conduct periodic reviews of existing state and FWS criteria for sand placement projects and modify as necessary.
        212. Ensure all beach sand placement projects are in compliance with state and FWS criteria.
        213. Ensure sand compaction levels following beach sand placement do not hinder sea turtle nesting or hatchling productivity.
            2131. Evaluate sand compaction levels on native beaches for all recovery units to determine thresholds for tilling.
            2132. Investigate alternative methods for monitoring sand compaction.
            2133. Implement tilling as a means of softening compacted beaches.
        214. Implement escarpment leveling on constructed beaches.
        215. Ensure sediment grain size, composition, and color are compatible with native beaches.
        216. Ensure sediment sources do not contain contaminants that impact sea turtle nests.
            2161. Conduct research on contaminant levels of sediment sources and their effects on loggerheads.
            2162. Evaluate and revise, if necessary, current Federal guidelines for contaminant levels of sediment sources to ensure compatibility with loggerhead development.
            2163. Conduct statistically valid sampling of borrow sediments for contaminants (pre- and post-construction) and ensure sediment sources do not exceed existing Federal guidelines for contaminant levels.
        217. Design and evaluate beach construction profiles to more closely mimic natural beaches.
        218. Re-establish natural dune structure and native vegetation during sand placement projects.
        219. Monitor suitability of post-construction beaches for nesting.

22. Minimize degradation of nesting habitat from barriers to nesting.
    221. Categorize and inventory all beach armoring, shoreline stabilization structures, and all other barriers to nesting to establish baseline levels and develop a GIS.
    222. Ensure that the percentage of nesting beach free of any barriers to nesting is stable or increasing relative to baseline levels determined in 221.
        2221. Convene an expert panel to develop a strategy to strengthen and guide regulations to minimize the effects of coastal armoring on loggerheads and to ensure that the percentage of nesting beach free of any barriers to nesting is stable or increasing relative to baseline levels determined in 221.
        2222. Modify existing regulations or promulgate new regulations to implement the strategy developed in 2221.
        2223. Ensure regulations governing placement and design of new coastal buildings and infrastructure eliminate any future need for coastal armoring.
        2224. Require removal of failed or ineffective erosion control structures.
        2225. Prohibit recreational equipment on nesting beaches at night.
        2226. Evaluate the effectiveness of dune crossovers for protecting dunes and strengthen existing regulations or promulgate new regulations to minimize effects from dune crossovers.
        2227. Evaluate the effectiveness of sand fences for building beaches and strengthen existing regulations or promulgate new regulations for sand fence construction.
        2228. Ensure regulations pertaining to barriers to nesting are enforced.
23. Maintain and acquire nesting beaches and adjacent uplands to be held in public trust.
    231. Maintain at least the current length and quality of protected nesting beach.
    232. Acquire additional parcels of nesting beach and adjacent uplands or otherwise ensure long-term protection.
        2321. Acquire additional beachfront and upland properties (undeveloped and developed) within the boundaries of the Archie Carr National Wildlife Refuge, Florida.
        2322. Acquire additional beachfront and upland properties (undeveloped and developed) on Hutchinson Island, Florida, and develop a plan to ensure long-term protection.
        2323. Acquire additional beachfront and upland properties (undeveloped and developed) within the nesting range of the Peninsular Florida Recovery Unit and develop a plan to ensure long-term protection.
        2324. Acquire additional beachfront and upland properties (undeveloped and developed) within the nesting range of the Northern Recovery Unit and develop a plan to ensure long-term protection.
        2325. Acquire additional beachfront and upland properties (undeveloped and developed) within the nesting range of the Northern Gulf Recovery Unit and develop a plan to ensure long-term protection.
        2326. Acquire storm-damaged nesting beachfront and upland properties on loggerhead nesting beaches.

24. Develop a model that describes the effects of sea level rise on the nesting range of loggerheads.
25. Minimize effects of beachfront light pollution on hatchlings and nesting females.
    251. Develop, fully implement, and effectively enforce light management plans on nesting beaches to ensure that the annual percentage of total nests with hatchlings affected (disoriented, misoriented) by artificial lighting does not exceed 5%.
        2511. Implement and enforce lighting ordinances on lands under local government jurisdiction.
        2512. Implement and enforce lighting management plans on all lands under state and Federal jurisdiction.
    252. Evaluate the extent of hatchling disorientation on nesting beaches based on standardized surveys.
    253. Prosecute individuals or entities responsible for hatchling disorientation under the Endangered Species Act or appropriate state laws.
26. Conduct other activities to improve the quality of nesting habitat.
    261. Encourage the manual removal of manmade beach debris through regular coastal cleanup programs.
    262. Remove exotic vegetation harmful to loggerheads on and adjacent to nesting beaches.
27. Inventory and protect neritic habitats used by loggerheads.
    271. Assess, categorize, and map neritic habitats used by loggerheads.
    272. Assess human activities and their effects on neritic habitats used by loggerheads.
        2721. Assess the effects of bottom trawl and dredge fisheries on neritic habitats used by loggerheads.
        2722. Assess the effects of eutrophication on neritic habitats used by loggerheads.
        2723. Assess the effects of water management on neritic habitats used by loggerheads.
        2724. Assess the effects of oil and gas production activities on neritic habitats used by loggerheads.
        2725. Assess the effects of channel dredging on neritic habitats used by loggerheads.
        2726. Assess the effects of salvage operations on neritic habitats used by loggerheads.
        2727. Assess the effects of other human activities on neritic habitats used by loggerheads.
    273. Develop and implement a strategy to protect and monitor neritic habitats used by loggerheads.
28. Inventory and protect oceanic habitats used by loggerheads.
    281. Assess, categorize, and map oceanic habitats used by loggerheads.
    282. Assess human activities and their effects on oceanic habitats used by loggerheads.
        2821. Assess the effects of oil and gas activities on oceanic habitats used by loggerheads.

2822. Assess the effects of marine debris on oceanic habitats used by loggerheads.
2823. Assess the effects of toxins and other pollutants on oceanic habitats used by loggerheads.
283. Develop and implement a strategy to protect and monitor oceanic habitats used by loggerheads.
29. Develop and maintain a comprehensive GIS database of neritic and oceanic habitats (used by loggerheads) and human activities that impact these habitats.
3. Prevent overutilization for commercial, scientific, or educational purposes.
31. Work with foreign nations to quantify and minimize commercial and subsistence harvest.
32. Educate local peoples in foreign nations on the economic benefits of sea turtle ecotourism as an alternative to harvest.
33. Develop and implement guidelines for public turtle walks that minimize disturbance to loggerheads.
34. Minimize take of wild turtles for captive display.
4. Assess and manage disease and predation.
41. Reduce nest predation.
411. Reduce the annual rate of mammalian predation to at or below 10% of nests within each recovery unit using ecologically sound predator control programs.
412. Control fire ants on and adjacent to sea turtle nesting beaches.
42. Develop diagnostic health assessment protocols and establish baselines for wild populations.
421. Develop a condition index to allow rapid evaluation of physiological status.
422. Develop protocols for collecting, handling, and analyzing baseline blood chemistry parameters from wild loggerheads.
423. Establish representative baseline blood chemistry parameters by sex, size class, season, and location.
424. Establish representative baseline toxicological parameters by sex, size class, season, and habitat.
425. Establish representative baseline levels of parasitic infection in wild turtles.
426. Establish representative baseline levels of bacterial, fungal, and viral infections in wild turtles.
43. Develop and implement a program to monitor loggerhead health at representative in-water index sites and index/standardized nesting beaches.
44. Evaluate the effects of harmful algal blooms on loggerhead health.
45. Investigate the lethal and sublethal role of contaminants.
46. Develop and implement protocols for handling turtles to limit transfer of disease.
47. Ensure the use of best practices in the rehabilitation, captive holding, transportation, and release of loggerheads.
471. Develop and/or finalize protocols for the proper care and maintenance of loggerheads held in captivity.
472. Develop protocols for transport and release of captive loggerheads.
473. Develop a manual for the assessment and treatment of loggerhead diseases and injuries.
474. Develop and maintain a list of veterinarians qualified to diagnose and treat

health problems in loggerheads.

48. Develop a strategy to recognize, respond to, and investigate mass strandings, disease episodes, or unusual mortality events.

5. Ensure adequacy of regulatory mechanisms.

51. Develop, implement, and enforce regulatory mechanisms to protect loggerheads and their habitats in the U.S.

511. Develop and implement Federal regulations to ensure long-term protection of loggerheads and their habitats post-delisting.

512. Ensure full and active enforcement of Federal regulations designed to protect loggerheads.

513. Develop and/or maintain, implement, and enforce state and local legislation to protect loggerheads and their habitats.

52. Ensure adequacy of regulatory mechanisms to protect loggerheads and their habitats in foreign nations.

521. Assist foreign countries in developing national regulations to protect loggerheads and their habitats.

522. Assist foreign countries with enforcement of national regulations to protect loggerheads.

53. Encourage development of and participation in multi-national agreements that facilitate conservation of loggerheads and their habitats.

531. Encourage non-signatory nations of the western hemisphere to accede to the Inter-American Convention for the Conservation and Protection of Marine Turtles.

532. Encourage non-signatory nations to accede to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartegena Convention), specifically the Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean (SPAW Protocol).

533. Ensure the U.S. becomes a party to the United Nations Convention on the Law of the Sea and the Convention on Migratory Species.

6. Minimize other causes of disturbance, harassment, injury, and mortality.

61. Minimize impacts to sea turtles on nesting beaches.

611. Eliminate nest management techniques that are not scientifically based.

6111. Evaluate the effects of nest management activities on nest productivity, hatchling fitness, and sex ratios and develop scientifically based standardized protocols for nest management.

6112. Implement scientifically based standardized protocols for nest management.

6113. Use the least manipulative method to protect nests.

6114. Discontinue the use of hatcheries as a nest management technique.

612. Minimize and control vehicular traffic on nesting beaches.

6121. Prohibit nighttime driving on beaches during the loggerhead nesting season.

6122. Ensure that the linear kilometers of nesting beach where vehicular traffic is permitted does not increase above 2006 levels.

6123. Manage daytime driving to minimize impacts to loggerheads.

613. Strengthen existing regulations or promulgate new regulations to manage

mechanical beach cleaning on nesting beaches.

614. Minimize harassment of nesting females and hatchlings.
  - 6141. Evaluate the extent and effects of harassment of nesting females and hatchlings and develop management recommendations.
  - 6142. Conduct public education campaigns to minimize harassment of nesting females and hatchlings.
  - 6143. Increase the number of interpretive turtle walks to meet demand and minimize overall disturbance to nesting females and hatchlings.
  - 6144. Enforce laws to minimize harassment of nesting females and hatchlings.

615. Develop and enforce guidelines for special events on the beach to minimize impacts on nesting females, nests, and hatchlings.

616. Minimize the impacts of military activities on nesting females, nests, and hatchlings.

617. Ensure oil spills affecting nesting beaches do not impact nesting females, nests, and hatchlings.
  - 6171. Conduct a risk management assessment of oil spill effects on nesting beaches.
  - 6172. Ensure that oil spill response plans exist and adequately protect all nesting beaches.

618. Minimize the impacts of coastal construction activities on nesting females, nests, and hatchlings.
  - 6181. Conduct all non-emergency coastal construction activities outside the main portion of the nesting season to eliminate impacts on nesting females, nests, and hatchlings.
  - 6182. Strengthen existing regulations or promulgate new regulations to minimize impacts from emergency construction activities during the nesting season on nesting females, nests, and hatchlings.
  - 6183. Develop and implement ordinances to eliminate the effects of stormwater outfalls and swimming pool drainage on nesting females, nests, and hatchlings.

619. Ensure that law enforcement activities eliminate poaching of eggs and nesting females.

62. Minimize loggerhead bycatch in domestic fisheries using a gear-based strategy.

621. Minimize loggerhead bycatch in domestic commercial gillnet fisheries.
  - 6211. Describe and characterize domestic commercial gillnet fisheries.
  - 6212. Integrate information gathered in 6211 with turtle distribution data (linked to actions 141 and 29).
  - 6213. Implement observer programs to determine bycatch levels and identify key characteristics of domestic commercial gillnet fisheries that affect bycatch levels.
  - 6214. Implement measures to minimize bycatch in large mesh gillnet fisheries.
  - 6215. Implement measures to minimize bycatch in other gillnet fisheries as appropriate.

622. Minimize loggerhead bycatch in domestic shrimp trawl fisheries.

6221. Describe and characterize domestic commercial and recreational shrimp trawl fisheries.
6222. Integrate information gathered in 6221 with turtle distribution data (linked to actions 141 and 29).
6223. Increase observer coverage to a statistically robust level to adequately monitor bycatch levels in the domestic commercial shrimp fishery and modify TED regulations if necessary.
6224. Promulgate regulations to require TEDs in all trynets in the domestic commercial shrimp fishery.
6225. Continue efforts to educate domestic commercial shrimp fishers on the proper installation and use of larger-opening TEDs.
6226. Investigate the physiological effects of multiple captures and exclusions of loggerheads in domestic commercial shrimp trawls equipped with TEDs.
6227. Monitor and reduce effort in the domestic commercial shrimp trawl fishery to minimize loggerhead bycatch.
6228. Investigate turtle exclusion rates for soft TEDs under field conditions using videography.
6229. Implement statistically valid observer programs to determine bycatch levels in domestic commercial skimmer trawl fisheries and require TEDs if necessary.

623. Minimize loggerhead bycatch in domestic commercial non-shrimp trawl fisheries.
6231. Describe and characterize domestic commercial non-shrimp trawl fisheries.
6232. Integrate information gathered in 6231 with turtle distribution data (linked to actions 141 and 29).
6233. Implement statistically valid observer programs to determine bycatch levels in domestic commercial non-shrimp trawl fisheries.
6234. Implement seasonal TED regulations for domestic commercial non-shrimp trawl fisheries operating from Cape Charles, Virginia, north to Long Island Sound.
6235. Promulgate regulations to require TEDs in domestic commercial flynet trawl fisheries.
6236. Promulgate regulations to require TEDs in all domestic commercial non-shrimp trawl fisheries south of Cape Hatteras, North Carolina.

624. Minimize loggerhead bycatch in domestic commercial pelagic and demersal longline fisheries.
6241. Describe and characterize domestic commercial pelagic and demersal longline fisheries.
6242. Integrate information gathered in 6241 with turtle distribution data (linked to actions 141 and 29).
6243. Maintain and/or increase observer coverage to a statistically robust level to adequately monitor bycatch levels in domestic commercial pelagic and demersal longline fisheries.
6244. Continue to conduct focused experiments on domestic commercial

longline gear and fishing practices to minimize loggerhead interactions and secondarily to minimize post-interaction mortality.

6245. Investigate the effectiveness of time-area closures to minimize loggerhead interactions in domestic commercial pelagic and demersal longline fisheries.

6246. Promulgate regulations to implement proven measures that minimize loggerhead interactions with commercial pelagic and demersal longline fisheries.

6247. Develop and implement effective approaches to enforcing longline regulations in the U.S. EEZ and on the high seas.

6248. Promote the use of safe handling practices and careful release tools in domestic commercial pelagic and demersal longline fisheries.

625. Minimize loggerhead bycatch in domestic commercial and recreational pot/trap fisheries.

6251. Describe and characterize pot/trap fisheries.

6252. Integrate information gathered in 6251 with turtle distribution data (linked to actions 141 and 29).

6253. Develop gear modifications to prevent entanglement of loggerheads in pot/trap lines.

6254. Promulgate regulations to incorporate modifications to whelk pot bridles to prevent loggerhead entanglement.

6255. Promulgate appropriate regulations to reduce incidental capture of loggerheads in pots/traps.

6256. Require identification on pot/trap gear.

626. Minimize loggerhead bycatch in domestic commercial dredge fisheries.

6261. Describe and characterize domestic commercial dredge fisheries.

6262. Integrate information gathered in 6261 with turtle distribution data (linked to actions 141 and 29).

6263. Evaluate the effectiveness of gear modifications developed to reduce loggerhead bycatch in the domestic commercial scallop dredge fishery.

6264. Promulgate regulations that reduce loggerhead bycatch and mortality in the domestic commercial scallop dredge fishery.

6265. Investigate bycatch and mortality of loggerheads in commercial whelk dredge fisheries.

6266. Investigate bycatch and mortality of loggerheads in commercial surf clam dredge fisheries.

627. Minimize loggerhead bycatch in other domestic commercial fisheries.

6271. Describe and characterize other domestic commercial fisheries.

6272. Integrate information gathered in 6271 with turtle distribution data (linked to actions 141 and 29).

6273. Investigate bycatch and mortality of loggerheads in other domestic commercial fisheries and implement bycatch reduction measures as necessary.

6274. Ensure that no increase in effort over 2003 levels occurs in the *Sargassum* fishery to minimize loggerhead bycatch.

628. Enforce domestic commercial fishery regulations to minimize loggerhead

bycatch.

63. Minimize loggerhead bycatch in foreign commercial fisheries.
    631. Disseminate results of bycatch reduction experiments and transfer demonstrated bycatch reduction technologies to foreign nations.
    632. Encourage and assist foreign nations in collecting data on loggerhead bycatch via observer programs for commercial fisheries where bycatch levels are undocumented.
    633. Encourage and assist foreign nations to develop, implement, and enforce fishery regulations to minimize loggerhead bycatch in commercial pelagic longline fisheries.
    634. Encourage and assist foreign nations to develop, implement, and enforce fishery regulations to minimize loggerhead bycatch in commercial trawl fisheries.
    635. Encourage and assist foreign nations to develop, implement, and enforce fishery regulations to minimize loggerhead bycatch in commercial gillnet fisheries.
    636. Encourage and assist foreign nations to develop, implement, and enforce fishery regulations to minimize loggerhead bycatch in other commercial fisheries.
    637. Develop economic incentives to reduce fishery interactions and mortality of loggerheads in foreign high seas fisheries.
    638. Encourage ICCAT, Canada, Mexico, and the European Union to implement standards for collecting loggerhead bycatch information and requirements to minimize loggerhead bycatch.
64. Develop and implement a strategy to assess, monitor, and minimize effects of trophic changes on loggerheads from fishing and habitat alteration.
    641. Assess loggerhead diets and food web linkages in neritic and oceanic habitats.
    642. Assess and minimize effects of commercial harvest of loggerhead prey species.
    643. Assess effects of habitat alteration from commercial fisheries on distribution and abundance of loggerhead prey species.
65. Develop and implement a strategy to minimize the effects of marine debris ingestion and entanglement.
    651. Determine frequency of marine debris ingestion and entanglement by loggerheads in neritic and oceanic habitats.
    652. Evaluate the sublethal effects of marine debris ingestion and entanglement on loggerheads.
    653. Enforce the International Convention for the Prevention of Pollution from Ships (MARPOL).
    654. Explore feasibility and provide incentives to reduce the amount of abandoned recreational and commercial fishing gear that causes loggerhead injury and mortality.
    655. Explore feasibility and provide incentives to reduce the amount of non-fisheries related marine debris that causes loggerhead injury and mortality.
    656. Maintain or implement marine debris cleanup programs in coastal waters.
66. Develop and implement a strategy to reduce vessel strikes.
    661. Develop a comprehensive GIS database to assess vessel interactions with loggerheads.
    662. Develop and implement a strategy to reduce vessel interactions with loggerheads.

- 67. Monitor and minimize mortality from channel dredging activities.
  - 671. Assess effects of new technologies for channel dredge equipment on loggerhead captures.
  - 672. Incorporate effective channel dredge equipment modifications into future operations.
  - 673. Maintain current requirements for channel dredging activities in the southeast U.S. and Gulf of Mexico and evaluate whether additional measures are required to minimize loggerhead mortality.
  - 674. Implement regional requirements for channel dredging activities north of North Carolina to minimize loggerhead mortality.

7. Facilitate recovery through public awareness, education, and information transfer.
   - 71. Develop and distribute educational materials.
     - 711. Develop a video about the impacts of beachfront lighting on loggerheads and ways to minimize impacts.
     - 712. Maintain websites with comprehensive information about loggerheads.
     - 713. Develop an educational curriculum for students and the public about loggerhead demography and ecological roles.
     - 714. Use computer gaming technologies to engage young people in sea turtle conservation.
   - 72. Facilitate international scientific communication and information sharing.
   - 73. Ensure facilities permitted to hold and display captive loggerheads have appropriate informational displays.
   - 74. Ensure standard criteria and recommendations for sea turtle nesting interpretive walks are followed.
   - 75. Develop guidelines for and encourage interpretive daytime turtle walks.
   - 76. Place educational signs at public access points on nesting beaches.
   - 77. Conduct a contingent valuation study to measure the economic value of sea turtle related ecotourism.

F.2. RECOVERY ACTION NARRATIVE

1. Determine demographic parameters, refine population genetic structure, and monitor distribution, abundance, and trends.

11. Monitor and refine population genetic structure.

111. Refine geographic boundaries of recovery units.

Current research on genetic markers in loggerheads that nest in the southeast U.S. suggests four distinct regional stocks (the Northern Population, the South Florida Population, the Dry Tortugas Population, and the Florida Panhandle Population) based on analysis of haplotypes from mtDNA. The geographic boundaries of U.S. recovery units may need to be refined in order to correctly apply population status assessments, threats assessments, and recovery actions. Genetic analyses, including continuous spatial sampling of nesting females, are needed to fully describe spatial population structure throughout the loggerhead's Atlantic nesting range and to identify recovery unit boundaries based on breakpoints in nesting occurrence and nesting female relatedness. To fully describe nesting female relatedness, additional analyses are needed using the non-coding regions of the mtDNA genome and more precise analyses of nuclear DNA using microsatellite techniques.

112. Monitor population genetic structure on foraging grounds.

To effectively manage sea turtle stocks and determine the efficacy of nest protection activities, we need to determine the origin of juvenile and subadult turtles. Such knowledge could be critical if progeny from specific nesting beaches exhibit different behavior, movements, or foraging ranges than turtles from other beaches. Such differences could result in high mortality in some nesting populations and low mortality rates in other populations.

113. Develop new techniques for refining population genetic structure.

Rapidly evolving techniques for analyzing genetic data provide increasing resolution of population structure. Analysis of nuclear DNA (microsatellites), representing both male and female contributions to date, suggests that males from particular subpopulation units mate with females from other subpopulation units producing a homogeneous population at the nuclear DNA level. Genetic analyses of paternity have also shown that females mate with multiple males (eggs in an individual nest have one to three fathers). It is not yet known how many males contribute to the nesting within a rookery. It is possible that future genetic analyses will reveal even more detailed population structure.

12. Monitor nesting abundance and trends by recovery unit.

Nesting surveys are undertaken on the majority of loggerhead nesting beaches in the U.S. and on the major loggerhead nesting beaches in Mexico. However, in the past, beach coverage from year to year varied, as did the frequency of surveys, experience and training of surveyors, and data reporting. Consequently, nesting survey data did not represent regionwide nesting population trends. Survey data should be derived from observations of tracks and other nesting signs left on beaches by sea turtles. Species identifications and determinations of nesting or non-nesting emergences should be based on evaluations of features of tracks and nests (e.g., track configuration, size of the body pit) as described by Pritchard *et al*. (1983) and Schroeder and Murphy (1999).

121. Maintain and/or adopt standardized criteria for on-the-ground nesting surveys.

Standardized nesting survey criteria, such as those developed by the FFWCC [http://myfwc.com/seaturtle/Guidelines/MarineTurtleGuidelines.htm], should be maintained and/or adopted across all recovery units to gather a long-term (approaching a generation time of 50 years) database on nesting activity that can be used as an index of nesting population trends representing each recovery unit over the entire nesting range in the Northwest Atlantic.

122. Continue to monitor trends in nesting and non-nesting emergences on index/standardized beaches.

Daily surveys of specific beach areas are necessary to identify, enumerate, and evaluate nesting activities. To minimize variation that results from sampling error, ensure that index beaches continue to represent a broad geographic range, that daily surveys represent all nesting during the index period, and that annual training workshops are conducted to ensure standardization and consistency.

123. Incorporate index/standardized nesting survey protocols on additional beaches to fully represent recovery units.

Additional beaches should be surveyed in accordance with index/standardized nesting survey protocols to fully represent the four recovery units located in the southeast U.S. including Bon Secour NWR, Alabama; Dry Tortugas National Park, Florida; Cape Romain NWR, South Island, Kiawah Island, and Hilton Head, South Carolina; and Cape Lookout National Seashore, Cape Hatteras National Seashore, Onslow Beach, and Bald Head Island, North Carolina. Outside of the U.S., additional beaches should be surveyed to fully represent the Greater Caribbean Recovery Unit.

124. Monitor annual nesting and non-nesting emergences on non-index/non-standardized beaches as extensively as possible.

Although nesting surveys on non-index/non-standardized beaches may be too inconsistent to allow an accurate trend assessment, these surveys can provide a more complete assessment of nesting range and seasonality than the spatial/temporal subsample of index beaches and index season. When conducted extensively, these surveys can provide a near census of loggerhead nesting that is valuable as an estimate of total abundance. Although they are variable in occurrence, non-index/non-standardized beach surveys ensure that nesting data for management decisions is not only limited to the smaller subset of index beaches.

125. Conduct periodic censuses of recovery units to obtain total nest counts and geographic distribution of nesting.

Periodic censuses (once every 5 years) of nesting throughout the range for each recovery unit are needed to obtain total nest counts and to detect changes in geographic distribution. These surveys should encompass the complete geographic range and the entire nesting season (April 15 to September 15). To completely represent geographic range, daily surveys are needed on beaches where recent surveys have never been undertaken or are rarely undertaken due to difficult access (e.g., Chandeleur Islands, Louisiana; Ten Thousand Islands NWR and Cape Sable, Florida; Wolf Island, Pine Island, and Little Tybee Island, Georgia; Myrtle Beach and Waites Island, South Carolina; Masonboro Island, North Carolina; and representative beaches in the GCRU (e.g., Cay Sal Bank, The Bahamas).

13. Monitor in-water population abundance and trends.

131. Establish a network of index in-water study sites across the range of all habitats (neritic and oceanic) and develop sampling protocols to estimate indices of abundance and determine trends.

A network of index in-water study sites representing all loggerhead life stages across neritic and oceanic habitats is needed to monitor population trends. While sampling methods (e.g., tangle nets, hand capture, trawl capture) do not have to be standardized among studies, consistent sampling protocols within studies need to be developed. Additionally, a repository must be identified to maintain annual survey data such that comprehensive trend analyses can be conducted across the range of the species.

132. Evaluate, improve, maintain, and expand in-water surveys at index sites to estimate indices of abundance and determine trends.

Approximately 15 to 20 in-water sites are currently sampled, at varying effort levels, to collect information on loggerheads. An evaluation of these existing sampling sites is needed to determine their ability to contribute to long-term population trend analyses. As necessary, efforts should be undertaken to improve and/or expand these sampling efforts to ensure that resulting data will contribute to the overall effort of population monitoring. The maintenance of these sampling programs over the long-term is critical to their success.

133. Develop sampling protocols for conducting large-scale in-water surveys to estimate indices of abundance and determine trends.

Large-scale surveys to estimate loggerhead abundance and to monitor population trends are needed in conjunction with smaller-scale index site monitoring. An evaluation of large-scale survey techniques for sea turtles (e.g., aerial, shipboard, etc.) should be conducted, perhaps through a workshop forum, to thoroughly assess the feasibility, cost, and likelihood of success of the different techniques. Specific sampling protocols and sampling regimes should be developed to ensure success.

134. Implement large-scale in-water surveys to estimate indices of abundance and determine trends.

Large-scale surveys to estimate loggerhead abundance and to monitor population trends should be implemented in a timely manner following the development of sampling protocols. Regular evaluations of the effectiveness of these survey techniques and the applicability of results to monitoring recovery should be conducted. As with smaller scale index surveys, maintaining these sampling programs over the long-term is critical to their success.

14. Determine geographic distribution patterns of in-water populations.

141. Develop and maintain a comprehensive GIS database of distribution and abundance.

The use of spatial analysis tools is an extremely valuable and ultimately cost effective way of identifying distribution patterns and incorporating this information into conservation strategies and actions. A comprehensive GIS database, incorporating all available information on loggerhead distribution and abundance should be developed, maintained, and made available to facilitate effective management decisions. Linked to action 29.

142. Determine migratory pathways for all life history stages.

Tag recapture data provide point-to-point information on movements of loggerheads away from nesting beaches, from foraging areas to nesting beaches, or from one foraging area to another. More recent satellite tagging technologies provide higher resolution location information on movements of loggerheads in marine habitats, at both large and small scales. The effective integration and analysis of turtle movement data with oceanographic data in a GIS format is critical to understanding and predicting movements and habitat use. These technologies, when fully exploited, will ultimately result in more effective and targeted conservation strategies and actions.

15. Determine and monitor female reproductive output by recovery unit.

To understand sea turtle nest productivity, it is necessary to determine the number of eggs laid, the number of eggs that successfully hatch (hatching success), and the number of hatchlings that successfully emerge from nests (emerging success). Monitoring changes in these numbers over time will allow for decisions to be made on management actions that may be needed to address problems.

Knowing the remigration interval (interval between nesting seasons) and the clutch frequency (number of clutches laid by an individual in a nesting season) of females allows us to assess the status of a nesting population by allowing us to estimate the total number of mature females in a population. To convert the number of nesting females per year to the total number of reproductively active females in a population, the average remigration interval and clutch frequency must be known.

151. Adopt standardized hatchling production assessment criteria.

The FFWCC guidelines for *Hatching Success Evaluations (Nest Inventories)* [http://myfwc.com/seaturtle/Guidelines/MarineTurtleGuidelines.htm] provide a good method for ensuring nest productivity data are collected in a manner that will allow assessments of hatching and emerging success that can be compared to other beaches and to other nesting seasons.

152. Implement annual assessments of hatchling production using standardized criteria.

Hatching and emerging success on nesting beaches should be evaluated on all nests or on a random and representative sample of nests. The evaluation of hatching success involves excavating and inventorying a nest after the hatchlings have left it (or should have left it) to determine the fate of each egg. Selecting a sufficient number of representative sample nests will allow accurate assessments of nest productivity. An insufficient number of sample nests or a sample of nests that is poorly representative, no matter how numerous, will yield potentially misleading information about hatching and emerging success.

153. Determine and monitor clutch frequency.

If the number of nesting emergences varies significantly among years, this could reflect changes in the number of nesting females, clutch frequency, or both. Therefore, it is essential that clutch frequency be regularly monitored. Saturation tagging programs (programs that attempt to place identification tags on every nesting turtle) have proven to be valuable in measuring clutch frequency. However, logistical limitations of saturation tagging programs are not likely to allow unbiased estimates of clutch frequency (measured by nests per nesting season). Recent advances in satellite telemetry (e.g., GPS-linked satellite tags) may allow the development of reproductive histories of individual turtles so that a mean and variance can be calculated for clutch frequency.

154. Determine and monitor remigration interval.

A variety of techniques (e.g., satellite telemetry, laparoscopy, saturation tagging) should be evaluated to determine which technique(s) is best suited to ascertain and monitor remigration intervals. The most effective technique(s) should be implemented on a representative sample of nesting beaches.

155. Determine female reproductive lifespan.

Reproductive lifespan is the number of years over which individuals remain reproductively active and can be estimated as the difference between age at sexual maturity and maximum age, if reproductive senescence does not occur. Maximum age can be estimated from population models that include annual survival estimates. Reproductive lifespan can also be estimated from long-term tagging studies of reproductive females if corrections for tag loss, resighting probabilities, and lack of site fixity can be incorporated.

16. Determine and monitor demographic parameters at index in-water sites.

Monitoring population trends and developing indices of abundance at in-water sites provides information on whether populations are stable, increasing, or declining, but does not provide information on the causes behind these observed population trends. Monitoring demographic parameters at in-water sites can provide information on potential causes for changes in population trends and may provide early warning signals of impending population declines. Concurrent with a large-scale index in-water sampling program aimed at monitoring population trends, data on demographic parameters that can be monitored over the long-term and compared among index sites should be collected.

161. Develop sampling and data collection protocols for demographic parameters.

1611. Refine and develop techniques for determining sex ratios.

Because sea turtles have environmentally determined sex ratios, changes in geographic ranges of loggerheads or climate may skew sex ratios sufficiently to affect demography. All demographic models to date are female-based. We need to better understand and monitor this demographic parameter across all recovery units. Techniques using blood hormone levels or laparoscopy allow researchers to determine the sex of live immature turtles, so distribution by sex can be determined from in-water surveys. Sex ratios may also be determined from necropsies of stranded turtles.

1612. Refine and develop aging techniques.

Aging techniques for loggerhead sea turtles are improving, but we need to continue to refine and develop this technology. Age/size keys will allow large data sets on size structures of loggerhead aggregations to be converted into age structures. Size information has been useful to track size-biased sources of mortality or changes in population size structure, but models based on age structure may be even more valuable.

1613. Determine somatic growth rates and evaluate sources of variation.

Somatic growth rates have direct effects on other demographic parameters such as survival, duration in life-stage, and age at sexual maturity. Somatic growth rates can be used as an index of habitat quality and population health. Several techniques have been used to determine somatic growth rates in loggerheads, and most studies have suffered from small sample size. Studies are needed that (1) compare techniques, (2) are based on large sample sizes, and (3) explicitly model the effects of biological and environmental covariates on somatic growth.

1614. Determine age-specific survival probabilities.

Age/stage-specific survival probabilities are key parameters for models predicting population growth rates and recovery of sea turtles. Determining survival rates for all life stages and for all recovery units is critical.

1615. Determine age at sexual maturity for females.

All species of sea turtles exhibit late maturity. Initial estimates of age at sexual maturity for female loggerheads from the southeast U.S. were around 20 years, but recent estimates exceed 30 years. The correct age or, more accurately, the correct age range for reproductive maturity for any loggerhead population remains to be determined. Age at maturity is a key feature of demographic models, and our understanding of this parameter and how it may differ across recovery units is critical. Long-term population growth rates and responses to perturbations are strongly influenced by age at sexual maturity.

1616. Determine age at sexual maturity, reproductive frequency, and reproductive lifespan for males.

Relative to female loggerheads, survival and reproductive activity of males are poorly studied, largely because males are less accessible. Because global warming may result in lowered production of male hatchlings and males may provide genetic exchange between different subpopulations, greater effort is needed to collect data on demographic parameters for male loggerheads.

162. Implement sampling and data collection protocols at index in-water sites.

Standardized protocols (see action 161) should be implemented at index in-water sites and a repository should be established and maintained such that demographic parameter data from identified index sites can be comprehensively archived, analyzed, and used to gauge recovery status, evaluate management actions, and develop additional conservation strategies.

17. Maintain and improve the Sea Turtle Stranding and Salvage Network.

The Sea Turtle Stranding and Salvage Network (STSSN) was established in 1980 to collect information on and document strandings of sea turtles along the U.S. Atlantic and Gulf coasts. The network encompasses the coastal areas of the 18-state region from Maine through Texas, and includes portions of the U.S. Caribbean. Data are compiled through the efforts of network participants who document sea turtle strandings in their respective areas and contribute those data to the centralized STSSN database. Stranding survey data are less comprehensive outside the U.S.

171. Maintain the Sea Turtle Stranding and Salvage Network.

Most accessible U.S. beaches in the Atlantic and Gulf of Mexico are surveyed for stranded sea turtles by volunteer or contract personnel. Through the STSSN, stranding data are archived and summarized by the SEFSC. These data provide information relative to at-sea mortality and can be a cost effective means of evaluating the effectiveness of recovery actions, including regulatory requirements. These data also provide basic biological information on sea turtles and are useful in determining other sources of mortality. The expansion of stranding surveys in the GCRU would provide additional data on at-sea mortality for this region.

172. Implement improvements to the Sea Turtle Stranding and Salvage Network.

Improvements to the STSSN are needed for improving data submission, timeliness of data availability, data access, response to large-scale stranding events, and assessing causes of death. Understanding and measuring (where possible) stranding survey effort is important to ensure that stranding trends are not influenced by changes in survey effort. Efforts should be undertaken to incorporate near real-time data reporting through on-line data entry and uploading high quality digital photographs of strandings. Map utility tools should be investigated and employed on-line to ensure accurate location assignment for stranding locations. Improvements in time to data availability and data access are needed to ensure rapid and appropriate response to unusual stranding events and to gauge the success of management actions.

18. Maintain and enhance centralized administration and coordination of tagging programs.

A database exists to archive flipper tag series used by researchers [http://accstr.ufl.edu/taginv.html], although not all researchers have provided their tag series. Maintenance and expansion of this database should be supported. A similar database needs to be maintained for PIT tags. Compatability issues among PIT tag readers and PIT tags need to be considered and addressed.

In addition to the tag series database, a centralized turtle tagging database, including all tagging data, would substantially benefit loggerhead management and should be pursued. Major challenges to establishing such a database include the reluctance of individuals to provide their data, appropriate protection against unethical use of data, and support for the demanding curatorial work that would be required.

2. Assess, monitor, and protect habitats.

Coastal development is responsible for degrading or destroying many miles of nesting habitat. Currently, the majority of nesting in the U.S. occurs on over 2,400 km of beaches in North Carolina (531 km), South Carolina (303 km), Georgia (164 km), Florida (1,327 km), and Alabama (78 km). Degradation or loss of nesting habitat will lead to a significant population decline if not effectively regulated. Available sea turtle habitat has been significantly reduced over the past century. Among the factors contributing to this loss of habitat are coastal development and industrialization, increased commercial and recreational vessel activities, river and estuarine pollution, channelization, offshore oil and gas development, and commercial fishing activities. If present trends continue, the cumulative loss of suitable foraging and developmental habitat could reduce the likelihood of recovery of loggerheads.

21. Ensure beach sand placement projects are conducted in a manner that accommodates loggerhead needs and does not degrade or eliminate nesting habitat.

Beach sand placement projects (e.g., beach nourishment, beach restoration, inlet sand bypassing) in the U.S. may increase sea turtle nesting habitat if the placed sediment is highly compatible (i.e., grain size, shape, color, composition, etc.) with naturally occurring beach sediments in the area, and compaction and escarpment remediation measures are incorporated into the project. In addition, a constructed beach that is designed and engineered to mimic a natural beach system may be more stable than the eroding one it replaces, thereby benefiting sea turtles.

211. Conduct periodic reviews of existing state and FWS criteria for sand placement projects and modify as necessary.

State resource agencies and FWS currently review proposed sand placement projects for potential impacts on sea turtles. Terms and conditions are subsequently incorporated into state and U.S. Army Corps of Engineers permits to ensure impacts are minimized. A panel composed of sea turtle biologists and coastal biologists and engineers should be formed to review existing terms and conditions and ensure they are adequate and feasible.

212. Ensure all beach sand placement projects are in compliance with state and FWS criteria.

All beach sand placement projects should be conducted in compliance with state and FWS requirements to minimize incidental take of sea turtles during and following beach sand placement projects. These requirements address protection of nests laid within the project area, sand quality (e.g., coloration, grain size distribution), compaction and escarpment monitoring and remediation, placement and nighttime storage of construction equipment, and project lighting.

213. Ensure sand compaction levels following beach sand placement do not hinder sea turtle nesting or hatchling productivity.

Beach sand placement may result in changes in sediment composition, sand density, beach shear resistance, sand grain size, and sand grain shape. These changes could result in adverse impacts on nest site selection, digging behavior, hatching success, and emerging success. Studies have shown that beach sand compaction following nourishment projects may be persistent. Therefore, multi-year sand compaction monitoring should be required for all nourishment and dune building projects.

2131. Evaluate sand compaction levels on native beaches for all recovery units to determine thresholds for tilling.

Impacts on sea turtles can be minimized by using suitable sand and by tilling the beach after nourishment if the sand becomes compacted. Tilling a nourished beach may reduce sand compaction to levels comparable to unnourished beaches. In order to determine thresholds that trigger the need for tilling, sand compaction levels should be evaluated on a representative number of native beaches (i.e., beaches that have never had sand placement on them) within all recovery units. Evaluation of sand compaction should include the entire beach profile.

2132. Investigate alternative methods for monitoring sand compaction.

Cone penetrometers are the standard means of measuring sand compaction on sea turtle nesting beaches. Many investigators have experienced problems with inconsistent and non-repeatable results when measuring beach compaction with cone penetrometers. Other tools for measuring beach compaction are available; however, their applicability in assessing the suitability of a beach for turtle nesting is still unknown.

2133. Implement tilling as a means of softening compacted beaches.

Tilling a nourished beach with a root rake can reduce sand compaction to levels comparable to unnourished beaches. However, researchers have found that tilled beaches may become compacted again over time. Therefore, multi-year beach compaction monitoring should be conducted and, if necessary, tilling should be undertaken to ensure that project impacts on sea turtles are minimized. Tilling should be conducted to a minimum depth of 36 inches. Tilling is usually conducted by using heavy equipment (e.g., bulldozers), preferably with the rake being pulled behind the heavy equipment to minimize compaction during tilling.

214. Implement escarpment leveling on constructed beaches.

On constructed beaches, steep escarpments may develop along the water line interface as the beach adjusts from the construction profile to a more natural beach profile. These escarpments can hamper or prevent access of female turtles to suitable nesting sites. Leveling escarpments prior to the nesting season should be conducted to minimize this impact.

215. Ensure sediment grain size, composition, and color are compatible with native beaches.

Guidelines should be followed to ensure sand grain size, composition, and color of sediments used in sand placement projects are suitable for turtle nesting. To provide the most suitable sediment for nesting sea turtles, the sand grain shape, size, and mineral content, as well as the color of the nourished sediments, must resemble the natural beach sand in the area. Natural reworking of sediments and bleaching from exposure to the sun would help to lighten dark nourishment sediments; however, the timeframe for sediment mixing and bleaching to occur could be critical to one or more successful sea turtle nesting seasons.

216. Ensure sediment sources do not contain contaminants that impact sea turtle nests.

Chemical residues in sea turtle eggs have been recognized as both a regional and global concern. Researchers have identified elevated concentrations of organochlorine pesticides, polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), and a variety of metals and trace elements in unhatched sea turtle eggs from the Florida Panhandle. However, it was uncertain if these contaminants contributed to embryonic mortality of unhatched eggs or if these contaminants otherwise affected turtle hatching success. It was also undetermined if the elevated contaminant levels were the result of maternal transfer or exposure at the nesting site.

2161. Conduct research on contaminant levels of sediment sources and their effects on loggerheads.

Although coarse borrow sediment is not conducive to adherence by contaminants, plankton and other organic materials can hold contaminants and are likely present in the borrow sediments, which could negatively affect sea turtle nests. The U.S. Environmental Protection Agency (EPA) and U.S. Army Corps of Engineers (1998) testing manual for the evaluation of dredged materials for discharge in waters of the U.S. provides a tiered approach that should be followed for determining what contaminants might be present dependent on the borrow source. In addition, EPA has tight controls on inlet material testing and ocean disposal testing, and the Clean Water Act section 404(b)(1) guidelines at 40 CFR 230.60 should be followed when considering testing.

2162. Evaluate and revise, if necessary, current Federal guidelines for contaminant levels of sediment sources to ensure compatibility with loggerhead development.

Core samples of potential borrow sediments are required to be taken and analyzed for compatibility prior to placement on nesting beaches. In addition to looking at the compatibility of these sediments to sand on native beaches in an area, contaminant (both organic and inorganic) levels should also be evaluated.

2163. Conduct statistically valid sampling of borrow sediments for contaminants (pre- and post-construction) and ensure sediment sources do not exceed existing Federal guidelines for contaminant levels.

Studies are needed to better define the relationship of environmental contaminants on constructed beaches and reproductive success in sea turtles.

217. Design and evaluate beach construction profiles to more closely mimic natural beaches.

Traditionally constructed beaches tend to be wide and flat, whereas heavily nested natural beaches are often relatively narrow and steeply sloped. Reduced nesting and increased nest loss to erosion typically reduce hatchling production on constructed beaches relative to natural beaches. Research should be conducted to determine the aspects of beaches that make them good nesting habitat and, to the greatest extent practicable, alternative construction templates should be designed, built, and monitored to mimic those conditions.

218. Re-establish natural dune structure and native vegetation during sand placement projects.

Beach nourishment projects should include dune restoration, and appropriate native salt-resistant dune vegetation should be established on the restored dunes. This will enhance beach stability and nesting habitat and require less frequent sand placement activities.

219. Monitor suitability of post-construction beaches for nesting.

Post-construction monitoring of sediment quality, profile equilibration, and effectiveness of tilling and escarpment leveling, as well as nesting, hatching, and emerging success, should be conducted to (1) ensure projects meet design specifications, (2) determine the effectiveness of remediation measures, and (3) ensure projects are not having a significant negative impact on sea turtles.

22. Minimize degradation of nesting habitat from barriers to nesting.

221. Categorize and inventory all beach armoring, shoreline stabilization structures, and all other barriers to nesting to establish baseline levels and develop a GIS.

Despite the importance of beach habitat quality to sea turtle nesting, there has been no inventory of potential barriers to nesting on any significant stretch of beach in the southeast U.S. Southeast U.S. beaches should be inventoried for potential barriers to sea turtle nesting to obtain a complete catalog of anthropogenic structures on nesting beaches. A technique should be developed to allow for rapid, repeated inventories that could measure changes in beach habitat over time.

222. Ensure that the percentage of nesting beach free of any barriers to nesting is stable or increasing relative to baseline levels determined in 221.

Coastal development, coupled with critical beach erosion, has led to the placement of structures such as armoring (e.g., seawalls, revetments, etc.), sand fences, and other erosion control structures to protect upland property. These structures, in addition to other hard anthropogenic features that range from recreational equipment (e.g., beach furniture, catamarans) to actual buildings, are often barriers to nesting females and have already destroyed or degraded many miles of nesting habitat.

2221. Convene an expert panel to develop a strategy to strengthen and guide regulations to minimize the effects of coastal armoring on loggerheads and to ensure that the percentage of nesting beach free of any barriers to nesting is stable or increasing relative to baseline levels determined in 221.

An expert panel should be convened to assess the effects of coastal armoring on sea turtles and develop a strategy to minimize any negative effects. At a minimum, consideration should be given to the placement and types of armoring, prohibition of armoring, gap closure, removal of existing armoring structures, options for eliminating the need for or reducing the impacts of armoring (e.g., coastal construction setbacks, beach nourishment, inlet sand bypassing, jetties, channel deepening), and emergency situations/exceptions.

2222. Modify existing regulations or promulgate new regulations to implement the strategy developed in 2221.

State regulations prohibiting or discouraging some forms of coastal armoring now exist in Florida, South Carolina, and North Carolina. State resource agencies should review existing state regulations related to coastal armoring and other barriers to nesting and modify or promulgate new regulations as appropriate to implement the strategy developed by the expert panel from 2221.

2223. Ensure regulations governing placement and design of new coastal buildings and infrastructure eliminate any future need for coastal armoring.

State resource agencies should review existing state regulations related to placement and design of new coastal structures (e.g., design elevations, pile foundations, heights of structural members of habitable structures) and modify or promulgate new regulations as appropriate to reduce the potential for damage due to storm tides and waves and thus reduce the need for coastal armoring.

2224. Require removal of failed or ineffective erosion control structures.

Failed erosion control structures, such as uncovered geotextile bags or tubes and fragmented concrete or wooden structures, degrade nesting habitat and deter nesting activities. State resource agencies should ensure failed or ineffective structures are removed from nesting beaches.

2225. Prohibit recreational equipment on nesting beaches at night.

Sea turtles prefer to nest on the mid to upper beach, protecting their nests from repeated and prolonged high tides. Recreational equipment (e.g., beach furniture, umbrellas, marine craft, tents) that are left on the beach at night can prevent nesting turtles from reaching the mid to upper beach. Therefore, at night, all recreational equipment should be completely removed from the beach by hand and stored behind the primary dune. Regulations should be developed and enforced to ensure these types of impediments to nesting are managed or eliminated.

2226. Evaluate the effectiveness of dune crossovers for protecting dunes and strengthen existing regulations or promulgate new regulations to minimize effects from dune crossovers.

State resource agencies should evaluate the effectiveness of the variety of dune crossover options in protecting dunes and dune vegetation and for their propensity to block sea turtle access to nesting sites and entrap nesting females. States should modify or promulgate new regulations as appropriate based on the results of this evaluation. Consideration should be given to reducing the number of crossovers associated with individual residences by requiring crossover sharing. State resource agencies should also require that new crossovers be constructed in a manner that will minimize interactions with nesting turtles (e.g., monopole construction, stopping short of the beach itself, roped corridors).

2227. Evaluate the effectiveness of sand fences for building beaches and strengthen existing regulations or promulgate new regulations for sand fence construction.

Research is needed to determine how the negative effects of sand fences on sea turtles can be minimized. Research should include assessments of sand fence effectiveness and alternative techniques such as degradable fencing, hay bales, and planting native pioneering vegetation. Regulations should be modified or new regulations promulgated as appropriate based on the results of this research. In Florida, South Carolina, and North Carolina standard requirements for sand fence construction have been established to minimize impacts to sea turtles, and state resource agencies should ensure these requirements are enforced. Similar regulations should be developed and enforced in other states where they do not currently exist.

2228. Ensure regulations pertaining to barriers to nesting are enforced.

Illegal coastal armoring occurs, and in some cases no effective action is taken to ensure the material is removed and the habitat restored. In addition, coastal armoring structures sometimes fail and break apart, which results in the presence of debris on the beach. The same holds true for other barriers, such as stairways and ramps that have been built on the beach to allow human access. State resource agencies and local governments with coastal permitting responsibilities should frequently monitor beaches and maintain strict enforcement when violations are observed and ensure all debris and structural material from failed structures is removed from the nesting beach area and properly deposited offsite.

23. Maintain and acquire nesting beaches and adjacent uplands to be held in public trust.

Maintenance of sea turtle recovery units is dependent on securing and protecting sufficient stretches of nesting beaches. Beachfront development invariably generates human demands for coastal armoring to protect private property. Upland development also results in artificial lighting behind nesting beaches. Nighttime human activities on beaches can also deter nesting females. Resident and visitor use of developed and developing nesting beaches can adversely affect nesting sea turtles, incubating egg clutches, and hatchlings. For these reasons, nesting beaches should be acquired and protected to ensure long-term availability of suitable beaches for nesting.

231. Maintain at least the current length and quality of protected nesting beach.

As of 2005, 1,581 km of nesting beach in the U.S. were identified as being within conservation lands in public (Federal, state, or local government) ownership and privately owned conservation lands (e.g., non-profit conservation foundations) (Appendix 4). Most of these lands are generally managed in a way that benefits sea turtle conservation. Public lands that have lighted development, armoring, or other profound threats to sea turtle nesting have not been included. In compiling the list of conservation lands, human visitation was not considered a profound threat to sea turtle nesting. Therefore, public lands designated for human recreation have been included. At a minimum, the amount of nesting beach in such protected status should be maintained.

232. Acquire additional parcels of nesting beach and adjacent uplands or otherwise ensure long-term protection.

Important nesting beaches and adjacent upland buffers should be acquired through fee title acquisition. Conservation easements and development rights should be acquired on properties where fee title acquisition is not possible.

2321. Acquire additional beachfront and upland properties (undeveloped and developed) within the boundaries of the Archie Carr National Wildlife Refuge, Florida.

About 60% of the available beachfront acquisitions for the Archie Carr NWR have been completed. Approximately 9.2 km (5.7 miles) (of which approximately 8.0 km (5.0 miles) are within the original acquisition boundary) have been acquired and about 1.9 km (1.2 miles) remain undeveloped and are awaiting purchase. The remaining lands have been purchased for private development and are no longer available. Escalating coastal development in Brevard and Indian River Counties threatens the remaining parcels identified for acquisition. Ongoing development continues to fragment the remaining habitat, and a narrow window of opportunity is left to acquire the last remaining lands required for the Refuge.

Efforts should also be made to acquire beachfront properties adjacent to the Refuge boundaries, including both undeveloped and developed parcels, as well as coastal strand, scrub, and maritime hammocks to the west of the Refuge, which would not only protect some of the most fragile and endangered natural upland communities in Florida and the nation, but also protect the nesting beaches from artificial lighting encroachments and other human impacts.

2322. Acquire additional beachfront and upland properties (undeveloped and developed) on Hutchinson Island, Florida, and develop a plan to ensure long-term protection.

Approximately 10% of loggerhead nesting in the U.S. occurs along this 37-km (22.9-mile) beach. Development is degrading nesting habitat and public use is greatly disturbing nesting activities. Threats should be evaluated and appropriate measures taken, including acquisition, to ensure long-term protection. FWS has already identified 3.2 km (2.0 miles) within this stretch of beach for inclusion as part of the Hobe Sound NWR; however, funding has not been allocated for this acquisition. High priority should be given to acquiring this parcel and other undeveloped and developed parcels on Hutchinson Island.

2323. Acquire additional beachfront and upland properties (undeveloped and developed) within the nesting range of the Peninsular Florida Recovery Unit and develop a plan to ensure long-term protection.

Other nesting beaches that contribute to the historic nesting distribution of the Peninsular Florida Recovery Unit should be acquired to ensure permanent protection.

2324. Acquire additional beachfront and upland properties (undeveloped and developed) within the nesting range of the Northern Recovery Unit and develop a plan to ensure long-term protection.

Other nesting beaches that contribute to the historic nesting distribution of the Northern Recovery Unit should be acquired to ensure permanent protection. Examples include properties on Bald Head Island and

Sunset Beach, North Carolina; Bay Point, South Carolina; and Little St. Simons, Georgia.

2325. Acquire additional beachfront and upland properties (undeveloped and developed) within the nesting range of the Northern Gulf Recovery Unit and develop a plan to ensure long-term protection.

Other nesting beaches that contribute to the historic nesting distribution of the Northern Gulf Recovery Unit should be acquired to ensure permanent protection. Examples include the area from Little Lagoon Pass west to the end of the Fort Morgan Peninsula in Alabama, and properties adjacent to the St. Joseph Peninsula State Park in Gulf County, Florida.

2326. Acquire storm-damaged nesting beachfront and upland properties on loggerhead nesting beaches.

In the U.S., the Federal Emergency Management Agency (FEMA) has a Hazard Mitigation Grant Program that takes a percentage of Federal money spent on recovering from a disaster, like a hurricane or tropical storm, and uses it for projects that reduce future risk. By law, FEMA can contribute 15 or 20% of a disaster's cost to this grant program. How this money is used is determined by the state where the disaster occurs. States may use the money for the acquisition of property, usually referred to as buyouts. Although buyout projects are 75% funded by FEMA, they are administered by state and local communities. State and local communities should work together to identify coastal areas where buyouts are most appropriate, acquire title to these properties, and set them aside as sea turtle conservation areas.

24. Develop a model that describes the effects of sea level rise on the nesting range of loggerheads.

Research has identified sea level rise as one of the most important potential impacts of global climate change. The best available science indicates that by 2100 South Florida seas will be approximately 20 inches higher than they were in 1990 (IPCC 2001). An increase of this magnitude would drastically alter the coastline, changing the extent, quality, and location of sandy beaches available for loggerhead nesting. In the short term, even small changes in sea level could be expected to exacerbate beach erosion and increase artificial beach/dune alterations meant to protect coastal properties.

A model is needed to describe the potential effects of sea level rise on loggerhead nesting beaches. An example of such a model might be a three dimensional GIS model describing mean high water locations relative to permanent manmade structures such as buildings and roadways. An important prediction of the model would be short-term effects on the erosion classification of beaches. Erosion classifications predicted would be defined by beach changes that would bring about needs for beach nourishment, dune reconstruction, and coastal armoring. An ultimate goal of the model would be to predict the extent, suitability, and locations of loggerhead nesting beaches during the coming 2 to 3 loggerhead generation lengths (90 to 135 years).

25. Minimize effects of beachfront light pollution on hatchlings and nesting females.

251. Develop, fully implement, and effectively enforce light management plans on nesting beaches to ensure that the annual percentage of total nests with hatchlings affected (disoriented, misoriented) by artificial lighting does not exceed 5%.

Five percent was chosen as a goal because it has been met on many developed beaches. Light management plans should meet minimum standards identified in the Florida Model Lighting Ordinance (Witherington and Martin 2000).

2511. Implement and enforce lighting ordinances on lands under local government jurisdiction.

Where lighting ordinances have been adopted and adequately enforced, hatchling disorientation has been managed at acceptable levels. All coastal counties and communities with nesting beaches should adopt and fully enforce ordinances from March through October in Brevard through Broward Counties, Florida, and from May through October elsewhere. The State of Florida's Model Lighting Ordinance [http://myfwc.com/seaturtle] should be used as a template for developing new or revising existing lighting ordinances. In addition, Port Authorities should develop and enforce lighting management plans to ensure their direct and indirect lighting does not impact nesting and hatchling turtles on nearby beaches.

2512. Implement and enforce lighting management plans on all lands under state and Federal jurisdiction.

Light management plans should be implemented and enforced on all state and Federal properties where the potential for lighting impacts to nesting and hatchling sea turtles exists.

252. Evaluate the extent of hatchling disorientation on nesting beaches based on standardized surveys.

Many lighting ordinance requirements do not become effective until 11 p.m., whereas over 30% of hatchling emergence occurs prior to this time. Hatchling disorientation problems should be evaluated on all beaches to ensure lighting management efforts are successful in eliminating sea turtle disorientation events. Standardized surveys for disorientation events should be developed or refined, comprehensively implemented, and findings should be used to identify problem areas where light management efforts should be targeted.

253. Prosecute individuals or entities responsible for hatchling disorientation under the Endangered Species Act or appropriate state laws.

Law enforcement efforts should be focused where lighting ordinances are not being implemented or adequately enforced and where flagrant and repeated violations are not corrected.

26. Conduct other activities to improve the quality of nesting habitat.

261. Encourage the manual removal of manmade beach debris through regular coastal cleanup programs.

Local governments and other responsible entities should organize individuals to participate in regular coastal cleanup programs, such as The Ocean Conservancy's International Ocean Cleanup and others organized locally.

262. Remove exotic vegetation harmful to loggerheads on and adjacent to nesting beaches.

Removal of exotic vegetation that is ongoing at the St. Lucie Inlet State Park, Hobe Sound NWR, and Dry Tortugas National Park in Florida should continue. Other important nesting beaches where exotic vegetation is degrading nesting habitat should be identified and natural vegetation should be restored. In North and South Carolina, the efforts of the Carolina Beach Vitex Task Force, which was established to document and eradicate beach vitex from loggerhead nesting beaches, should be continued.

27. Inventory and protect neritic habitats used by loggerheads.

Loggerheads are distributed throughout the neritic habitat of the continental shelf including nearshore, inshore, and estuarine waters of the Atlantic, Greater Caribbean, and Gulf of Mexico. Where the continental shelf does not exist (e.g., Greater Caribbean), the neritic habitat includes the marine environment to water depths less than 200 m. Loggerheads are opportunistic foragers that frequently feed around coral reefs, rocky places, and boat wrecks, and often enter bays, lagoons, and estuaries. Little information on habitat preference of specific age/size/sex classes is available. To effectively protect the species, habitat research should be conducted. A comprehensive strategy to identify habitat preference and use needs to be developed and implemented.

Habitats requiring protection need to be identified and prioritized with respect to urgency of needing protection, and then appropriate action taken to ensure protection.

271. Assess, categorize, and map neritic habitats used by loggerheads.

Review and collate existing data and gather additional data where necessary to locate and describe the type, quantity, and quality of available habitats throughout the neritic range. There have been a number of Federal and state initiatives to map habitat types in the marine environment. These databases need to be synthesized and integrated with respect to what is known about loggerhead habitat use (see action 29).

Existing data need to be identified and synthesized using GIS based habitat maps. New initiatives to evaluate habitat use need to be supported to identify neritic habitat use by loggerheads (e.g., seasonal foraging locations, developmental and reproductive corridors, inter-nesting, courtship and mating).

272. Assess human activities and their effects on neritic habitats used by loggerheads.

Coastal development and associated changes in land utilization have led to severe degradation of habitat through contamination and/or loss of food sources in estuarine and marine waters. Declines in water quality resulting from industrial pollution, channel dredging and maintenance, harbor activities, farm runoff, and sewage disposal have rendered large water bodies marginally habitable. Appropriate minimum water quality standards should be researched, established, and enforced. Land use decisions and associated construction projects also should be carefully considered by regulatory and permitting agencies.

2721. Assess the effects of bottom trawl and dredge fisheries on neritic habitats used by loggerheads.

Bottom tending fishing gears can be destructive to a wide variety of habitats. Coral reefs, other live bottom habitats, and seagrass beds are particularly vulnerable to destruction from these types of fishing gears. The potential loss of habitat from these activities should be evaluated and appropriate actions taken to ensure long-term protection of reefs and other habitats important to loggerheads.

2722. Assess the effects of eutrophication on neritic habitats used by loggerheads.

Excessive nutrient pollution in coastal waters can degrade loggerhead foraging habitats. The presence of harmful algal blooms and associated biotoxins may influence distribution and abundance of food resources.

An assessment of the effects of eutrophication on loggerhead foraging habitat should be conducted.

2723. Assess the effects of water management on neritic habitats used by loggerheads.

The timing, volume, and quality of freshwater inputs to coastal systems may have profound effects on loggerhead foraging habitats. Associated changes (e.g., salinity, nutrients, turbidity) may affect the distribution and abundance of loggerhead prey.

2724. Assess the effects of oil and gas production activities on neritic habitats used by loggerheads.

Oil exploration and development may disrupt the availability of food resources by smothering benthic organisms with sediments and drilling muds. Some sediments may contain heavy metals or other contaminants. The distribution and magnitude of oil production-related impacts and their effects on loggerhead populations should be assessed.

2725. Assess the effects of channel dredging on neritic habitats used by loggerheads.

Channel dredging projects may have greater impacts on habitat than the obvious mechanical destruction of the channel bottom. Channelization can alter natural current patterns, disrupt sediment transport, and suspended materials from dredging may severely damage adjacent corals and seagrasses. Additionally, disposal of dredged materials in offshore disposal sites usually smothers existing flora and fauna. Regulatory agencies should carefully consider the potential environmental consequences before permitting any new channel dredging projects or designating new offshore disposal sites.

2726. Assess the effects of salvage operations on neritic habitats used by loggerheads.

Efforts to salvage valuable artifacts from shipwrecks commonly entail extensive excavation of the sea floor. This type of excavation may damage reefs, destroy benthic organisms, and increase local turbidity that may damage adjacent habitat. Efforts are needed to evaluate the effects of salvage operations on loggerhead habitats.

2727. Assess the effects of other human activities on neritic habitats used by loggerheads.

A host of other human activities, both direct and indirect, may affect neritic habitats that loggerheads use. Damage to seagrass, coral reef, and hardbottom habitats results from propeller and anchor damage. The widespread harvest of sand from neritic habitats for beach nourishment projects significantly alters large areas of neritic habitat and may damage adjacent habitats and their benthic organisms. Artificial reef placement has not been evaluated sufficiently to determine the effects of these programs on loggerheads. Upland and beachfront development and infrastructure can increase freshwater runoff, increase contaminant loads in such runoff, and alter nearshore habitats. The direct and indirect effects of these human activities on neritic habitats must be evaluated to understand their potential effects on loggerhead recovery.

273. Develop and implement a strategy to protect and monitor neritic habitats used by loggerheads.

Long-term protection of neritic habitats, extensively used by loggerheads, is essential to an effective recovery program for this species. A strategy for evaluating and prioritizing habitats requiring protection is needed. Integrating this task with efforts to map sea turtle distribution and movements in a GIS environment will be necessary. Key threats affecting the various habitats should be identified and prioritized as to their actual/potential effects on loggerhead recovery and conservation. Change to existing local, state, or national legislation and/or regulations should be considered and implemented, as necessary to ensure the long-term health, viability, and protection of these essential neritic habitats.

28. Inventory and protect oceanic habitats used by loggerheads.

The oceanic habitat is the vast open ocean environment where bottom depths exceed 200 m. This habitat is characterized by bathymetric features (e.g., seamounts, banks) and dynamic oceanographic processes (e.g., fronts, convergence zones, eddies). The oceanic stage is primarily pelagic and occupies the upper 100 m of this habitat, although occasionally may be benthic in areas of seamounts and shallow banks.

281. Assess, categorize, and map oceanic habitats used by loggerheads.

Review and collate existing data and gather additional data where necessary to locate and describe the type, quantity, and quality of available habitats throughout the oceanic range. There have been a number of international and global initiatives to map sea turtle distributions in the marine environment based on telemetry research and fisheries bycatch studies. These databases need to be synthesized and integrated with respect to current knowledge of loggerhead habitat use (see action 29).

Existing data need to be identified and synthesized using GIS based habitat maps. New initiatives to evaluate habitat use need to be supported to identify oceanic habitat use by loggerheads (e.g., juvenile foraging and developmental locations, adult foraging locations, seasonal distributions, migratory and reproductive corridors).

282. Assess human activities and their effects on oceanic habitats used by loggerheads.

Oceanic habitats important to loggerheads can be affected and severely degraded by human activities (e.g., oil and gas exploration and transportation, marine debris, marine pollution, toxic wastes). These environmental stressors can cause habitat alterations that are both structural and functional and frequently result in food web alterations and trophic shifts. Human activities that affect oceanic habitats extensively used by loggerheads should be carefully regulated by both national and international authorities.

2821. Assess the effects of oil and gas activities on oceanic habitats used by loggerheads.

Oil and gas activities may negatively impact sea turtle oceanic habitats primarily during exploration, production, and transport phases. Of particular concern are impacts of oil spills, disposal of toxic materials, and increased vessel traffic. Areas in which sea turtle distribution and seasonal use of marine habitats overlap with oil and gas development should be identified. MMS, appropriate international conventions, and the oil and gas industry should ensure that impacts to sea turtles are adequately addressed during planning of oil and gas development and that known sources of pollution and toxic waste disposal are eliminated. Additional precautions are needed to prevent oil spills. A team, with expertise in sea turtles, should be established to respond to oil spills.

2822. Assess the effects of marine debris on oceanic habitats used by loggerheads.

Marine debris accumulates in oceanic habitats and can interfere with foraging activities of sea turtles. Quantities and types of marine debris should be monitored in oceanic habitats. Sources of the debris (e.g., onshore, military ships, cruise vessels, cargo ships) should be identified where possible so that appropriate agencies can be encouraged to address the problem. MARPOL and other conventions addressing marine debris should be strictly enforced.

2823. Assess the effects of toxins and other pollutants on oceanic habitats used by loggerheads.

A wide range of toxins and pollutants from vessels, pipelines, terrestrial run-off, and airborne pollutants can affect oceanic habitats through changes in water quality or food availability. Research is needed to assess the risks from these toxins. Areas in which loggerhead oceanic habitats overlap with areas at high risk of toxic spills should be identified. Contingency plans should be developed to clean up toxic areas.

283. Develop and implement a strategy to protect and monitor oceanic habitats used by loggerheads.

Long-term protection of oceanic habitats extensively used by loggerheads is essential to an effective recovery program for this species. A strategy for evaluating and prioritizing habitats requiring protection is needed. Integrating this task with efforts to map sea turtle distribution and movements in a GIS environment will be necessary. Key threats affecting the various habitats should be identified and prioritized as to their actual/potential effects on loggerhead recovery and conservation. Changes to existing international agreements should be considered and implemented, as necessary, to ensure the long-term health, viability, and protection of these essential oceanic habitats.

29. Develop and maintain a comprehensive GIS database of neritic and oceanic habitats (used by loggerheads) and human activities that impact these habitats.

Based on the comprehensive GIS database of the distribution and abundance of loggerheads (see action 141), habitat requirements for loggerheads should be defined and a GIS database of all potential habitats should be developed. All human activities that can negatively impact these habitats should be included in the database so that maps of these activities can be overlaid on potential loggerhead habitats. These activities would include fisheries that degrade loggerhead habitat (e.g., bottom trawls), point sources of pollution (e.g., oil rigs), and shipping lanes.

3. Prevent overutilization for commercial, scientific, or educational purposes.

Although the potential for overutilization of loggerheads for scientific and educational purposes is probably minimal, controls are necessary to insure that overutilization does not occur. However, legal harvest of loggerheads outside of U.S. waters remains substantial and continues to present a threat to the species (see Appendix 3).

31. Work with foreign nations to quantify and minimize commercial and subsistence harvest.

The extent of legal harvest (commercial and subsistence) of loggerheads in the Atlantic, Caribbean, and Mediterranean needs to be quantified. Efforts should be undertaken to minimize legal harvest through international agreements, bilateral efforts, capacity building, and education.

32. Educate local peoples in foreign nations on the economic benefits of sea turtle ecotourism as an alternative to harvest.

Environmentally responsible ecotourism has been used by local communities to support sea turtle conservation activities, change human behavior to reduce threats from human activities, and provide economic benefits that filter throughout the community. In addition to the economic gains from the ecotourism activity itself (e.g., through donations for being taken out to see nesting sea turtles by a trained biologist), the local community as a whole has the potential to benefit economically through increased use of local businesses (e.g., hotels, shops, restaurants) by ecotourists. Efforts should continue to educate local peoples in foreign nations on the potential economic benefits of environmentally responsible sea turtle ecotourism as a more sustainable alternative to harvest.

33. Develop and implement guidelines for public turtle walks that minimize disturbance to loggerheads.

Human disturbance of female loggerheads attempting to nest has been shown to cause turtles to shift nesting locations, delay egg deposition, and choose poor nesting sites. Organized, permitted loggerhead walks provide a unique opportunity for the public to view nesting loggerheads in a manner that minimizes the likelihood of impacts and raises their awareness about threats to sea turtle survival. In areas where human disturbance of nesting sea turtles is a concern, state resource agencies should encourage the establishment of organized, permitted loggerhead walks and develop new or maintain existing turtle walk guidelines for permittees conducting walks. This should help reduce the number of unsupervised individuals that go out on the beach at night to observe and inadvertently harass turtles.

34. Minimize take of wild turtles for captive display.

The number of healthy wild loggerheads taken into captivity for educational display should be minimized by encouraging the display of non-releasable loggerheads and temporary loans of turtles from other captive facilities.

4. Assess and manage disease and predation.

41. Reduce nest predation.

411. Reduce the annual rate of mammalian predation to at or below 10% of nests within each recovery unit using ecologically sound predator control programs.

Both nonlethal and lethal predator control methods (e.g., nest screening, nest caging, humane trapping and removal) should be explored to determine which methods are the most ecologically sound and will work best for the target predators and the beach habitat under consideration. Individual problem animals can be targeted and removed without negatively affecting the local populations of native species. Populations of feral hogs should be eliminated if possible. All control measures should be implemented in accordance with ecologically sound and humane practices and applicable Federal and state laws. The mammalian predation rate target of 10% or below should be evaluated on all nests or on a random and representative sample of nests based on standardized or index surveys.

412. Control fire ants on and adjacent to sea turtle nesting beaches.

The red fire ant is native to Brazil and arrived in the U.S. in the 1940s. It now occurs in 10 U.S. states/territories where sea turtles nest and has been documented as a predator on sea turtle eggs and hatchlings. More recently, the red fire ant has moved into Mexico. Given the widespread distribution and continuing expansion of fire ants in coastal areas, their impact on sea turtle nests and hatchlings merits greater attention. Monitoring the impacts of fire ants on sea turtles should be undertaken to determine the extent of the problem. Impacts should be reduced using ecologically sound methods (e.g., use of ecologically appropriate baits) to control fire ant populations. In addition, efforts should be made to educate the public about the proper disposal of fish carcasses and other garbage that can promote fire ant infestation. Proper disposal would include off-beach burial and composting.

42. Develop diagnostic health assessment protocols and establish baselines for wild populations.

Standardized health assessment tools are needed to monitor the health of wild sea turtle populations. Once such tools are established, loggerhead populations could best be monitored at a network of neritic and oceanic sampling sites that represents the geographic range as well as oceanic and neritic loggerhead life history stages.

421. Develop a condition index to allow rapid evaluation of physiological status.

A rapid method of estimating the physiological status/condition of wild loggerheads is needed. Methods by which this may be done include traditional mass/length condition indices, visual estimates of fat reserves in the axillary areas, and epibiotic load.

422. Develop protocols for collecting, handling, and analyzing baseline blood chemistry parameters from wild loggerheads.

Blood is a very fragile tissue and must be handled in a careful and consistent manner. Strict, standard protocols for collecting, handling, and analyzing blood chemical parameters must be developed. These standards are necessary for assessing and comparing life-stage, geographic, and seasonal differences in blood chemistries. Researchers must report how blood was collected and handled prior to analysis.

423. Establish representative baseline blood chemistry parameters by sex, size class, season, and location.

Baseline blood chemistry parameters can be used to assess the physiological status of loggerhead populations. However, to be able to use blood chemistry parameters, representative baselines need to be established for each life stage (oceanic vs. neritic), size class, sex, and season. Changes in habitat, temperature, and diet, as well as sex of the individual, may affect blood biochemical parameters.

424. Establish representative baseline toxicological parameters by sex, size class, season, and habitat.

Known toxics, such as heavy metals and halogenated hydrocarbons, should be monitored in loggerhead tissues particularly in habitats where such pollutants have been identified as potential threats. In addition, representative tissue samples, particularly of live turtles and gonads, should be archived for future analysis for formerly unrecognized toxics. Such tissues could be collected from fresh dead strandings or through laparoscopic biopsy on live turtles.

425. Establish representative baseline levels of parasitic infection in wild turtles.

Baseline levels of parasitic infections, including both external and major internal parasites, should be established. Principal external parasites include barnacles and leeches. Whereas external parasites can be observed on living and dead stranded turtles, detection of internal parasites (principally diagenean trematodes) requires necropsy of fresh dead animals.

426. Establish representative baseline levels of bacterial, fungal, and viral infections in wild turtles.

Baseline levels of bacterial, fungal, and viral infections in natural populations of loggerheads should be established. Causes of mass die-offs can only be evaluated if these baselines are available. This information would also allow rapid assessment of health of wild populations and evaluation of potential disease hazards from releasing captive turtles into the wild.

43. Develop and implement a program to monitor loggerhead health at representative in-water index sites and index/standardized nesting beaches.

A protocol should be established to assess and monitor parasite loads, infectious agents, fibropapillomatosis, and other diseases in loggerheads at index sites. In the case of fibropapillomatosis, the protocol will, by necessity, be limited to external examination and will include identifying numbers, locations, and sizes of tumors. The protocol should be incorporated into index site monitoring plans. If tumors are identified in a population, the assessment should be expanded to include collections of tumor tissue or blood samples after consultation with a veterinarian. In the case of other diseases, blood samples, swabs, and external examination should be used to detect parasites, microbial infection, and other disorders.

44. Evaluate the effects of harmful algal blooms on loggerhead health.

Toxic dinoflagellate blooms have adverse effects at several levels of marine trophic systems and could have potentially lethal effects on loggerheads. Perhaps of even greater importance are insidious sublethal effects, which may be becoming more widespread because of more frequent algal blooms in the coastal zone associated with increased eutrophication. As a result, there is a need to better evaluate the effects of harmful algal blooms on loggerhead health.

45. Investigate the lethal and sublethal role of contaminants.

Organochlorine contaminants, pesticides, and heavy metals have all been detected in sea turtles and sea turtle eggs, but their effects on sea turtles are relatively unknown. Researchers have also collected baseline information on heavy metal contamination in loggerhead populations at several locations throughout the southeast U.S. Heavy metals have been recorded in the tissues of stranded turtles and eggs. Phthalate esters, which are used in the manufacture of plastics and are known to cause mutations and cancer, have also been found in sea turtle eggs. Further studies are required to determine the precise causal relationships between these contaminants and health effects in sea turtles.

46. Develop and implement protocols for handling turtles to limit transfer of disease.

Protocols for handling sea turtles should be developed so as to minimize the chance of transmitting diseases among captive animals and particularly from captive to wild turtles.

47. Ensure the use of best practices in the rehabilitation, captive holding, transportation, and release of loggerheads.

471. Develop and/or finalize protocols for the proper care and maintenance of loggerheads held in captivity.

Loggerheads are maintained in captivity for rehabilitation, research, or educational display. Proper care will ensure that the maximum number of rehabilitated turtles is returned to the wild and that the minimum number is removed from the wild for research or education purposes. Appropriate research should be conducted to develop and/or improve captive holding criteria. Guidelines should be formalized that will serve as minimum requirements for sea turtles held in captivity in the U.S. These criteria should be published and required for any permit to hold sea turtles in captivity and should include appropriate annual inspections. Captive guidelines should include requirements relative to tank size, lighting, water quality, water quantity, foods and feeding, behavior and intermixing of stock, and veterinary care to ensure turtles are held in a humane manner.

472. Develop protocols for transport and release of captive loggerheads.

Protocols should be developed for the transporting and releasing turtles back into the wild in a manner that minimizes risk to the wild population. Protocols for releasing captive loggerheads into the marine environment must strive to ensure that disease transmission does not occur and that turtles are returned to the appropriate habitat. Objective criteria should be developed to determine whether captive-raised or long-term exhibit turtles are suitable for release into the wild (i.e., capable of performing normal foraging behavior and local movements or migrations), as well as to determine when rehabilitated turtles are sufficiently recovered to survive after release. If a captive animal is deemed suitable for release, protocols should be developed to determine how the potential for disease transmission can be avoided. Release locations should be chosen to maximize survivorship and consideration should include both habitat and seasonal factors.

473. Develop a manual for the assessment and treatment of loggerhead diseases and injuries.

Although some information is available on sea turtle rehabilitation (e.g., Campbell 1996, George 1997, Herbst 1999, Walsh 1999, Whitaker and Krum 1999), a more comprehensive manual on the diagnosis and treatment of disease problems associated with captive and wild sea turtles should be developed. This manual should include treatment for common injuries. This will improve rehabilitative success and captive care of research and display turtles.

474. Develop and maintain a list of veterinarians qualified to diagnose and treat health problems in loggerheads.

A national registry of veterinarians qualified to diagnose and treat sea turtles should be established and made available on appropriate agency websites. The list should be updated annually.

48. Develop a strategy to recognize, respond to, and investigate mass strandings, disease episodes, or unusual mortality events.

A formalized strategy is needed to facilitate rapid response to and investigation of unusual mortality events (mass strandings, disease episodes, or other extraordinary stranding events). The response strategy should outline key elements including determination of an unusual stranding event, establishment of regional rapid response teams, data and sample collection and analysis protocols, budgetary needs, and interagency coordination procedures.

5. Ensure adequacy of regulatory mechanisms.

51. Develop, implement, and enforce regulatory mechanisms to protect loggerheads and their habitats in the U.S.

Loggerheads are exposed to and threatened by a plethora of anthropogenic activities. Impacts from these activities directly injure and kill loggerheads, disrupt necessary behaviors, and alter terrestrial and marine habitat used by the species. Appropriate regulatory control is the most effective means of minimizing the negative effects of these human activities. In order to promulgate and enforce effective regulations, the regulatory infrastructure must be in place to provide for the implementation of conservation regulations.

511. Develop and implement Federal regulations to ensure long-term protection of loggerheads and their habitats post-delisting.

Loggerheads are long-lived, late maturing species with little capacity to withstand extraneous mortality beyond natural levels. In addition, many of the coastal and all beach nesting habitats necessary for loggerhead survival are extremely vulnerable to anthropogenic perturbations. Consequently, loggerheads and their key habitats should remain protected even after delisting in order to avoid rapid population relapse.

512. Ensure full and active enforcement of Federal regulations designed to protect loggerheads.

Adequate regulatory authority exists under the ESA to protect loggerheads; however, resources for both Federal and state enforcement are woefully lacking. Law enforcement activities critical to the recovery of loggerhead populations include the enforcement of fishery and marine conservation regulations and criminal investigations of poaching and harassment. Currently, Federal and state agencies lack the resources and personnel necessary to ensure compliance with fishery regulations. In some cases, officers do not have sufficient training to interpret complex fishery regulations. Additional resources are necessary to ensure officers are properly trained and personnel are sufficiently numerous to ensure compliance with fishery regulations.

513. Develop and/or maintain, implement, and enforce state and local legislation to protect loggerheads and their habitats.

State and local governments should regulate activities impacting sea turtles and their nesting habitat. For example, local lighting ordinances and coastal construction regulations should be developed and/or maintained to protect loggerheads.

52. Ensure adequacy of regulatory mechanisms to protect loggerheads and their habitats in foreign nations.

There is compelling evidence that post-hatchling loggerheads from U.S. nesting beaches spend several years as juveniles in a transatlantic developmental stage. In the northeastern Atlantic (Madeira, Azores, and Canary Islands), small juveniles are exploited for curios and food. Larger juveniles are common throughout The Bahamas where exploitation for food also is common. Populations in coastal waters of Cuba and Hispaniola undoubtedly include loggerheads originating from U.S. recovery units. Protecting loggerheads on U.S. nesting beaches and in U.S. waters, therefore, is not sufficient alone to ensure the continued existence of loggerheads. Cooperative international agreements and programs should be developed with the governments of The Bahamas, Cuba, Dominican Republic, Haiti, Portugal, Spain, and other countries where loggerheads originating from U.S. nesting populations occur.

521. Assist foreign countries in developing national regulations to protect loggerheads and their habitats.

Loggerheads are exposed to and threatened by a plethora of anthropogenic activities. Impacts from these activities directly injure and kill loggerheads, disrupt necessary behaviors, and alter terrestrial and marine habitat used by the species. Appropriate regulatory control is the most effective means of minimizing the negative effects of these human activities. In order to promulgate and enforce effective regulations, the regulatory infrastructure must be in place to provide for the implementation of conservation regulations.

522. Assist foreign countries with enforcement of national regulations to protect loggerheads.

A necessary and integral component of any regulatory action is the capacity to enforce such regulations. As appropriate, the U.S. should help foreign nations build capacity for enforcement of conservation laws aimed at protecting loggerheads.

53. Encourage development of and participation in multi-national agreements that facilitate conservation of loggerheads and their habitats.

531. Encourage non-signatory nations of the western hemisphere to accede to the Inter-American Convention for the Conservation and Protection of Marine Turtles.

The IAC holds significant promise for facilitating the conservation of loggerheads in the western hemisphere. However, to be fully effective, all nations hosting populations of loggerheads in the region must accede to the Convention. Of particular note are the non-signatory nations of Cuba and The Bahamas, which provide important foraging and migratory habitat for significant numbers of neritic loggerheads. Efforts should be continued and strengthened to encourage key non-signatory nations to accede to the IAC.

532. Encourage non-signatory nations to accede to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartegena Convention), specifically the Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean (SPAW Protocol).

Within the Wider Caribbean, the SPAW Protocol of the Cartagena Convention is an important diplomatic tool that can enhance loggerhead conservation and recovery in the region. The U.S. should expand its role in implementing the SPAW Protocol and explore opportunities to facilitate loggerhead recovery in the region through this avenue. Key non-signatory nations, notably The Bahamas, should be encouraged to accede to the Convention and relevant Protocols.

533. Ensure the U.S. becomes a party to the United Nations Convention on the Law of the Sea and the Convention on Migratory Species.

The United Nations Convention on the Law of the Sea contains treaty text specifically focused on conservation and management of living marine resources and protection of the marine environment. The U.S. is not currently a party to the Convention. Acceding to the Convention would provide the U.S. with another multi-lateral instrument within which to facilitate recovery of the loggerhead across its range.

The U.S. is not currently a party to the Convention on Migratory Species, although the U.S. has signed two sea turtle-specific Memoranda of Understanding negotiated under the auspices of the Convention. Acceding to Convention, and encouraging key nations within the range of the loggerhead to accede, could provide additional avenues for facilitating loggerhead recovery in the international arena.

6. Minimize other causes of disturbance, harassment, injury, and mortality.

61. Minimize impacts to sea turtles on nesting beaches.

611. Eliminate nest management techniques that are not scientifically based.

A management plan that outlines appropriate strategies and standardized protocols for protecting nests from both natural and manmade impacts is needed to ensure biologically sound management practices are employed.

6111. Evaluate the effects of nest management activities on nest productivity, hatchling fitness, and sex ratios and develop scientifically based standardized protocols for nest management.

The effects of nest management activities (e.g., nest relocation, nest screening) and natural factors (e.g., nest washovers) on nest productivity, hatchling fitness, and sex ratios should be evaluated. Tidal inundation can diminish hatching success depending on frequency, duration, and developmental stage of embryos. The extent to which eggs can tolerate tidal inundation should be better measured to enable development of guidelines for nest management relative to tidal threats. Similarly, the impacts of nest relocation under varying scenarios should be evaluated to determine whether nest relocation might be an appropriate management tool. Resource agencies should support research to evaluate the impacts of nest management activities and natural factors on nests and hatchlings.

The effects of nest screening and caging on hatchling navigation and homing behavior should be evaluated as well. Irwin *et al*. (2004) found that galvanized wire mesh cages measurably alter the inclination angle and intensity of the magnetic field beneath them, but that the magnitude of field distortions decreased with distance below the cage. One hypothesis is that hatchlings imprint on magnetic features of the natal beach and use them as cues in homing to their natal beaches as adults. If such magnetic imprinting occurs, then the use of wire screens and cages poses a potential risk of disrupting magnetic navigation.

Based on the findings of research, recommendations for nest management should be developed.

6112. Implement scientifically based standardized protocols for nest management.

Implement the recommendations for nest management developed under 6111.

6113. Use the least manipulative method to protect nests.

Until such time as a management plan for protecting nests is developed, the least manipulative method should be employed to protect nests. Because the incubation environment greatly influences the developing embryo, nest relocation can involve the transfer of eggs from an appropriate environment to an inappropriate one. As a general rule, nests should only be relocated if they are low enough on the beach to be washed daily by tides or if they are situated in well documented high-risk areas that routinely experience serious erosion and egg loss (e.g., nests laid near river mouths or beneath eroding sea walls).

Natural events, like storms, that accelerate beach erosion and accretion can sometimes reduce hatching success in existing nests. While damage from storm events can be severe, it is difficult to predict the precise areas where the storm is most likely to inflict damage. Because of the negative effects of relocating eggs and the unpredictability of storm events, nests should not be moved out of areas threatened by storms.

Nests should not be relocated in areas where heavy foot traffic, lighting problems, or beach cleaning are a concern. Foot traffic generally is not a problem for nests, but depending on the nesting substrate, pedestrian traffic over nests near the time of emergence can cause the nests to collapse and result in hatchling mortality. Therefore, in areas where foot traffic is heavy, nests can be marked so pedestrians can avoid them. If a nest is made near a light that may misorient the hatchlings, efforts should focus on getting the light turned off or shielded (if protection is necessary, the nest should be caged). If nests are deposited on beaches that are periodically raked with mechanical equipment, beach raking should be discontinued or the nests should be marked clearly so they can be avoided by the beach cleaners.

6114. Discontinue the use of hatcheries as a nest management technique.

Relocation of sea turtle nests to hatcheries located higher on the beach was once a common practice throughout the southeast U.S. to mitigate the effects of naturally occurring events, such as erosion and vegetation encroachment, predation, and a variety of human-induced factors. In some areas, the extent and type of coastal development have resulted in significant light pollution problems. As a result, a few hatcheries are still used to protect hatchlings from disorientation. However, relocating nests into hatcheries concentrates eggs in an area and makes them more susceptible to catastrophic events and predation from both land and marine predators. Therefore, in areas where hatcheries are still being used to protect nests and hatchlings from light pollution, management efforts should be shifted to eliminate the lighting problems and phase out the use of hatcheries. At Cape Romain NWR in South Carolina, hatcheries are being used as a last resort in response to severe erosion. In this case, the conservation benefits (i.e., embryo survivorship) are believed to outweigh the potential conservation risks (e.g., hatchling predation). Given these circumstances, the use of hatcheries is currently considered appropriate until sufficient habitat for successful incubation is available. Continued use of hatcheries on the refuge should be based on periodic quantitative assessments of their effectiveness as a management tool.

612. Minimize and control vehicular traffic on nesting beaches.

Driving exists on some Florida, Georgia, North Carolina, and Texas beaches, including National Seashores. The effects of vehicular traffic on nesting activities should be evaluated, and a plan should be developed to minimize the effects of beach driving on nesting beaches.

6121. Prohibit nighttime driving on beaches during the loggerhead nesting season.

Vehicles on the beach have the greatest potential to come into contact with nesting females and emerging hatchlings at night. In areas where beach driving is still allowed, nighttime vehicle use should be limited to essential vehicles (e.g., emergency or permitted research vehicles) only. When essential vehicles are allowed on the beach at night during the sea turtle nesting season, their potential for harming turtles should be minimized by driving at speeds of 5 miles per hour or less (except when higher speeds are necessary for law enforcement, human safety, or medical emergencies), and by driving seaward of the wrack or debris line or just above it during high tide conditions. In addition, regardless of the time of year, vehicles or equipment driven or used on the beach should be equal to or less than 10 pounds per square inch (psi) based on ground loading characteristics (e.g., all terrain vehicles) to minimize the potential for sand compaction.

6122. Ensure that the linear kilometers of nesting beach where vehicular traffic is permitted does not increase above 2006 levels.

In the U.S., public vehicular traffic is still permitted on beaches in North Carolina, Georgia, Florida, and Texas. Efforts should be made to ensure that the linear extent of beach driving does not increase above 2006 levels (see below and in Section H.1. – Beach Vehicular Driving).

In North Carolina, public driving is allowed on the entire stretch of beach running north of the Town of Corolla to the Virginia state line (including the Currituck NWR and the Currituck Banks National Estuarine Research Reserve) due to the presence of beach homes in that area and the lack of roads to access them. Driving is also allowed on Cape Hatteras National Seashore, Cape Lookout National Seashore, and Fort Fisher State Recreation Area.

In Georgia, as a result of beach driving concerns on Cumberland Island National Seashore and other barriers islands, the GDNR adopted a regulation that only authorizes beach driving by individuals who are engaged in bona fide educational activities or scientific research, are a legal resident on the island, are involved in beach maintenance or security, and/or own or have an interest in real property on the island in question.

In 1985, the Florida Legislature severely restricted vehicular driving on Florida's beaches, except that which is necessary for cleanup, repair, or public safety. However, this legislation allowed an exception for six counties to continue allowing vehicular access on coastal beaches due to the availability of less than 50% of its peak user demand for off-beach parking. The counties affected by this exception were Volusia, St. Johns, Duval, Gulf, Nassau, and Flagler Counties, as well as limited vehicular access on Walton County beaches for boat launching. However, Flagler County passed an ordinance in 2004 that now bans public beach driving.

In Texas, driving occurs on nearly the entire Texas coast (as per the Texas Open Beaches Act). However, a highly developed section of South Padre Island is closed to beach driving, and closed beaches at Padre Island National Seashore, San Jose Island, Matagorda Island, and Matagorda Peninsula (south of the Colorado River) are only open to driving by agency personnel, land owners, and/or approved individuals (such as researchers).

Public and/or mission-related driving is also authorized on a few military installations (e.g., Naval Station Mayport, Tyndall Air Force Base, and Eglin Air Force Base in Florida; Camp Lejeune Marine Corps Base in North Carolina).

6123. Manage daytime driving to minimize impacts to loggerheads.

In addition to prohibiting nighttime driving of non-essential vehicles on the beach, other measures should be implemented to minimize the potential for impacts to sea turtles. Examples of minimization measures include the designation and enforcement of no-driving zones in areas where the greatest concentration of nests are typically located (e.g., conservation zones near the dunes), monitoring and marking of all sea turtle nests for avoidance, and developing and implementing a vehicle rut removal program seaward of nests during periods when hatchlings are expected to emerge.

613. Strengthen existing regulations or promulgate new regulations to manage mechanical beach cleaning on nesting beaches.

Special protective measures should be required during the nesting season to ensure that mechanized beach cleaning equipment does not harm sea turtles or sea turtle nests. In higher density nesting areas where marking every nest is not feasible, non-mechanical methods of cleaning, such as hand raking, should be employed. To protect nests, the following conditions should be required for beach cleaning activities: (1) cleaning should only occur seaward of the high tide line and only during daylight hours, (2) cleaning should only occur after an authorized sea turtle permit holder has surveyed the beach for nests, (3) all nests within 3.1 m (10 feet) of the high tide line should be marked by the sea turtle permit holder, (4) only equipment with less than 10-psi tire pressure should operate on the beach, (5) cleaning equipment should not penetrate more than 5.1 cm (2 inches) into the beach surface, (6) all material collected should be removed from the beach, and (7) cleaning equipment should stay at least 3.1 m (10 feet) from salt-tolerant vegetation.

The wrack line runs the length of the beach and marks the place where the tide reaches its highest point. Material in the wrack is an important component of beach stabilization and dune building. It acts in much the same way as a sand fence -- it slows wind velocity and causes sand to be deposited. When sand is blown over the wrack line by the wind, it falls out of the air and begins to accumulate around the wrack line. Efforts should be undertaken to educate the public about the benefits of allowing wrack material to remain on the beach.

614. Minimize harassment of nesting females and hatchlings.

Resident and visitor use of nesting beaches can adversely affect nesting sea turtles, incubating egg clutches, and hatchlings. Intentional and unintentional disturbance and harassment of nesting females and hatchlings is an increasing problem on many beaches. Problem areas where repeated incidents of turtle harassment have been reported should be identified, and law enforcement efforts should be focused there.

6141. Evaluate the extent and effects of harassment of nesting females and hatchlings and develop management recommendations.

The most serious threat caused by human presence on the beach is the disturbance of nesting females and hatchlings. This disturbance can cause turtles to abort nesting attempts, shift their nesting beaches, and select poor nesting sites. Campfires and flashlight use by pedestrians on nesting beaches at night can disorient hatchlings and deter nesting females. Efforts should be undertaken to determine the extent of these impacts on sea turtles, and protocols should be developed to minimize their effects.

6142. Conduct public education campaigns to minimize harassment of nesting females and hatchlings.

Resident and visitor use of nesting beaches can adversely affect nesting sea turtles and hatchlings. The most serious threat caused by human presence on the beach is the disturbance of nesting females. Disturbance of nesting females can cause them to leave the beach without finishing nesting and thus delay egg laying, shift their nesting beaches, and select poor nesting sites. Hatchlings rely on a store of energy and nutrients within their retained yolk sac to make their way from the nest to their offshore developmental habitat. Any delays they encounter on the beach by pedestrians may impair their ability to migrate offshore. Beachgoers should be informed through presentations and educational materials about the potential impacts to sea turtles from pedestrians on the beach and how to avoid frightening or disorientating any nesting and hatchling turtles encountered. In addition, signage at access points to the beach is recommended to further inform residents and visitors about proper nesting beach etiquette.

6143. Increase the number of interpretive turtle walks to meet demand and minimize overall disturbance to nesting females and hatchlings.

In the U.S., numerous state-permitted organizations conduct organized turtle walks to allow the public to view the nesting process. Thousands of coastal visitors and local residents attend these organized turtle watches each year; however, thousands more are turned away due to the limited number of walks available. As a result, numerous unsupervised individuals who were unable to get into a turtle walk often try to find turtles by themselves and inadvertently end up harassing them. Interpretive turtle walks also are a mechanism for garnering support for sea turtle conservation through education and should be expanded to accommodate the high public demand for participation.

6144. Enforce laws to minimize harassment of nesting females and hatchlings.

Intentional and unintentional disturbance and harassment of nesting turtles and hatchlings is an increasing problem on many beaches. Problem areas should be identified and law enforcement efforts should be focused in these areas to deter harassment of nesting turtles and hatchlings.

615. Develop and enforce guidelines for special events on the beach to minimize impacts on nesting females, nests, and hatchlings.

A wide variety of special events (e.g., volleyball tournaments, concerts) take place on the beach. Some of these events considerably increase the number of people and equipment in a given area. Many events are scheduled outside of the sea turtle nesting period, but some do occur during the nesting season. State resource agencies and local governments should develop and enforce guidelines for special events that will occur during the nesting season to ensure there will be no direct or indirect impacts on nesting turtles, nests, and emerging hatchlings.

616. Minimize the impacts of military activities on nesting females, nests, and hatchlings.

Several military bases in the southeast U.S. (e.g., Camp Lejeune Marine Corps Base, Naval Station Mayport, Cape Canaveral Air Force Station, Patrick Air Force Base, Tyndall Air Force Base, Eglin Air Force Base) have sea turtle nesting beaches. Activities on or near these beaches include a variety of military training activities, rocket launches, etc. During ESA section 7 consultations with the military on activities that may affect sea turtles, FWS should ensure the inclusion of appropriate reasonable and prudent measures to minimize incidental take of nesting females, nests, and hatchlings.

617. Ensure oil spills affecting nesting beaches do not impact nesting females, nests, and hatchlings.

Oil spills in the vicinity of nesting beaches just prior to or during the sea turtle nesting season could place nesting females, incubating egg clutches, and hatchlings at significant risk. A risk assessment and response plans are needed to ensure sea turtles are protected from nearshore spills.

6171. Conduct a risk management assessment of oil spill effects on nesting beaches.

A risk assessment of oil spill effects on sea turtle nesting beaches should be undertaken. The objectives of the risk assessment should focus on providing an independent assessment of the overall risks of oil pollution to nesting beaches, identifying key locations at risk, and determining the main causes of these risks. Spill scenarios should be modeled for ships in transit, ships in port waters, ships at berth, transfer operations at sea and at berth, and all offshore facilities. The risk model should be used to calculate risks based on historical accident rates from around the world. Based on the results of the risk assessment, recommendations should be made to protect key nesting beaches (e.g., by ensuring that oil ship traffic does not travel near these nesting beaches during the nesting season if appropriate).

6172. Ensure that oil spill response plans exist and adequately protect all nesting beaches.

A response plan should be developed and implemented to ensure appropriate actions are taken to minimize the likelihood of nesting females, hatchlings, and eggs coming into contact with oil when a spill occurs on or near a nesting beach. This plan should include recommendations, such as those mentioned in *Oil and Sea Turtles: Biology, Planning, and Response* (Shigenaka 2003), that address response considerations for nests that have been deposited on the beach prior to the oil spill, hatchlings emerging from nests in areas where oil is present on the beach and/or in the adjacent offshore area, and females attempting to emerge onto the oiled beach to nest.

618. Minimize the impacts of coastal construction activities on nesting females, nests, and hatchlings.

A variety of coastal construction activities (e.g., 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; dune restoration; and vehicular traffic and lighting associated with any of these activities) may affect sea turtles. These activities may alter nesting habitat and harm nesting females, nests, and hatchlings.

6181. Conduct all non-emergency coastal construction activities outside the main portion of the nesting season to eliminate impacts on nesting females, nests, and hatchlings.

Direct impacts to sea turtles from non-emergency construction activities (e.g., dune crossovers, groins, etc.) should be avoided by conducting these activities outside of the main portion of the nesting season. The main portion of the loggerhead nesting season is from May 1 to October 31 (other sea turtle species may broaden this nesting period).

6182. Strengthen existing regulations or promulgate new regulations to minimize impacts from emergency construction activities during the nesting season on nesting females, nests, and hatchlings.

Guidelines to minimize impacts from emergency construction activities that are allowed to take place during the nesting season should be developed and implemented by the state and local governments. Guidelines should include requirements such as (1) conduct sea turtle nesting surveys and mark all detected nests for avoidance; (2) conduct work from the upland portion of the property if practicable; (3) ensure heavy equipment (e.g., tracked or wheeled motorized machinery, such as bobcats, bulldozers, front-end loaders, etc.) is not operated on the beach if a reasonable upland alternative exists; (4) ensure heavy equipment that must be operated on the beach accesses the site as close to the construction site as possible and that a marked path, no wider than 15.3 m (50.0 ft) and running perpendicular to the beach from the dune to the high tide line, is used for beach access; (5) ensure that once on the beach equipment is only moved to and from the construction site along the wetted portion of the beach (i.e., below the previous high tide line); and (6) ensure that heavy equipment or construction materials are not stored on the nesting beach.

6183. Develop and implement ordinances to eliminate the effects of stormwater outfalls and swimming pool drainage on nesting females, nests, and hatchlings.

Stormwater runoff on nesting beaches is believed to be widespread in coastal communities; however, a comprehensive inventory of stormwater outfalls has not been compiled. Coastal communities should assess this threat and develop and implement actions to address the problem on sea turtle nesting beaches.

619. Ensure that law enforcement activities eliminate poaching of eggs and nesting females.

Although not a significant cause of nest loss in the U.S., poaching is occasionally a local problem. In other countries where loggerheads from Northwest Atlantic recovery units occur, illegal take has been reported but not quantified. Problem areas should be identified, and law enforcement efforts should be focused there to eliminate poaching.

62. Minimize loggerhead bycatch in domestic fisheries using a gear-based strategy.

Loggerheads are incidentally captured in many domestic commercial fisheries. The principal fisheries known to incidentally capture turtles are those employing trawls, gillnets, longlines, pots/traps, pound nets, hook and line, dredges, and seines. Captures of loggerheads in domestic commercial fisheries number in the tens of thousands annually; a substantial number of these turtles die. Reducing bycatch in these fisheries will require an integrated approach including measures such as gear modifications, changes to fishing practices, effort reduction, and time/area closures.

Current approaches to managing bycatch of loggerheads in domestic commercial fisheries have ranged from reasonably broad (e.g., TED requirements for shrimp trawls in the southeast U.S.) to fragmented and local and often are target species-based (e.g., prohibitions of certain gillnets in limited areas of Pamlico Sound). However, even in the case of TED requirements, fishers deploying the same or similar gear north of Cape Charles, Virginia, are not required to use TEDs, even though loggerheads are seasonally abundant there. A shift in approach to one that is primarily gear-based, and considers the effects of fishing gear on loggerheads throughout their range, will focus bycatch reduction efforts where they are most needed and will result in more comprehensive and effective solutions.

621. Minimize loggerhead bycatch in domestic commercial gillnet fisheries.

A comprehensive characterization of all gillnet fisheries in domestic waters should be completed to identify fishing areas, effort, gear characteristics, fishing practices, loggerhead bycatch data, and relevant regulations.

6211. Describe and characterize domestic commercial gillnet fisheries.

The geographic and temporal distribution of gillnet fisheries should be documented along the U.S. Atlantic coast, as well as in other countries where loggerheads from Northwest Atlantic recovery units occur. Details as to mesh sizes, target species, etc. should be included.

6212. Integrate information gathered in 6211 with turtle distribution data (linked to actions 141 and 29).

A comprehensive GIS integrating domestic commercial gillnet fishery and turtle data should be developed to assist in analyzing fishery interactions and developing effective solutions to minimize bycatch of loggerheads in this fishery.

6213. Implement observer programs to determine bycatch levels and identify key characteristics of domestic commercial gillnet fisheries that affect bycatch levels.

Direct and/or alternative platform observer programs should be enhanced or developed, and implemented through a prioritized approach, to measure bycatch in gillnet fisheries. Bycatch data should be examined to determine characteristics of gillnet gear and fishing practices that may contribute to increased bycatch levels.

6214. Implement measures to minimize bycatch in large mesh gillnet fisheries.

Large mesh gillnets used in areas where sea turtles are abundant can result in high sea turtle bycatch. Rangewide restrictions, with temporal components if appropriate, should be implemented.

6215. Implement measures to minimize bycatch in other gillnet fisheries as appropriate.

Appropriate actions should be taken to implement restrictions to reduce loggerhead bycatch in gillnet fisheries through gear modifications, time/area closures, and/or changes in fishing practices.

622. Minimize loggerhead bycatch in domestic shrimp trawl fisheries.

A comprehensive characterization of commercial shrimp trawl fisheries in domestic waters should be completed to identify fishing areas, effort, gear characteristics, fishing practices, loggerhead bycatch data, and relevant regulations.

6221. Describe and characterize domestic commercial and recreational shrimp trawl fisheries.

A full characterization of distribution, seasonality, and effort (trawl effort and number of vessels) would improve our understanding of the threats posed by the domestic commercial and recreational shrimp trawl fishery. These data should be developed in a spatially referenced format to allow for integration into the GIS described in 6222.

6222. Integrate information gathered in 6221 with turtle distribution data (linked to actions 141 and 29).

A comprehensive GIS integrating domestic commercial and recreational shrimp trawl fishery distribution, gear characteristics, effort data, turtle distribution and bycatch data, and oceanographic information should be developed and periodically updated to assist in analyzing shrimp fishery interactions and developing effective solutions to minimize bycatch of loggerheads in this fishery.

6223. Increase observer coverage to a statistically robust level to adequately monitor bycatch levels in the domestic commercial shrimp fishery and modify TED regulations if necessary.

To gauge success of conservation measures that have been implemented, observer programs should be maintained to ensure statistically valid coverage across the range of the domestic commercial shrimp trawl fishery. Loggerhead bycatch data collected through observer programs should be summarized and reported quarterly to monitor bycatch levels and to evaluate conservation measures. Comprehensive annual analyses of observer data are needed in a timely manner to ensure loggerhead bycatch is minimized.

6224. Promulgate regulations to require TEDs in all trynets in the domestic commercial shrimp fishery.

Observer data indicate that loggerheads are regularly captured in trynets smaller than the minimum size required to have TEDs (greater than 12 ft headrope length). Tow time requirements for exempted trynets are not currently enforceable. Regulations requiring TEDs in all trynets are needed to reduce loggerhead bycatch in this gear type.

6225. Continue efforts to educate domestic commercial shrimp fishers on the proper installation and use of larger-opening TEDs.

Continued outreach efforts to provide workshops and educational materials to the shrimp fishing community are needed to ensure that the required larger opening TEDs are constructed, installed, and used properly. Outreach efforts, including conducting workshops and providing educational materials in multiple languages as needed in the southeast U.S., should be continued and enhanced.

6226. Investigate the physiological effects of multiple captures and exclusions of loggerheads in domestic commercial shrimp trawls equipped with TEDs.

Despite comprehensive TED regulations, serious concerns remain regarding the repeated capture and exclusion of individual loggerheads on densely fished shrimping grounds. The cumulative effects of repeated forced submergence while navigating the trawl and TED warrant focused evaluation. The physiological effects, measured through blood chemistry, should be evaluated under semi-controlled conditions in the wild. Videography should be employed to evaluate behavior and escapement rates of individuals repeatedly exposed to shrimp trawls under commercial conditions.

6227. Monitor and reduce effort in the domestic commercial shrimp trawl fishery to minimize loggerhead bycatch.

Despite the implementation of larger TED openings, estimated bycatch of loggerheads in the southeast U.S. shrimp fishery remains extraordinarily high due to the enormous total effort (assuming 97% turtle exclusion rate, which may be an overestimate). Overcapacity in the shrimp fishery should be addressed through a limited entry permit system, effort reduction through time/area closures, or other approaches that reduce total trawl hours.

6228. Investigate turtle exclusion rates for soft TEDs under field conditions using videography.

The primary method for testing the efficiency of TEDs is the NMFS Small Turtle TED Testing Protocol. NMFS personnel release captive-raised sea turtles in shrimp nets fitted with TEDs under controlled conditions in the clear waters of the Gulf of Mexico. Divers film each turtle as it is released into the net and record turtle escape times. Although the NMFS Small Turtle TED Testing Protocol has been effective in identifying problems with some TED designs, there have been several criticisms of the protocol including: (1) captive raised turtles used for testing behave differently than wild turtles, (2) the captive turtles used in testing are uniformly small in size and do not represent the range of sizes encountered by trawlers, and (3) TED designs are tested under ideal conditions with gear specialists adjusting nets for optimum performance. As a result of these concerns, NMFS, in cooperation with the Georgia Marine Extension Service, has developed an alternative method for TED testing. A net with two cameras attached at key locations on the net (trawl body and TED) allows researchers to monitor the net while trawling for wild turtles. TED efficiency is monitored with video monitors on the boat. This method is known as the "wild turtle" testing protocol and eliminates concerns over the behavior and size of captive turtles. Since 2002, candidate TEDs and modifications to existing TEDs have been tested using both the small turtle and wild turtle testing protocols.

The original soft TED design proposed for certification included an 8-inch mesh webbing ramp to direct turtles to the net opening. As a result of high turtle capture rates, the original soft TED design did not pass the NMFS Small Turtle TED Testing Protocol. The original soft TED design was modified to include two panels of 4-inch mesh on either side of the 8-inch mesh-webbing ramp. The modified soft TED design, known as the Parker Soft TED, subsequently passed the protocol and was certified as a NMFS approved TED design. The soft TED design has shown a history of problems during development, including inconsistent installation by net shops and documented deformation of the mesh ramp with repeated use. Stretching of the soft TED meshes form a bag that will trap and drown turtles. Because there is continued concern that the mesh ramp will stretch with repeated use, the efficiency of the Parker Soft TED should be further tested using the wild turtle testing protocol and the small turtle protocol with a net that has been fished under commercial conditions over a period of time.

6229. Implement statistically valid observer programs to determine bycatch levels in domestic commercial skimmer trawl fisheries and require TEDs if necessary.

The skimmer trawl fishery is suspected as having high interaction rates with loggerheads. Two areas are of particular concern, North Carolina and Louisiana. An observer program to estimate loggerhead bycatch in skimmer trawls should be developed and implemented. TEDs may be required based on this evaluation.

623. Minimize loggerhead bycatch in domestic commercial non-shrimp trawl fisheries.

A comprehensive characterization of commercial non-shrimp trawl fisheries in domestic waters should be completed to identify fishing areas, effort, gear characteristics, fishing practices, loggerhead bycatch data, and relevant regulations.

6231. Describe and characterize domestic commercial non-shrimp trawl fisheries.

A full characterization of distribution, gear and fishing characteristics, seasonality, and effort (trawl effort and number of vessels) would improve our understanding of the threats posed by the domestic commercial non-shrimp trawl fishery. These data should be developed in a spatially referenced format to allow for integration into the GIS described in 6232.

6232. Integrate information gathered in 6231 with turtle distribution data (linked to actions 141 and 29).

A comprehensive GIS integrating domestic commercial non-shrimp trawl fishery distribution and effort data, turtle distribution and bycatch data, and oceanographic information should be developed and periodically updated to assist in analyzing fishery interactions and developing effective solutions to minimize bycatch of loggerheads in this gear type.

6233. Implement statistically valid observer programs to determine bycatch levels in domestic commercial non-shrimp trawl fisheries.

Observer programs should be maintained (or implemented if they do not exist) and improved to ensure statistically valid coverage across the range of domestic non-shrimp trawl fisheries. Loggerhead bycatch data collected through observer programs should be summarized and reported in a timely manner to evaluate conservation measures that have been undertaken. Comprehensive annual analyses of observer data are needed in a timely manner to ensure loggerhead bycatch is minimized in non-shrimp trawl fisheries.

6234. Implement seasonal TED regulations for domestic commercial non-shrimp trawl fisheries operating from Cape Charles, Virginia, north to Long Island Sound.

There are ample data documenting the seasonal distribution of loggerheads north of Cape Charles, Virginia (current northern extent of domestic requirements for TEDs) and demonstrating the overlap of loggerheads with non-shrimp trawl fishing effort. The neritic habitats between Cape Charles, Virginia, and Long Island Sound provide important seasonal migratory and foraging habitats for both juvenile and adult loggerheads. To reduce bycatch, regulations should be promulgated to require TEDs seasonally from Cape Charles, Virginia, to Long Island Sound.

6235. Promulgate regulations to require TEDs in domestic commercial flynet trawl fisheries.

The flynet trawl fishery operates primarily in neritic waters off the mid-Atlantic coast, an area that provides important habitat for juvenile and adult loggerheads. Sea turtles have been documented and are not uncommon as bycatch in this fishery. A flynet TED has been developed and tested in the fishery, and regulations should be promulgated to require TED use to minimize loggerhead bycatch.

6236. Promulgate regulations to require TEDs in all domestic commercial non-shrimp trawl fisheries south of Cape Hatteras, North Carolina.

There are ample data documenting the seasonal distribution of loggerheads south of Cape Hatteras, North Carolina, and demonstrating the overlap of loggerheads with non-shrimp trawl fishing effort in this area. The neritic habitats south of Cape Hatteras, North Carolina, provide critically important, year-round migratory and foraging habitats for both juvenile and adult loggerheads. To reduce loggerhead bycatch, regulations should be promulgated to require TEDs year-round in non-shrimp trawl fisheries operating south of Cape Hatteras, North Carolina, through Texas.

624. Minimize loggerhead bycatch in domestic commercial pelagic and demersal longline fisheries.

6241. Describe and characterize domestic commercial pelagic and demersal longline fisheries.

A comprehensive characterization of all U.S. longline fisheries should be completed to identify fishing areas, effort, gear characteristics, fishing practices, loggerhead bycatch data, and relevant regulations.

6242. Integrate information gathered in 6241 with turtle distribution data (linked to actions 141 and 29).

A comprehensive GIS integrating domestic commercial pelagic and demersal longline fishery distribution and effort data, turtle distribution and bycatch data, and oceanographic information should be developed and periodically updated to assist in analyzing fishery interactions and developing effective solutions to minimize bycatch of loggerheads in this gear type.

6243. Maintain and/or increase observer coverage to a statistically robust level to adequately monitor bycatch levels in domestic commercial pelagic and demersal longline fisheries.

Observer programs should be maintained to ensure statistically valid coverage over the range of the surface and demersal longline fishery. Loggerhead bycatch data collected through observer programs should be summarized, reported, and reviewed quarterly to monitor bycatch levels, gauge success of conservation measures that have been implemented, and provide additional information on key characteristics of longline fisheries that affect loggerhead bycatch levels.

6244. Continue to conduct focused experiments on domestic commercial longline gear and fishing practices to minimize loggerhead interactions and secondarily to minimize post-interaction mortality.

Significant and important progress has been made in developing gear modifications that reduce loggerhead bycatch in swordfish directed fisheries. The most promising results are related to hook type and bait type. Reduction of daylight soak-time has also been shown to significantly reduce bycatch. Results should be field tested in the tuna directed fishery to ensure comparable bycatch reduction.

6245. Investigate the effectiveness of time-area closures to minimize loggerhead interactions in domestic commercial pelagic and demersal longline fisheries.

Pelagic and demersal longline fishery observer data, loggerhead distribution data, loggerhead movement data, and fishery effort data should be fully analyzed in a GIS environment to evaluate the effectiveness of time-area closures to minimize loggerhead bycatch.

6246. Promulgate regulations to implement proven measures that minimize loggerhead interactions with commercial pelagic and demersal longline fisheries.

Enforceable bycatch reduction measures, which include proven and specific gear modifications, time/area closures, and/or changes in fishing practices, should be implemented by regulation. Regulations must be specific and enforceable.

6247. Develop and implement effective approaches to enforcing longline regulations in the U.S. EEZ and on the high seas.

Enforcement of regulations such as gear modifications, time-area closures, and safe handling practices are particularly difficult to enforce offshore and on the high seas. Vessel monitoring systems should be required on all vessels engaging in fisheries that operate under time/area restrictions. NMFS Enforcement and USCG must maintain an active role in the development and promulgation of regulatory regimes to ensure that they are enforceable and that capacity exists to carry out such enforcement.

6248. Promote the use of safe handling practices and careful release tools in domestic commercial pelagic and demersal longline fisheries.

Proper handling of loggerheads captured in pelagic and demersal longline gear may increase their probability of survival after release. Sea turtle careful handling and release protocols have been developed with the goal of minimizing injuries and maximizing survival after release (Epperly *et al*. 2004). These protocols should be promoted domestically and internationally.

625. Minimize loggerhead bycatch in domestic commercial and recreational pot/trap fisheries.

6251. Describe and characterize pot/trap fisheries.

A comprehensive characterization of all pot/trap fisheries in domestic waters should be completed to identify fishing areas, effort, gear characteristics, fishing practices, loggerhead bycatch data, and relevant regulations.

6252. Integrate information gathered in 6251 with turtle distribution data (linked to actions 141 and 29).

A comprehensive GIS integrating pot/trap fishery distribution and effort data, gear and fishing characteristics, turtle distribution and bycatch data, and oceanographic information should be developed and periodically updated to assist in analyzing fishery interactions and developing effective solutions to minimize bycatch of loggerheads in this gear type.

6253. Develop gear modifications to prevent entanglement of loggerheads in pot/trap lines.

Modifications to pot/trap gear should be explored and tested to reduce loggerhead bycatch (e.g., stiffened lines, weighted line to eliminate extra line on the surface, and weighted groundlines to connect pots/traps).

6254. Promulgate regulations to incorporate modifications to whelk pot bridles to prevent loggerhead entanglement.

NMFS has initiated research to characterize loggerhead interactions with whelk pot bridles and to develop gear modifications that will prevent entanglement of loggerheads. Research conducted to date should be fully analyzed and expanded as appropriate to develop bycatch solutions. Regulations requiring appropriate gear modifications in the whelk pot fishery should be promulgated.

6255. Promulgate appropriate regulations to reduce incidental capture of loggerheads in pots/traps.

Successful gear modifications resulting from 6253 should be implemented by regulation.

6256. Require identification on pot/trap gear.

Marking of pot/trap gear that allows owner identification will create incentives for fishers to remove all gear outside of fishing seasons thereby reducing the amount of abandoned gear in the water.

626. Minimize loggerhead bycatch in domestic commercial dredge fisheries.

6261. Describe and characterize domestic commercial dredge fisheries.

A comprehensive characterization of all commercial dredge fisheries in domestic waters should be completed to identify fishing areas, effort, gear characteristics, fishing practices, loggerhead bycatch data, and relevant regulations.

6262. Integrate information gathered in 6261 with turtle distribution data (linked to actions 141 and 29).

A comprehensive GIS integrating domestic commercial dredge fishery distribution and effort data, gear and fishing characteristics, turtle distribution and bycatch data, and oceanographic information should be developed and periodically updated to assist in analyzing fishery interactions and developing effective solutions to minimize bycatch of loggerheads in this gear type.

6263. Evaluate the effectiveness of gear modifications developed to reduce loggerhead bycatch in the domestic commercial scallop dredge fishery.

Efforts to reduce bycatch in the commercial scallop dredge fishery operating in the mid-Atlantic have resulted in a modification to the dredge that appears to keep turtles from entering the dredge bag. However, video-monitored testing of this modification using loggerhead carcasses show that severe, likely lethal, damage occurs when the leading edge of the dredge strikes the turtle. Despite keeping turtles out of the dredge bag, severe injuries and death are likely to have already occurred. Efforts are underway to develop a dredge with modified cutting bar and bail to guide sea turtles up and over the dredge, rather than passing under the cutting bar and dredge bag where severe injuries likely occur. Additional controlled testing and field testing using video technology is needed to ascertain the actual effectiveness of these modifications.

6264. Promulgate regulations that reduce loggerhead bycatch and mortality in the domestic commercial scallop dredge fishery.

The commercial scallop dredge fishery, operating off the mid- and northeast Atlantic coastline, incidentally captures up to 749 loggerheads per year. Many of these turtles are killed or seriously injured by this heavy, bottom-tending gear. Efforts are underway to develop a modified dredge to reduce the severity of injuries when loggerheads are struck by dredge gear on the bottom. However, this testing is preliminary and further work needs to be completed to assess whether the gear is effective at reducing the severity of the injuries.

6265. Investigate bycatch and mortality of loggerheads in commercial whelk dredge fisheries.

A statistically valid observer program should be developed and implemented to monitor and estimate bycatch, injury, and mortality of loggerheads in the commercial whelk dredge fishery. The sampling program must be designed to provide sufficient observer coverage across the range of the fishery during the seasons when loggerheads are known to inhabit the targeted fishing areas.

6266. Investigate bycatch and mortality of loggerheads in commercial surf clam dredge fisheries.

A statistically valid observer program should be developed and implemented to monitor and estimate bycatch, injury, and mortality of loggerheads in the commercial surf clam dredge fishery. The sampling program must be designed to provide sufficient observer coverage across the range of the fishery during the seasons when loggerheads are known to inhabit the targeted fishing areas.

627. Minimize loggerhead bycatch in other domestic fisheries.

6271. Describe and characterize other domestic commercial fisheries.

A comprehensive characterization of all other commercial fisheries that are likely to take loggerheads during their operations in domestic waters should be completed to identify fishing areas, effort, gear characteristics, fishing practices, loggerhead bycatch data, and relevant regulations.

6272. Integrate information gathered in 6271 with turtle distribution data (linked to actions 141 and 29).

A comprehensive GIS integrating other domestic commercial fishery distribution and effort data, turtle distribution and bycatch data, and oceanographic information should be developed and periodically updated to assist in analyzing fishery interactions and developing effective solutions to minimize bycatch of loggerheads in these fisheries.

6273. Investigate bycatch and mortality of loggerheads in other domestic commercial fisheries and implement bycatch reduction measures as necessary.

A statistically valid observer program should be developed and implemented to monitor and estimate bycatch, injury, and mortality of loggerheads in the other domestic commercial fisheries. The sampling program must be designed to provide sufficient observer coverage across the range of the fishery during the seasons when loggerheads are known to inhabit the targeted fishing areas. Appropriate bycatch reduction measures should be identified and implemented.

6274. Ensure that no increase in effort over 2003 levels occurs in the *Sargassum* fishery to minimize loggerhead bycatch.

Sargassum harvest by surface trawling removes habitat essential to post-hatchling loggerheads and has been documented to result in the bycatch of young loggerheads. The current Fishery Management Plan for pelagic *Sargassum* habitat contains a number of actions that limit how, when, where, and how much *Sargassum* may be harvested annually. NMFS must ensure that no additional effort is authorized in this fishery. Unregulated, the threat posed by this fishery is substantial since post-hatchlings depend on *Sargassum* communities for forage and shelter.

628. Enforce domestic commercial fishery regulations to minimize loggerhead bycatch.

Without comprehensive at-sea and dockside enforcement, regulations designed to reduce loggerhead bycatch will not be effective. For example, the 2003 larger opening TED regulations are expected to significantly reduce mortality of large immature and adult loggerheads that interact with the southeast U.S. shrimp trawl fishery. However, if TEDs are not installed or used properly, their effectiveness is significantly diminished and expected conservation gains will not be realized.

63. Minimize loggerhead bycatch in foreign commercial fisheries.

Work with foreign governments and international fishery management organizations to reduce loggerhead bycatch in foreign commercial fisheries (i.e., foreign fleets fishing in their domestic waters and fishing on the high seas).

631. Disseminate results of bycatch reduction experiments and transfer demonstrated bycatch reduction technologies to foreign nations.

NMFS and U.S. Department of State (DOS) should continue to work together to inform relevant foreign fishing nations and international fishery organizations (e.g., ICCAT, FAO-COFI) of demonstrated loggerhead bycatch reduction solutions including, but not limited to, larger opening TEDs, modifications to longline gear, and restrictions to large mesh gillnets. Capacity building efforts should continue to be expanded to transfer developed technologies through organized fisherman-training workshops and dissemination of targeted educational materials (including videos) in appropriate languages. If necessary, the U.S. should explore the development of economic incentives to encourage the adoption of bycatch reduction approaches by foreign nation fleets that interact with loggerheads.

632. Encourage and assist foreign nations in collecting data on loggerhead bycatch via observer programs for commercial fisheries where bycatch levels are undocumented.

A number of existing, expanding, and/or developing foreign fisheries have the potential for high loggerhead bycatch and mortality. NMFS and DOS should work through all available avenues to encourage and assist foreign nations with implementing valid data collection programs to document loggerhead bycatch.

Of high priority are the black scabbard hook and line fishery in Madeira and the Azores and the deep-sea crab pot fisheries of the northeastern Atlantic.

633. Encourage and assist foreign nations to develop, implement, and enforce fishery regulations to minimize loggerhead bycatch in commercial pelagic longline fisheries.

NMFS and DOS should work via existing bi-lateral and multi-lateral agreements and forums to encourage foreign nations to reduce loggerhead bycatch in their domestic commercial pelagic longline fisheries. Where appropriate, incentives such as enhanced market access should be explored to provide strong incentives for reducing bycatch. Significant efforts should be directed at improving enforcement capacity in foreign nations through workshops, training, and exchange programs.

634. Encourage and assist foreign nations to develop, implement, and enforce fishery regulations to minimize loggerhead bycatch in commercial trawl fisheries.

NMFS and DOS should work via existing bi-lateral and multi-lateral agreements and forums to encourage foreign nations to reduce loggerhead bycatch in their domestic commercial trawl fisheries. Where appropriate, incentives such as enhanced market access should be explored to provide strong incentives for bycatch reduction. Significant efforts should be directed at improving enforcement capacity in foreign nations through workshops, training, and exchange programs.

635. Encourage and assist foreign nations to develop, implement, and enforce fishery regulations to minimize loggerhead bycatch in commercial gillnet fisheries.

NMFS and DOS should work via existing bi-lateral and multi-lateral agreements and forums to encourage foreign nations to reduce loggerhead bycatch in their domestic commercial gillnet fisheries. Where appropriate, incentives such as enhanced market access should be explored to provide strong incentives for reducing bycatch. Significant efforts should be directed at improving enforcement capacity in foreign nations through workshops, training, and exchange programs.

636. Encourage and assist foreign nations to develop, implement, and enforce fishery regulations to minimize loggerhead bycatch in other commercial fisheries.

NMFS and DOS should work via existing bi-lateral and multi-lateral agreements and forums to encourage foreign nations to reduce loggerhead bycatch in their other domestic commercial fisheries. Where appropriate, incentives such as enhanced market access should be explored to provide strong incentives for reducing bycatch. Significant efforts should be directed at improving enforcement capacity in foreign nations through workshops, training, and exchange programs.

637. Develop economic incentives to reduce fishery interactions and mortality of loggerheads in foreign high seas fisheries.

The U.S. should work to develop positive economic incentives that will encourage foreign nations to minimize bycatch of loggerheads on the high seas. An evaluation of the effectiveness of turtle-safe, eco-labeling should be carried out to determine if such an effort would have a positive effect on minimizing bycatch in foreign fisheries that import product to the U.S. The U.S. should explore all other constructive avenues to provide incentives to foreign nations to minimize loggerhead bycatch.

638. Encourage ICCAT, Canada, Mexico, and the European Union to implement standards for collecting loggerhead bycatch information and requirements to minimize loggerhead bycatch.

NMFS and DOS should work to encourage ICCAT to fully incorporate loggerhead bycatch reduction in fisheries within their purview as one of its primary objectives. ICCAT should implement binding turtle bycatch data collection and annual reporting standards. NMFS and DOS should work together to advance binding adoption of demonstrated and specific loggerhead bycatch reduction techniques (including gear and fishing practice changes and time-area closures as appropriate) in fisheries prosecuted under the auspices of ICCAT.

64. Develop and implement a strategy to assess, monitor, and minimize effects of trophic changes on loggerheads from fishing and habitat alteration.

Fisheries may reduce the abundance of species important in loggerhead diets and could potentially alter the trophic structure of ecosystems upon which loggerheads depend. Habitat alteration from fishing gear may also affect prey distribution and abundance.

641. Assess loggerhead diets and food web linkages in neritic and oceanic habitats.

Loggerheads are able to exist on a wide variety of food items with ontogenetic and regional differences in diet. Loggerhead diets have been described from just a few coastal regions, and very little information is available about differences or similarities in diet at various life stages. Very little is known of the diet of oceanic juveniles. Studies on loggerhead diet are challenging, and relating diet to food webs in neritic and oceanic habitats is complex. To effectively gather data and improve our knowledge in this area, it may be advantageous to convene an expert group to develop an action plan for moving forward effectively.

642. Assess and minimize effects of commercial harvest of loggerhead prey species.

In the U.S., fishery management plans (FMPs) drafted by regional Fishery Management Councils must undergo review in accordance with section 7 of the ESA. Management plans for state fisheries developed by the Atlantic or Gulf States Marine Fisheries Commissions (ASMFC and GSMFC) also undergo review for protected species concerns, albeit not a Federal section 7 consultation. To date, evaluation of these plans has focused on direct mortality of ESA-listed species but has not considered trophic or ecosystem effects from fishery harvest of loggerhead prey species. Both Federal and state fishery management plans should include a thorough evaluation of fishery induced trophic and ecosystem changes on loggerheads.

Fishery induced diet shifts may be detrimental to loggerheads. Such shifts should be evaluated and consideration should include relative nutritional value of prey items and energetic costs of prey capture. Where diets have shifted to fish, an evaluation should be made as to whether loggerheads are more vulnerable to being taken in fishing gear. In addition to fishery capture of target prey species, which may affect loggerheads, fishery bycatch may also potentially have trophic impacts on loggerheads.

643. Assess effects of habitat alteration from commercial fisheries on distribution and abundance of loggerhead prey species.

Alterations in the structure, function, and community composition of benthic habitats from bottom trawl and dredge fisheries can have a major effect on the distribution of loggerhead turtles as a result of changes in food/prey availability, habitat structure and function, and water quality. Bottom tending fishing gear can be destructive to a wide variety of habitats. Hard bottom habitats are particularly vulnerable to destruction from roller rig trawler gear because benthic fauna may be crushed by the weight of rollers and trawls. Seagrass, coral, sponge, and other live bottom habitats can also be destroyed or structurally and functionally altered by trawling gear. Anchoring vessels in sensitive habitats may also be destructive.

65. Develop and implement a strategy to minimize the effects of marine debris ingestion and entanglement.

Marine debris may originate from land or sea, primarily through careless disposal of non-biodegradable refuse. Suspected sources of these materials are large transport vessels pumping bilges and discarding garbage, commercial and recreational fishing vessels, oil and gas platforms, beachgoers, and cruise liners.

651. Determine frequency of marine debris ingestion and entanglement by loggerheads in neritic and oceanic habitats.

Ingestion of marine debris and entanglement in discarded nets, monofilament lines, and ropes affects immature and adult loggerheads. Young, oceanic-stage loggerheads are particularly vulnerable to ingestion of persistent materials. Studies should be expanded to categorize and quantify the ingestion of and entanglement in marine debris by loggerheads inhabiting Atlantic and Gulf waters.

652. Evaluate the sublethal effects of marine debris ingestion and entanglement on loggerheads.

Additional research is needed to evaluate the long-term effects of synthetic marine debris ingestion on sea turtles, particularly with regard to early life stages. Sublethal consequences of exposure to hydrocarbons and other toxic substances need to be investigated. The population dynamics of loggerheads are sensitive to survival and growth in the oceanic juvenile stage, and oceanic juveniles are often found in the same regions with aggregated synthetic debris. If these interactions significantly affect survival or growth, there could be substantial population-level effects. Research is also needed on the sublethal effects of entanglement on sea turtles. Loggerheads have been found entangled in a wide variety of man-made materials and are commonly found with scars and marks from previous entanglement. Turtles that survive marine debris entanglement incidents may incur permanent injuries, such as the loss of a flipper, which may reduce overall fitness.

653. Enforce the International Convention for the Prevention of Pollution from Ships (MARPOL).

The MARPOL Protocol (International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978) is the main international convention covering the prevention of pollution (including oil, chemicals, harmful substances in packaged form, sewage, and garbage) of the marine environment by ships from operational or accidental causes. As the 1973 Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention and entered into force in October 1983 (for Annexes I and II). Annex V, which prohibits the dumping of all plastic wastes, including plastic packaging materials and fishing gear, from all ships at sea, entered into force in December 1988. Not only did this mark the first effort in the U.S. law to address the problem of plastic debris in the oceans, but the ratification of Annex V enabled the law to come into force internationally. As of January 1989, the Marine Plastic Pollution Research and Control Act makes it against the law to dump plastics at sea and in all U.S. navigable waters. Continued and increased efforts are needed to collect data and identify sources of marine debris, spearhead educational activities, and vigorously enforce marine pollution laws to reduce marine debris throughout the world's oceans.

654. Explore feasibility and provide incentives to reduce the amount of abandoned

recreational and commercial fishing gear that causes loggerhead injury and mortality.

Efforts should be undertaken to explore whether economic incentives could be developed that would function as a viable mechanism to encourage the return of recreational and commercial fishing gear to land. Implementation of requirements for marking gear with unique identifiers can provide incentives for recovery of gear if penalties for abandoning gear are sufficient and enforced.

655. Explore feasibility and provide incentives to reduce the amount of non-fisheries related marine debris that causes loggerhead injury and mortality.

Economic incentives should be developed that would encourage the return of non-fisheries synthetic debris (e.g., plastic food and beverage containers, plastic bags, synthetic dunnage, cargo nets) for proper disposal or recycling on land. If people perceive a benefit from an action, they are more likely to undertake it or support it. Industry support for reducing plastic trash and encouraging greater recycling rates could reduce the amount of synthetic litter reaching rivers, coasts, and oceans.

656. Maintain or implement marine debris cleanup programs in coastal waters.

Regularly scheduled cleanups of nearshore and inshore marine habitats to remove and document debris should be continued, expanded, and/or implemented. The International Coastal Cleanup, coordinated by The Ocean Conservancy, is an excellent example of such an event.

66. Develop and implement a strategy to reduce vessel strikes.

In recent years, 15 to 20% of live and dead stranded loggerheads along the neritic coastline of the U.S. Atlantic and Gulf of Mexico had sustained injuries as a result of vessel strikes. While some injuries may occur post mortem, the prevalence of sea turtles with boat related injuries coincident with areas of high vessel activity (including recreational and commercial vessels) suggests a significant problem in some locations.

661. Develop a comprehensive GIS database to assess vessel interactions with loggerheads.

A comprehensive spatial assessment of loggerhead distribution, vessel strike-related strandings, vessel activity, and vessel infrastructure (boat ramps, channels, ports) should be undertaken in a GIS environment to assist in the analysis of vessel interactions with loggerheads.

662. Develop and implement a strategy to reduce vessel interactions with loggerheads.

A working group consisting of relevant experts should be convened to draft a strategy (using the information resulting from the analysis conducted in action 661) to reduce vessel strike injury and mortality to loggerheads. Measures such as protected areas, no motor zones, or speed regulations should be considered for specific areas as appropriate. This strategy should be implemented as rapidly as possible to address this serious threat to loggerheads.

67. Monitor and minimize mortality from channel dredging activities.

The COE is congressionally mandated to maintain U.S. navigational channels. To ensure that authorized channel depths are sustained, periodic dredging is required. Some types of dredges, particularly the hopper dredge, have been shown to take sea turtles and, on a cumulative basis, this take is believed to be significant. Turtle mortality can be documented by screening the inflows/outflows on a hopper dredge, by observation aboard a clamshell dredge, or by observing the discharge of a pipeline dredge. Presently, NMFS believes that few, if any, turtles are impacted by clamshell or pipeline dredges, but that the hopper dredge is a major problem. Therefore, observer coverage and appropriate screening on all hopper dredge operations should be required to document take and associated mortality.

671. Assess effects of new technologies for channel dredge equipment on loggerhead captures.

Channel dredging operations have historically relied on dredge machinery (hydraulic, hopper, clamshell) to remove sediments from navigational channels. However, other types of machinery are often used. For instance, on some channel dredging projects, bed levelers are used to smooth out ruts in the channel bottom created by hopper dredging activity. The bed leveler is a large steel blade (50 ft by 6 ft) that is dragged along the channel to smooth out the bottom. The bed leveler is generally lowered from a barge and pushed by a tug boat. Unusual stranding patterns (crushed carapace) documented by STSSN cooperators in Georgia suggested the bed leveler may crush and kill sea turtles. Controlled experiments should be conducted to determine the effects of new technologies such as bed levelers on turtle populations prior to use in dredging operations.

672. Incorporate effective channel dredge equipment modifications into future operations.

Additional research, development, and improved performance are needed for the currently used deflector dragheads on hopper dredges. Efforts should focus on improving currently used equipment modifications to further reduce sea turtle capture. Protocols for evaluating potential modifications on turtle capture should be developed in conjunction with NMFS, COE, and industry.

673. Maintain current requirements for channel dredging activities in the southeast

U.S. and Gulf of Mexico and evaluate whether additional measures are required to minimize loggerhead mortality.

Significant reductions in the capture of loggerheads during U.S. channel dredging operations have occurred over the past two decades. Reductions in capture have occurred primarily as a result of dredging windows and modifications to hopper dredge dragheads. However, despite these and other requirements, capture and mortality of loggerheads in hopper dredging gear continues to occur. Periodic evaluations of current dredging windows and operational requirements should be conducted and additional or modified measures implemented that will further minimize loggerhead capture. Evaluations of the effects of relocation trawling (relocating loggerheads away from channels scheduled for or undergoing dredging) on individual turtles should be thoroughly investigated, especially during breeding periods.

674. Implement regional requirements for channel dredging activities north of North Carolina to minimize loggerhead mortality.

Regional requirements, applicable to all channel dredging activities in the Gulf of Mexico and southeast U.S. Atlantic (south of Virginia) have been implemented through ESA section 7 consultations. Channel dredging activities north of North Carolina are evaluated on a case-by-case basis in accordance with ESA section 7. Efforts should be undertaken to develop a regional consultation to consider all anticipated channel dredging operations in this region and their cumulative effects on loggerheads. Regionwide requirements to minimize loggerhead capture and mortality in channel dredging operations north of North Carolina should be implemented through ESA section 7.

7. Facilitate recovery through public awareness, education, and information transfer.

Sea turtle conservation requires long-term public support over a large geographic area. The public must be factually informed of the issues particularly when conservation measures conflict with human activities on the beach, such as coastal development and public use of nesting beaches. Public education is the foundation upon which a long-term conservation program will succeed or fail.

71. Develop and distribute educational materials.

Informational brochures and other educational materials (e.g., posters, videos, Internet postings) on sea turtle ecology and conservation needs should be developed and distributed to the public.

711. Develop a video about the impacts of beachfront lighting on loggerheads and ways to minimize impacts.

A professionally produced video about the impacts of beachfront lighting on sea turtles and recommendations on how to minimize lighting while still meeting human safety needs would provide tremendous support and reinforcement of the many coastal lighting ordinances. A high quality video that could be used during the nesting season should be developed.

712. Maintain websites with comprehensive information about loggerheads.

Comprehensive information on sea turtles should be made readily available on the Internet (e.g., http://www.seaturtle.org, Sea Turtle Online Bibliography). NMFS, FWS, state resource agencies, and other agencies and organizations should provide support to ensure these web sites are maintained and updated regularly.

713. Develop an educational curriculum for students and the public about loggerhead demography and ecological roles.

An educational curriculum should be developed and distributed to schools for use in instructing children (K-12) about loggerhead demographics and their ecological roles. The curriculum should include information on the important roles they fulfill in marine ecosystems, such as their role in controlling prey species and themselves providing food to larger predators. The curriculum should also explain the potential widespread effects of the disappearance of loggerheads in the open ocean and coastal ecosystems.

714. Use computer gaming technologies to engage young people in sea turtle conservation.

Environmental education needs to tap into current technologies to reach groups increasingly attracted to the computer gaming technologies. Computer games can be developed that are challenging, engaging, and educational. Graphics technologies also allow visualization of turtles moving through their development in various habitats from beaches to the open ocean to nearshore marine habitats. Games could vary from following a single turtle through its life history to “management” simulations that allow the gamer to try different management decisions to see if they can “save the loggerheads.” Given all the threats, gamers could achieve different levels in the game by meeting new challenges to loggerhead populations. Recent cartoons, movies, and documentaries clearly demonstrate that youth can be engaged by sea turtles as “charismatic megafauna” or as charismatic individuals.

72. Facilitate international scientific communication and information sharing.

Publications like the Marine Turtle Newsletter, as well as information shared through organizations like the International Sea Turtle Society and through list servers like CTURTLE, are sources of up-to-date information on events occurring within the sea turtle community and are of vital importance in the recovery effort worldwide. Because most sea turtles are globally distributed and all are highly migratory, international availability of such sources of information ensures an open line of communication among scientists, conservationists, and policymakers in many countries. NMFS, FWS, state resource agencies, and other agencies and organizations should provide support to ensure their continuation.

73. Ensure facilities permitted to hold and display captive loggerheads have appropriate informational displays.

Over 50 facilities in the U.S. are permitted to hold sea turtles for rehabilitation, research, and public education. Many loggerheads are on public display, which affords opportunities for public education. Display of accurate information on the basic biology and conservation issues should be a requirement of all permitted facilities. All facilities should be inspected to ensure captive sea turtles are being displayed in a manner that meets these criteria.

74. Ensure standard criteria and recommendations for sea turtle nesting interpretive walks are followed.

In the U.S., sea turtle walks are popular with the public and afford tremendous opportunities for public education or, if poorly conducted, misinformation. State permitting agencies should develop or refine standards for permittees conducting both daytime and nighttime interpretive walks. These objective criteria should be used to evaluate sea turtle walks to ensure they are professional, provide accurate biological information, convey an accurate conservation message, and are a positive experience. Just as importantly, they should not cause unnecessary or significant disturbance to nesting turtles.

75. Develop guidelines for and encourage interpretive daytime turtle walks.

The establishment of daytime interpretive sea turtle walks should be encouraged. Guidelines should be developed to ensure nests are not impacted during walks and that appropriate information on sea turtle conservation is shared.

76. Place educational signs at public access points on nesting beaches.

Public access points on nesting beaches provide excellent opportunities to inform the public of necessary precautions for compatible public use on the nesting beach and to develop public support through educational signs. Educational signs should be placed on nesting beaches as appropriate.

77. Conduct a contingent valuation study to measure the economic value of sea turtle related ecotourism.

A contingent valuation study should be conducted to estimate the economic value of loggerheads. Estimates are needed for the public's perception of non-consumptive and intrinsic values of loggerheads. These values are appreciated by the public either intrinsically or through ecotourism activities such as turtle walks and aquaria visits. Contingent valuation studies involve carefully designed surveys in which people are asked how much they would be willing to pay for specific sea turtle related ecotourism activities or for the assurance that sea turtles would continue to exist in functional abundance. Analysis of survey results will allow economic comparisons between the values of sea turtles and other values measured in economic terms.

PART III. RECOVERY IMPLEMENTATION

Because loggerheads are highly migratory and use the waters of more than one country in their lifetimes, conservation efforts for loggerhead populations in one country may be hindered by activities in another. Therefore, recovery of the Northwest Atlantic population of the loggerhead will involve multiple partners, international cooperation, and a diversity of approaches.

The Implementation Schedule that follows outlines actions and estimated costs for the recovery program for the Northwest Atlantic population of the loggerhead as set forth in this recovery plan. It is a guide for meeting the recovery goals outlined in this plan. This schedule indicates action priorities, action numbers, action descriptions, duration of actions, the parties responsible for actions (either funding or carrying out), and estimated costs. It is important to note that many of the actions include other species of sea turtles; therefore, the costs contribute to their recovery as well. Parties with authority, responsibility, or expressed interest to implement a specific recovery action are identified in the Implementation Schedule. The listing of a party in the Implementation Schedule does not require the identified party to implement the action(s) or to secure funding for implementing the action(s). However, parties willing to participate will benefit by being able to show in their own budget submittals that their funding request is for a recovery action that has been identified in an approved recovery plan and is therefore part of the overall coordinated effort to recover the Northwest Atlantic population of the loggerhead. Also, section 7(a)(1) of the ESA directs all Federal agencies to use their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of threatened and endangered species.

We estimate the Northwest Atlantic loggerhead population will reach recovery in one to three generations (50 to 150 years, respectively). The lower estimate of one generation (50 years) assumes a rapid reversal of the current declining trends of the Northern, Peninsular Florida, and Northern Gulf Recovery Units. Projecting cost estimates out 50 to 150 years is problematic due to unpredictable economic fluctuations. While we are comfortable estimating costs for the first 5 years of plan implementation, any projections beyond this date are likely to be imprecise and unrealistic. In the Implementation Schedule, we have identified total costs only for the first 5 years of plan implementation. To estimate total costs to the earliest potential time to recovery (50 years), we have simply multiplied the 5-year estimate by 10, recognizing that some unanticipated costs may not be accounted for and some costs may increase or decrease over time.

Following are definitions used in the Implementation Schedule. Agency abbreviations may be found in the List of Acronyms and Abbreviations on page xii.

PRIORITY NUMBER

Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 - An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant impacts short of extinction.

Priority 3 - All other actions necessary to provide for full recovery of the species.

ACTION NUMBER AND ACTION

Recovery actions as numbered in Part II.F. of this plan.

ACTION DURATION AND COST

Ongoing - A task that is currently being implemented and will continue until action is no longer necessary.

TBD - To be determined.

IMPLEMENTATION SCHEDULE **Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle**												
Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
2	111	Refine geographic boundaries of recovery units.	4	FWS-ES, NMFS	Academia, ADCNR, FFWCC, GDNR, NCWRC, SCDNR	350	100	100	100	50		
2	112	Monitor population genetic structure on foraging grounds.	Ongoing	NMFS	Academia, State Resource Agencies	1250	250	250	250	250	250	Linked to 162
3	113	Develop new techniques for refining population genetic structure.	5	Academia	FWS-ES, NMFS	1000	200	200	200	200	200	
2	121	Maintain and/or adopt standardized criteria for on-the-ground nesting surveys.	2	FWS-ES	FFWCC, GDNR, SCDNR, NCWRC, ADCNR	40	20	20				Linked to 122; 123; 151
1	122	Continue to monitor trends in nesting and non-nesting emergences on index/standardized beaches.	Ongoing	FFWCC, GDNR, SCDNR, NCWRC, ADCNR	FWS-ES/ Refuges, FDEP, SCDPRT, NCDENR, NPS, DOD, Local Govts, NGOs, UCF, FPL	3750	750	750	750	750	750	Linked to 121; 123

IMPLEMENTATION SCHEDULE **Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle**												
Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
2	123	Incorporate index/ standardized nesting survey protocols on additional beaches to fully represent recovery units.	2	FWS-ES	FFWCC, SCDNR, NCWRC, FWS-Refuges, NPS, DOD, NGOs	20	10	10				Linked to 121; 122
3	124	Monitor annual nesting and non-nesting emergences on non-index/non-standardized beaches as extensively as possible.	Ongoing	FFWCC, GDNR, SCDNR, NCWRC, ADCNR	FWS, FDEP, SCDPRT, NCDENR, NPS, DOD, Local Govts, NGOs	1250	250	250	250	250	250	
2	125	Conduct periodic censuses of recovery units to obtain total nest counts and geographic distribution of nesting.	Ongoing	FWS-ES	ADCNR, FFWCC, GDNR, SCDNR, NCWRC, NPS, FWS-Refuges, Local Govts	500					500	Linked to 122, 124
2	131	Establish a network of index in-water study sites across the range of all habitats (neritic and oceanic) and develop sampling protocols to estimate indices of abundance and determine trends.	3	NMFS	State Resource Agencies, Academia	110	50	50	10			Linked to 133, 161

IMPLEMENTATION SCHEDULE Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle												
Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
1	132	Evaluate, improve, maintain, and expand in-water surveys at index sites to estimate indices of abundance and determine trends.	Ongoing	NMFS, State Resource Agencies	Academia, NGOs, NPS, FPL	3750	750	750	750	750	750	
2	133	Develop sampling protocols for conducting large-scale in-water surveys to estimate indices of abundance and determine trends.	3	NMFS	State Resource Agencies, Academia	55	25	25	5			Linked to 131, 134
1	134	Implement large-scale in-water surveys to estimate indices of abundance and determine trends.	Ongoing	NMFS	State Resource Agencies, Academia	TBD	TBD	TBD	TBD	TBD	TBD	Linked to 133
2	141	Develop and maintain a comprehensive GIS database of distribution and abundance.	Ongoing	NMFS, State Resource Agencies	Academia	500	100	100	100	100	100	Linked to 29
2	142	Determine migratory pathways for all life history stages.	10	NMFS, State Resource Agencies	FWS-ES, Academia	2500	500	500	500	500	500	
2	151	Adopt standardized hatchling production assessment criteria.	3	FWS-ES	FFWCC, GDNR, SCDNR, NCWRC, ADCNR	40	20	20				Linked to 121

IMPLEMENTATION SCHEDULE Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle												
Priority	Action Number	Action Description	Action Duration (Years)	Responsible Party		Total Cost ($1000s) for FY1-FY5	Cost Estimate by FY (by $1,000s)					Comments
				Lead	Others		FY1	FY2	FY3	FY4	FY5	
2	152	Implement annual assessments of hatchling production using standardized criteria.	Ongoing	FWS-ES FFWCC, GDNR, SCDNR, NCWRC, ADCNR	FWS-Refuges, FDEP, SCDPRT, NCDENR, NPS, FPL, DOD, Local Govts, NGOs, UCF	1000	200	200	200	200	200	
2	153	Determine and monitor clutch frequency.	Ongoing	FWS-ES, FFWCC, GDNR, SCDNR, NCWRC	Academia, NMFS	1000	200	200	200	200	200	Linked to 142
2	154	Determine and monitor remigration interval.	Ongoing	NMFS FFWCC, GDNR, SCDNR, NCWRC	FWS-ES, Academia	TBD	TBD	TBD	TBD	TBD	TBD	Linked to 122, 161, 162
3	155	Determine female reproductive lifespan.	Ongoing	NMFS	FWS-ES, FFWCC, GDNR, SCDNR, NCWRC, Academia	TBD	TBD	TBD	TBD	TBD	TBD	Linked to 171
2	1611	Refine and develop techniques for determining sex ratios.	3	NMFS	State Resource Agencies, Academia	150	50	50	50			Linked to 131
3	1612	Refine and develop aging techniques.	5	NMFS, Academia		250	50	50	50	50	50	Linked to 155
2	1613	Determine somatic growth rates and evaluate sources of variation.	10	NMFS,	State Resource Agencies, Academia	TBD	TBD	TBD	TBD	TBD	TBD	

IMPLEMENTATION SCHEDULE Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle												
Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
2	1614	Determine age-specific survival probabilities.	5	NMFS	FWS-ES, Academia, State Resource Agencies	250	50	50	50	50	50	Linked to 132, 162
2	1615	Determine age at sexual maturity for females.	10	NMFS	FWS-ES, State Resource Agencies, Academia	TBD	TBD	TBD	TBD	TBD	TBD	
3	1616	Determine age at sexual maturity, reproductive frequency, and reproductive lifespan for males.	Ongoing	NMFS	Academia, State Resource Agencies	TBD	TBD	TBD	TBD	TBD	TBD	Linked to 132, 162
2	162	Implement sampling and data collection protocols at index in-water sites.	Ongoing	NMFS	State Resource Agencies, Academia, NGOs, FPL	1250	250	250	250	250	250	Linked to 132
1	171	Maintain the Sea Turtle Stranding and Salvage Network.	Ongoing	NMFS, State Resource Agencies,	FWS-Refuges, Aquaria, NPS, DOD, USCG, Local Govts, NGOs, Academia, FPL	2500	500	500	500	500	500	
2	172	Implement improvements to the Sea Turtle Stranding and Salvage Network.	Ongoing	NMFS, State Resource Agencies		1250	250	250	250	250	250	

IMPLEMENTATION SCHEDULE Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle												
Priority	Action Number	Action Description	Action Duration (Years)	Responsible Party		Total Cost ($1000s) for FY1-FY5	Cost Estimate by FY (by $1,000s)					Comments
				Lead	Others		FY1	FY2	FY3	FY4	FY5	
3	18	Maintain and enhance centralized administration and coordination of tagging programs.	Ongoing	NMFS, ACCSTR		500	100	100	100	100	100	
3	211	Conduct periodic reviews of existing state and FWS criteria for sand placement projects and modify as necessary.	Ongoing	FWS-ES, FFWCC, GDNR, SCDNR, NCWRC, ADCNR	COE, FDEP, SCDHEC, ACDEM, NCDENR	40	20	0	0	0	20	
2	212	Ensure all beach sand placement projects are in compliance with state and FWS criteria.	Ongoing	FWS-ES, FFWCC, GDNR, SCDNR, NCWRC, ADCNR	COE, FDEP, SCDHEC, ACDEM, NCDENR	500	100	100	100	100	100	
3	2131	Evaluate sand compaction levels on native beaches for all recovery units to determine thresholds for tilling.	3	COE		150	50	50	50			
3	2132	Investigate alternative methods for monitoring sand compaction.	3	COE		75	25	25	25			
2	2133	Implement tilling as a means of softening compacted beaches.	Ongoing	COE	Sand Placement Project Sponsors	TBD	TBD	TBD	TBD	TBD	TBD	
2	214	Implement escarpment leveling on constructed beaches.	Ongoing	COE	Sand Placement Project Sponsors	TBD	TBD	TBD	TBD	TBD	TBD	
2	215	Ensure sediment grain size, composition, and color are compatible with native beaches.	Ongoing	COE	Sand Placement Project Sponsors	TBD	TBD	TBD	TBD	TBD	TBD	

IMPLEMENTATION SCHEDULE Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle												
Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
3	2161	Conduct research on contaminant levels of sediment sources and their effects on loggerheads.	5	COE	EPA	TBD	TBD	TBD	TBD	TBD	TBD	
3	2162	Evaluate and revise, if necessary, current Federal guidelines for contaminant levels of sediment sources to ensure compatibility with loggerhead development.	3	EPA	COE, FWS-ES	125	50	50	25			
3	2163	Conduct statistically valid sampling of borrow sediments for contaminants (pre- and post-construction) and ensure sediment sources do not exceed existing Federal guidelines for contaminant levels.	Ongoing	COE	Sand Placement Project Sponsors	0	0	0	0	0	0	Cost included in sand placement project budgets
2	217	Design and evaluate beach construction profiles to more closely mimic natural beaches.	Ongoing	COE, FDEP	Sand Placement Project Sponsors	500	100	100	100	100	100	
2	218	Re-establish natural dune structure and native vegetation during sand placement projects.	Ongoing	COE	Sand Placement Project Sponsors	TBD	TBD	TBD	TBD	TBD	TBD	Costs dependent on extent of sand placement projects

IMPLEMENTATION SCHEDULE Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle													
Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
3	219	Monitor suitability of post-construction beaches for nesting.	Ongoing	COE	Academia, Sand Placement Project Sponsors	TBD	TBD	TBD	TBD	TBD	TBD	Costs dependent on extent of sand placement projects
2	221	Categorize and inventory all beach armoring, shoreline stabilization structures, and all other barriers to nesting to establish baseline levels and develop a GIS.	3	FWS-ES	FFWCC, GDNR, SCDNR, NCWRC, ADCNR, FDEP, SCDHEC, NCDENR, ADEM	600	200	200	200			
1	2221	Convene an expert panel to develop a strategy to strengthen and guide regulations to minimize the effects of coastal armoring on loggerheads and to ensure that the percentage of nesting beach free of any barriers to nesting is stable or increasing relative to baseline levels determined in 221.	3	FWS-ES		125	50	50	25			
1	2222	Modify existing regulations or promulgate new regulations to implement the strategy developed in 2221.	5	FDEP, GDNR, SCDHEC, NCDENR, ADEM	FWS-ES	210	50	50	50	50	10	Linked to 2221

IMPLEMENTATION SCHEDULE **Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle**													
Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
1	2223	Ensure regulations governing placement and design of new coastal buildings and infrastructure eliminate any future need for coastal armoring.	5	FDEP, GDNR, SCDHEC, NCDENR, ADEM	FWS-ES	250	50	50	50	50	50	Linked to 2222
3	2224	Require removal of failed or ineffective erosion control structures.	Ongoing	FDEP, GDNR, SCDHEC, NCDENR, ADEM	FWS-ES	500	100	100	100	100	100	
3	2225	Prohibit recreational equipment on nesting beaches at night.	5	FDEP, GDNR, SCDHEC, NCDENR, ADEM, Local Govts	FWS-ES, FFWCC	250	50	50	50	50	50	
3	2226	Evaluate the effectiveness of dune crossovers for protecting dunes and strengthen existing regulations or promulgate new regulations to minimize effects from dune crossovers.	5	FDEP, FFWCC, GDNR, SCDHEC, SCDNR, NCDENR, NCWRC, ADEM, ADCNR	FWS-ES, Academics	250	50	50	50	50	50	
3	2227	Evaluate the effectiveness of sand fences for building beaches and strengthen existing regulations or promulgate new regulations for sand fence construction.	5	FDEP, FFWCC, GDNR, SCDHEC, SCDNR, NCDENR, NCWRC, ADEM, ADCNR	FWS-ES, Academics	250	50	50	50	50	50	

Implementation Schedule **Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle**												
Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
1	2228	Ensure regulations pertaining to barriers to nesting are enforced.	Ongoing	FDEP, GDNR, SCDHEC, NCDENR, ADEM, Local Govts	FWS-ES, FFWCC, SCDNR, NCWRC, ADCNR	1500	300	300	300	300	300	
1	231	Maintain at least the current length and quality of protected nesting beach.	Ongoing	FWS-ES	FWS-Refuges, NPS, DOD, FDEP, GDNR, SCDHEC, NCDENR, ADCNR, Local Govts, NGOs, FPL	100	20	20	20	20	20	
1	2321	Acquire additional beachfront and upland properties (undeveloped and developed) within the boundaries of the Archie Carr National Wildlife Refuge, Florida.	Ongoing	FWS-Refuges, FDEP, Brevard County, Indian River County	NGOs	50000	10000	10000	10000	10000	10000	
1	2322	Acquire additional beachfront and upland properties (undeveloped and developed) on Hutchinson Island, Florida, and develop a plan to ensure long-term protection.	Ongoing	FWS-Refuges, FDEP, St. Lucie County	NGOs	15000+	15000	TBD	TBD	TBD	TBD	

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Priority	Action Number	Action Description	Action Duration (Years)	Responsible Party		Total Cost ($1000s) for FY1-FY5	Cost Estimate by FY (by $1,000s)					Comments
				Lead	Others		FY1	FY2	FY3	FY4	FY5	
2	2323	Acquire additional beachfront and upland properties (undeveloped and developed) within the nesting range of the Peninsular Florida Recovery Unit and develop a plan to ensure long-term protection.	Ongoing	FDEP, Local Govts,	FWS-Refuges, NGOs	TBD	TBD	TBD	TBD	TBD	TBD	
2	2324	Acquire additional beachfront and upland properties (undeveloped and developed) within the nesting range of the Northern Recovery Unit and develop a plan to ensure long-term protection.	Ongoing	GDNR, NCDENR, SCDNR	FWS-Refuges, NPS, Local Govts, NGOs	TBD	TBD	TBD	TBD	TBD	TBD	
2	2325	Acquire additional beachfront and upland properties (undeveloped and developed) within the nesting range of the Northern Gulf Recovery Unit and develop a plan to ensure long-term protection.	Ongoing	FWS-Refuges, ADCNR, FDEP	NPS, Local Govts, NGOs	TBD	TBD	TBD	TBD	TBD	TBD	
3	2326	Acquire storm-damaged nesting beachfront and upland properties on loggerhead nesting beaches.	Ongoing	FEMA, FDEP, GDNR, SCDHEC, NCDENR, ADEM	FWS-Refuges, Local Govts, NGOs	TBD	TBD	TBD	TBD	TBD	TBD	

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Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
2	24	Develop a model that describes the effects of sea level rise on the nesting range of loggerheads.	4	NOAA, Academia	FWS-ES, FDEP	300	75	75	75	75		
2	2511	Implement and enforce lighting ordinances on lands under local government jurisdiction.	Ongoing	Local Govts, Ports Authority		2000	400	400	400	400	400	
2	2512	Implement and enforce lighting management plans on all lands under state and Federal jurisdiction.	Ongoing	FWS-ES, NPS, DOD, FDEP, GDNR, SCDNR, NCDENR, ADCNR		250	50	50	50	50	50	
3	252	Evaluate the extent of hatchling disorientation on nesting beaches based on standardized surveys.	Ongoing	FWS-ES, FFWCC, GDNR, NCWRC, SCDNR, ADCNR	FWS-Refuges, FDEP, SCDPRT, NCDENR, NPS, DOD, Local Govts, NGOs, UCF, FPL	250	50	50	50	50	50	
3	253	Prosecute individuals or entities responsible for hatchling disorientation under the Endangered Species Act or appropriate state laws.	Ongoing	FWS-LE, FFWCC, GDNR, SCDNR, NCWRC, ADCNR		100	20	20	20	20	20	

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Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
3	261	Encourage the manual removal of manmade beach debris through regular coastal cleanup programs.	Ongoing	NGOs	FWS, NPS, DOD, FDEP, GDNR, SCDNR, NCDENR, ADCNR, Local Govts	125	25	25	25	25	25	
3	262	Remove exotic vegetation harmful to loggerheads on and adjacent to nesting beaches.	Ongoing	FDEP, GDNR, SCDNR, NCDENR, ADCNR	FWS-ES, NPS, DOD, FPL, NGOs, Local Govts	TBD	TBD	TBD	TBD	TBD	TBD	
2	271	Assess, categorize, and map neritic habitats used by loggerheads.	10	NMFS, State Resource Agencies	Academia	500	100	100	100	100	100	
3	2721	Assess the effects of bottom trawl and dredge fisheries on neritic habitats used by loggerheads.	5	NMFS, State Resource Agencies	FMCs, Academia, NGOs	TBD	TBD	TBD	TBD	TBD	TBD	
3	2722	Assess the effects of eutrophication on neritic habitats used by loggerheads.	10	EPA, State Resource Agencies	Academia, NGOs, Local Govts	TBD	TBD	TBD	TBD	TBD	TBD	
3	2723	Assess the effects of water management on neritic habitats used by loggerheads.	10	EPA, State Resource Agencies	Academia, Local Govts, NGOs	TBD	TBD	TBD	TBD	TBD	TBD	
3	2724	Assess the effects of oil and gas production activities on neritic habitats used by loggerheads.	10	MMS		TBD	TBD	TBD	TBD	TBD	TBD	

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				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
3	2725	Assess the effects of channel dredging on neritic habitats used by loggerheads.	10	COE		TBD	TBD	TBD	TBD	TBD	TBD	
3	2726	Assess the effects of salvage operations on neritic habitats used by loggerheads.	10	COE, State Resource Agencies		TBD	TBD	TBD	TBD	TBD	TBD	
3	2727	Assess the effects of other human activities on neritic habitats used by loggerheads.	10	NMFS, State Resource Agencies	COE, Local Govts	TBD	TBD	TBD	TBD	TBD	TBD	
1	273	Develop and implement a strategy to protect and monitor neritic habitats used by loggerheads.	5	NMFS, State Resource Agencies	Academia, NGOs	450	100	100	100	100	50	
2	281	Assess, categorize, and map oceanic habitats used by loggerheads.	10	NMFS	Academia	1000	200	200	200	200	200	
3	2821	Assess the effects of oil and gas activities on oceanic habitats used by loggerheads.	10	MMS, NMFS	Academia	TBD	TBD	TBD	TBD	TBD	TBD	
3	2822	Assess the effects of marine debris on oceanic habitats used by loggerheads.	10	NMFS, EPA	Academia	TBD	TBD	TBD	TBD	TBD	TBD	
3	2823	Assess the effects of toxins and other pollutants on oceanic habitats used by loggerheads.	10	NMFS, EPA, MMS	Academia	TBD	TBD	TBD	TBD	TBD	TBD	
1	283	Develop and implement a strategy to protect and monitor oceanic habitats used by loggerheads.	5	NMFS, DOS	Academics, NGOs	450	100	100	100	100	50	

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				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
2	29	Develop and maintain a comprehensive GIS database of neritic and oceanic habitats (used by loggerheads) and human activities that impact these habitats.	5	NMFS, State Resource Agencies	Academia	500	100	100	100	100	100	Linked to 141, 271, 281
1	31	Work with foreign nations to quantify and minimize commercial and subsistence harvest.	Ongoing	NMFS, DOS	Academia, FWS-ES, NGOs	250	50	50	50	50	50	
3	32	Educate local peoples in foreign nations on the economic benefits of sea turtle ecotourism as an alternative to harvest.	Ongoing	NMFS, DOS	FWS-ES NGOs, Academia	1500	300	300	300	300	300	
3	33	Develop and implement guidelines for public turtle walks that minimize disturbance to loggerheads.	Ongoing	FWS-ES	FFWCC, GDNR, SCDNR, NCWRC, ADCNR	125	25	25	25	25	25	Guidelines developed in 3 years
3	34	Minimize take of wild turtles for captive display.	Ongoing	FWS-ES	NMFS, FFWCC, GDNR, SCDNR, NCWRC, ADCNR	0	0	0	0	0	0	
2	411	Reduce the annual rate of mammalian predation to at or below 10% of nests within each recovery unit using ecologically sound predator control programs.	Ongoing	FFWCC, GDNR, SCDNR, NCWRC, ADCNR	FWS-Refuges, NPS, DOD, FDEP, NCDENR, Local Govts, NGOs, FPL	3150	630	630	630	630	630	

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				Lead	Others		FY1	FY2	FY3	FY4	FY5	
3	412	Control fire ants on and adjacent to loggerhead nesting beaches.	Ongoing	FFWCC, GDNR, SCDNR, NCWRC, ADCNR	FWS-Refuges, NPS, DOD, FDEP, NCDENR, Local Govts, NGOs, FPL	125	25	25	25	25	25	
3	421	Develop a condition index to allow rapid evaluation of physiological status.	3	Academia	NMFS, FWS-ES	225	75	75	75			
3	422	Develop protocols for collecting, handling, and analyzing baseline blood chemistry parameters from wild loggerheads.	3	Academia	NMFS, FWS-ES, State Resource Agencies	125	50	50	25			
3	423	Establish representative baseline blood chemistry parameters by sex, size class, season, and location.	5	Academia	NMFS, FWS-ES, State Resource Agencies	500	100	100	100	100	100	
3	424	Establish representative baseline toxicological parameters by sex, size class, season, and habitat.	10	NMFS, Academia	NOS, FWS-ES, EPA, State Resource Agencies	TBD	TBD	TBD	TBD	TBD	TBD	
3	425	Establish representative baseline levels of parasitic infection in wild turtles.	10	Academia, NMFS	FWS-ES, State Resource Agencies	375	75	75	75	75	75	
3	426	Establish representative baseline levels of bacterial, fungal, and viral infections in wild turtles.	10	Academia, NMFS	FWS-ES, State Resource Agencies	TBD	TBD	TBD	TBD	TBD	TBD	

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				Lead	Others		FY1	FY2	FY3	FY4	FY5	
2	43	Develop and implement a program to monitor loggerhead health at representative in-water index sites and index/standardized nesting beaches.	Ongoing	NMFS, FWS-ES, State Resource Agencies	Academia	TBD	TBD	TBD	TBD	TBD	TBD	
3	44	Evaluate the effects of harmful algal blooms on loggerhead health.	10	FFWCC, NMFS, NOS	Academia	500	100	100	100	100	100	
3	45	Investigate the lethal and sublethal role of contaminants.	10	Academia, EPA	NOS, NMFS, FWS-ES, USGS-NWHC	TBD	TBD	TBD	TBD	TBD	TBD	
3	46	Develop and implement protocols for handling turtles to limit transfer of disease.	3	FWS-ES, NMFS	Academia, Aquaria, State Resource Agencies	125	50	50	25			
3	471	Develop and/or finalize protocols for the proper care and maintenance of loggerheads held in captivity.	3	FWS-ES, NMFS	FFWCC, Aquaria, Academia, State Resource Agencies	125	50	50	25			
3	472	Develop protocols for transport and release of captive loggerheads.	3	FWS-ES, NMFS	FFWCC, Aquaria, Academia, State Resource Agencies	--	--	--	--			Costs included in 471
3	473	Develop a manual for the assessment and treatment of loggerhead diseases and injuries.	5	FWS-ES, NMFS	FWS-ES, NMFS, Aquaria, Academia	200	50	50	50	25	25	

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				Lead	Others		FY1	FY2	FY3	FY4	FY5	
3	474	Develop and maintain a list of veterinarians qualified to diagnose and treat health problems in loggerheads.	3	State Resource Agencies	FWS-ES, NMFS, Aquaria, Academia	--	--	--	--			Costs included in 473
2	48	Develop a strategy to recognize, respond to, and investigate mass strandings, disease episodes, or unusual mortality events.	3	NMFS	NMFS, FWS-ES/ Refuges, NOS, Aquaria, Academia, State Resource Agencies	125	50	50	25			
3	511	Develop and implement Federal regulations to ensure long-term protection of loggerheads and their habitats post-delisting.	10	NMFS, FWS-ES	State Resource Agencies	TBD	TBD	TBD	TBD	TBD	TBD	
1	512	Ensure full and active enforcement of Federal regulations designed to protect loggerheads.	Ongoing	NMFS, FWS-ES, USCG	State Resource Agencies	10000	2000	2000	2000	2000	2000	
1	513	Develop and/or maintain, implement, and enforce state and local legislation to protect loggerheads and their habitats.	Ongoing	State Resource Agencies, Local Govts		5000	1000	1000	1000	1000	1000	
1	521	Assist foreign countries in developing national regulations to protect loggerheads and their habitats.	10	FWS-ES, NMFS, DOS		1250	250	250	250	250	250	

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				Lead	Others		FY1	FY2	FY3	FY4	FY5	
1	522	Assist foreign countries with enforcement of national regulations to protect loggerheads.	Ongoing	DOS	FWS-ES, NMFS, USCG	2500	500	500	500	500	500	
2	531	Encourage non-signatory nations of the western hemisphere to accede to the Inter-American Convention for the Conservation and Protection of Marine Turtles.	Ongoing	DOS	FWS-ES, NMFS	250	50	50	50	50	50	
2	532	Encourage non-signatory nations to accede to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartegena Convention), specifically the Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean (SPAW Protocol).	Ongoing	DOS	FWS-ES, NMFS	50	10	10	10	10	10	
2	533	Ensure the U.S. becomes a party to the United Nations Convention on the Law of the Sea and the Convention on Migratory Species.	5	DOS	NMFS, FWS-ES	0	0	0	0	0	0	

IMPLEMENTATION SCHEDULE **Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle**												
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				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
3	6111	Evaluate the effects of nest management activities on nest productivity, hatchling fitness, and sex ratios and develop scientifically based standardized protocols for nest management.	5	FFWCC, GDNR, SCDNR, NCWRC, ADCNR, FWS-ES	Academia, FWS-Refuges, FDEP, SCDPRT, NCDENR, NPS, DOD, Local Govts, NGOs	850	250	250	250	50	50	
3	6112	Implement scientifically based standardized protocols for nest management.	Ongoing	FFWCC, GDNR, SCDNR, NCWRC, ADCNR, FWS-ES	FWS-Refuges, FDEP, SCDPRT, NCDENR, NPS, DOD, Local Govts, NGOs, Academia	250	50	50	50	50	50	
3	6113	Use the least manipulative method to protect nests.	Ongoing	FFWCC, GDNR, SCDNR, NCWRC, ADCNR, FWS-ES	FWS-Refuges, FDEP, SCDPRT, NCDENR, NPS, DOD, Local Govts, NGOs, Academia	0	0	0	0	0	0	

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				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
3	6114	Discontinue the use of hatcheries as a nest management technique.	5	FFWCC, GDNR, SCDNR, NCWRC, ADCNR, FWS-ES	FWS-Refuges, FDEP, SCDPRT, NCDENR, NPS, DOD, Local Govts, NGOs, Academia	0	0	0	0	0	0	
3	6121	Prohibit nighttime driving on beaches during loggerhead nesting season.	Ongoing	FWS-ES, GDNR, Local Govts, NPS	FFWCC, FDEP, SCDNR, NCWRC, NCDENR, ADCNR	TBD	TBD	TBD	TBD	TBD	TBD	
3	6122	Ensure that the linear kilometers of nesting beach where vehicular traffic is permitted does not increase above 2006 levels.	Ongoing	FWS-ES, GDNR, NPS, Local Govts	FFWCC, FDEP, SCDNR, NCWRC, NCDENR, ADCNR	50	10	10	10	10	10	
3	6123	Manage daytime driving to minimize impacts to loggerheads.	Ongoing	FWS-ES, NPS, GDNR, Local Govts	FFWCC, FDEP, SCDNR, NCWRC, NCDENR, ADCNR	TBD	TBD	TBD	TBD	TBD	TBD	
3	613	Strengthen existing regulations or promulgate new regulations to manage mechanical beach cleaning on nesting beaches.	3	FDEP, GDNR, SCDHEC, NCDENR, ADEM	FWS-ES, FFWCC, SCDNR, NCWRC, ADCNR, Local Govts	60	25	25	10			

IMPLEMENTATION SCHEDULE **Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle**													
Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
3	6141	Evaluate the extent and effects of harassment of nesting females and hatchlings and develop management recommendations.	3	FWS-ES, FFWCC, GDNR, SCDNR, NCWRC, ADCNR,	Academia	300	100	100	100			
3	6142	Conduct public education campaigns to minimize harassment of nesting females and hatchlings.	Ongoing	FWS-ES, FFWCC, GDNR, SCDNR, NCWRC, ADCNR, NGOs	Local Govts, NGOs	500	100	100	100	100	100	
3	6143	Increase the number of interpretive turtle walks to meet demand and minimize overall disturbance to nesting females and hatchlings.	Ongoing	FWS-ES, FFWCC, GDNR, SCDNR, NCWRC, ADCNR, NGOs	NPS, FDEP, NCDENR, Local Govts	0	0	0	0	0	0	
3	6144	Enforce laws to minimize harassment of nesting females and hatchlings.	Ongoing	FWS-LE, FFWCC, GDNR, SCDNR, NCWRC, ADCNR	NPS, DOD, FDEP, NCDENR	--	--	--	--	--	--	Costs included in 512, 513
3	615	Develop and enforce guidelines for special events on the beach to minimize impacts on nesting females, nests, and hatchlings.	Ongoing	FDEP, GDNR, ADEM, SCDHEC, Local Govts	FWS, NPS, FFWCC, SCDNR, NCWRC, NCDENR, ACDNR	300	75	75	50	50	50	Guidelines developed in 3 years
3	616	Minimize the impacts of military activities on nesting females, nests, and hatchlings.	Ongoing	DOD	FWS-ES	125	25	25	25	25	25	

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Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
3	6171	Conduct a risk management assessment of oil spill effects on nesting beaches.	5	NOAA, USCG	MMS, EPA	TBD	TBD	TBD	TBD	TBD	TBD	
3	6172	Ensure that oil spill response plans exist and adequately protect all nesting beaches.	Ongoing	USCG	MMS, FWS-ES	125	25	25	25	25	25	
3	6181	Conduct all non-emergency coastal construction activities outside the main portion of the nesting season to eliminate impacts on nesting females, nests, and hatchlings.	Ongoing	FDEP, GDNR, SCDHEC, NCDENR, ADEM	FWS-ES, FFWCC, SCDNR, NCWRC, ADCNR, Local Govts	0	0	0	0	0	0	
3	6182	Strengthen existing regulations or promulgate new regulations to minimize impacts from emergency construction activities during the nesting season on nesting females, nests, and hatchlings.	3	FDEP, GDNR, SCDHEC, NCDENR, ADEM	FWS-ES, FFWCC, SCDNR, NCWRC, ADCNR, Local Govts	60	25	25	10			
3	6183	Develop and implement ordinances to eliminate the effects of stormwater outfalls and swimming pool drainage on nesting females, nests, and hatchlings.	3	Local Govts		60	25	25	10			

IMPLEMENTATION SCHEDULE **Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle**													
Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
3	619	Ensure that law enforcement activities eliminate poaching of eggs and nesting females.	Ongoing	FWS-LE, FFWCC, GDNR, SCDNR, NCWRC, ADCNR	NPS, DOD, FDEP, NCDENR	--	--	--	--	--	--	Costs included in 512, 513
2	6211	Describe and characterize domestic commercial gillnet fisheries.	2	NMFS	State Resource Agencies, ASMFC, GSMFC	500	250	250				
2	6212	Integrate information gathered in 6211 with turtle distribution data.	3	NMFS	State Resource Agencies, Academia	--	--	--	--			Costs included in 141
2	6213	Implement observer programs to determine bycatch levels and identify key characteristics of domestic commercial gillnet fisheries that affect bycatch levels.	5	NMFS, State Resource Agencies		2500	500	500	500	500	500	
1	6214	Implement measures to minimize bycatch in large mesh gillnet fisheries.	3	NMFS, FMCs, State Resource Agencies		150	50	50	50			
1	6215	Implement measures to minimize bycatch in other gillnet fisheries as appropriate.	3	NMFS, FMCs, State Resource Agencies		150	50	50	50			
3	6221	Describe and characterize domestic commercial and recreational shrimp trawl fisheries.	2	NMFS	State Resource Agencies, ASMFC, GSMFC	--	--	--				Cost included in 6211

IMPLEMENTATION SCHEDULE Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle												
Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
3	6222	Integrate information gathered in 6221 with turtle distribution data.	2	NMFS	State Resource Agencies, Academia	--	--	--	--			Costs included in 141
2	6223	Increase observer coverage to a statistically robust level to adequately monitor bycatch levels in the domestic commercial shrimp fishery and modify TED regulations if necessary.	5	NMFS, State Resource Agencies		5000	1000	1000	1000	1000	1000	
1	6224	Promulgate regulations to require TEDs in all trynets in the domestic commercial shrimp fishery.	2	NMFS, State Resource Agencies		50	25	25				
3	6225	Continue efforts to educate domestic commercial shrimp fishers on the proper installation and use of larger-opening TEDs.	Ongoing	NMFS	State Resource Agencies, Sea Grant	500	100	100	100	100	100	
2	6226	Investigate the physiological effects of multiple captures and exclusions of loggerheads in domestic commercial shrimp trawls equipped with TEDs.	3	NMFS	Academia, State Resource Agencies	750	250	250	250			

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				Lead	Others		FY1	FY2	FY3	FY4	FY5	
1	6227	Monitor and reduce effort in the domestic commercial shrimp trawl fishery to minimize loggerhead bycatch.	5	NMFS	SAFMC, GMFMC, State Resource Agencies	TBD	TBD	TBD	TBD	TBD	TBD	
2	6228	Investigate turtle exclusion rates for soft TEDs under field conditions using videography.	3	NMFS		450	150	150	150			
2	6229	Implement statistically valid observer programs to determine bycatch levels in domestic commercial skimmer trawl fisheries and require TEDs if necessary.	2	NMFS, State Resource Agencies		600	300	300				
2	6231	Describe and characterize domestic commercial non-shrimp trawl fisheries.	2	NMFS	State Resource Agencies, ASMFC, GSMFC	--	--	--				Cost included in 6211
2	6232	Integrate information gathered in 6231 with turtle distribution data.	2	NMFS	State Resource Agencies, Academia	--	--	--	--			Costs included in 141
2	6233	Implement statistically valid observer programs to determine bycatch levels in domestic commercial non-shrimp trawl fisheries.	4	NMFS, State Resource Agencies		2000	500	500	500	500		

Implementation Schedule Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle												
Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
1	6234	Implement seasonal TED regulations for domestic commercial non-shrimp trawl fisheries operating from Cape Charles, Virginia, north to Long Island Sound.	3	NMFS, State Resource Agencies	MAFMC, NEFMC,	150	50	50	50			
1	6235	Promulgate regulations to require TEDs in domestic commercial flynet trawl fisheries.	3	NMFS, , State Resource Agencies	SAFMC, GOMFMC	150	50	50	50			
1	6236	Promulgate regulations to require TEDs in all domestic commercial non-shrimp trawl fisheries south of Cape Hatteras, North Carolina.	3	NMFS, State Resource Agencies	SAFMC, GOMFMC,	150	50	50	50			
2	6241	Describe and characterize domestic commercial pelagic and demersal longline fisheries.	2	NMFS	State Resource Agencies	--	--	--				Cost included in 6211
2	6242	Integrate information gathered in 6241 with turtle distribution data.	2	NMFS	State Resource Agencies, Academia	--	--	--	--			Costs included in 141
2	6243	Maintain and/or increase observer coverage to a statistically robust level to adequately monitor bycatch levels in domestic commercial pelagic and demersal longline fisheries.	3	NMFS	State Resource Agencies	3000	1000	1000	1000			

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Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
2	6244	Continue to conduct focused experiments on domestic commercial longline gear and fishing practices to minimize loggerhead interactions and secondarily to minimize post-interaction mortality.	5	NMFS	Academia, Fishing Industry, NGOs	TBD	TBD	TBD	TBD	TBD	TBD	
1	6245	Investigate the effectiveness of time-area closures to minimize loggerhead interactions in domestic commercial pelagic and demersal longline fisheries.	3	NMFS	FMCs, Academia	300	100	100	100			
1	6246	Promulgate regulations to implement proven measures that minimize loggerhead interactions with commercial pelagic and demersal longline fisheries.	3	NMFS	FMCs	150	50	50	50			
1	6247	Develop and implement effective approaches to enforcing longline regulations in the U.S. EEZ and on the high seas.	Ongoing	NMFS, DOS	FMCs, USCG	1250	250	250	250	250	250	
3	6248	Promote the use of safe handling practices and careful release tools in domestic commercial pelagic and demersal longline fisheries.	Ongoing	NMFS	FMCs	250	50	50	50	50	50	

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Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
2	6251	Describe and characterize pot/trap fisheries.	2	NMFS	State Resource Agencies, ASMFC, GSMFC	--	--	--				Cost included in 6211
2	6252	Integrate information gathered in 6251 with turtle distribution data.	2	NMFS, Academia	State Resource Agencies,	--	--	--	--			Costs included in 141
2	6253	Develop gear modifications to prevent entanglement of loggerheads in pot/trap lines.	3	NMFS	Fishing Industry	750	250	250	250			
2	6254	Promulgate regulations to incorporate modifications to whelk pot bridles to prevent loggerhead entanglement.	3	NMFS	State Resource Agencies	125	50	50	25			
2	6255	Promulgate appropriate regulations to reduce incidental capture of loggerheads in pots/traps.	3	NMFS	State Resource Agencies	125	50	50	25			
3	6256	Require identification on pot/trap gear.	3	NMFS, State Resource Agencies	FMCs	125	50	50	25			
2	6261	Describe and characterize domestic commercial dredge fisheries.	2	NMFS	State Resource Agencies, ASMFC, GSMFC	--	--	--				Cost included in 6211
2	6262	Integrate information gathered in 6261 with turtle distribution data.	2	NMFS, Academia	State Resource Agencies	--	--	--	--			Costs included in 141

IMPLEMENTATION SCHEDULE Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle												
Priority	Action Number	Action Description	Action Duration (Years)	Responsible Party		Total Cost ($1000s) for FY1-FY5	Cost Estimate by FY (by $1,000s)					Comments
				Lead	Others		FY1	FY2	FY3	FY4	FY5	
2	6263	Evaluate the effectiveness of gear modifications developed to reduce loggerhead bycatch in the domestic commercial scallop dredge fishery.	2	NMFS	Fishing Industry	400	200	200				
2	6264	Promulgate regulations that reduce loggerhead bycatch and mortality in the domestic commercial scallop dredge fishery.	2	NMFS		100	50	50				
3	6265	Investigate bycatch and mortality of loggerheads in commercial whelk dredge fisheries.	3	NMFS, State Resource Agencies		750	250	250	250			
2	6266	Investigate bycatch and mortality of loggerheads in commercial surf clam dredge fisheries.	3	NMFS	State Resource Agencies	300			100	100	100	
3	6271	Describe and characterize other domestic commercial fisheries.	2	NMFS	State Resource Agencies, ASMFC, GSMFC	--	--	--				Cost included in 6211
3	6272	Integrate information gathered in 6271 with turtle distribution data.	2	NMFS, Academia	State Resource Agencies	--	--	--	--			Costs included in 141

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Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
3	6273	Investigate bycatch and mortality of loggerheads in other domestic commercial fisheries and implement bycatch reduction measures as necessary.	2	NMFS, Academia	State Resource Agencies	750	0	0	250	250	250	
3	6274	Ensure that no increase in effort over 2003 levels occurs in the *Sargassum* fishery to minimize loggerhead bycatch.	Ongoing	NMFS	SAFMC	0	0	0	0	0	0	
1	628	Enforce domestic commercial fishery regulations to minimize loggerhead bycatch.	Ongoing	NMFS, USCG, State Resource Agencies		--	--	--	--	--	--	Costs included in 512
2	631	Disseminate results of bycatch reduction experiments and transfer demonstrated bycatch reduction technologies to foreign nations.	Ongoing	DOS, NMFS	NGOs	1500	300	300	300	300	300	
2	632	Encourage and assist foreign nations in collecting data on loggerhead bycatch via observer programs for commercial fisheries where bycatch levels are undocumented.	Ongoing	DOS, NMFS	NGOs	1250	250	250	250	250	250	

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				Lead	Others		FY1	FY2	FY3	FY4	FY5	
1	633	Encourage and assist foreign nations to develop, implement, and enforce fishery regulations to minimize loggerhead bycatch in commercial pelagic longline fisheries.	Ongoing	DOS, NMFS	NGOs	1250	250	250	250	250	250	
1	634	Encourage and assist foreign nations to develop, implement, and enforce fishery regulations to minimize loggerhead bycatch in commercial trawl fisheries.	Ongoing	DOS, NMFS	NGOs	1250	250	250	250	250	250	
1	635	Encourage and assist foreign nations to develop, implement, and enforce fishery regulations to minimize loggerhead bycatch in commercial gillnet fisheries.	Ongoing	DOS, NMFS	NGOs	1250	250	250	250	250	250	
2	636	Encourage and assist foreign nations to develop, implement, and enforce fishery regulations to minimize loggerhead bycatch in other commercial fisheries.	Ongoing	DOS, NMFS	NGOs	1250	250	250	250	250	250	
2	637	Develop economic incentives to reduce fishery interactions and mortality of loggerheads in foreign high seas fisheries.	Ongoing	DOS, NMFS		TBD	TBD	TBD	TBD	TBD	TBD	

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				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
1	638	Encourage ICCAT, Canada, Mexico, and the European Union to implement standards for collecting loggerhead bycatch information and requirements to minimize loggerhead bycatch.	5	DOS, NMFS		0	0	0	0	0	0	
3	641	Assess loggerhead diets and food web linkages in neritic and oceanic habitats.	10	Academia	NMFS, State Resource Agencies,	TBD	TBD	TBD	TBD	TBD	TBD	
2	642	Assess and minimize effects of commercial harvest of loggerhead prey species.	10	NMFS, State Resource Agencies	FMCs, Academia	TBD	TBD	TBD	TBD	TBD	TBD	
2	643	Assess effects of habitat alteration from commercial fisheries on distribution and abundance of loggerhead prey species.	10	NMFS, State Resource Agencies	FMCs, Academia	TBD	TBD	TBD	TBD	TBD	TBD	
2	651	Determine frequency of marine debris ingestion and entanglement by loggerheads in neritic and oceanic habitats.	5	NMFS, State Resource Agencies, Academia		500	100	100	100	100	100	
2	652	Evaluate the sublethal effects of marine debris ingestion and entanglement on loggerheads.	5	NMFS, State Resource Agencies, Academia		TBD	TBD	TBD	TBD	TBD	TBD	

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				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
2	653	Enforce the International Convention for the Prevention of Pollution from Ships (MARPOL).	Ongoing	USCG	DOS	TBD	TBD	TBD	TBD	TBD	TBD	
3	654	Explore feasibility and provide incentives to reduce the amount of abandoned recreational and commercial fishing gear that causes loggerhead injury and mortality.	Ongoing	NMFS	Academia, NGOs, USCG, State Resource Agencies	TBD	TBD	TBD	TBD	TBD	TBD	
3	655	Explore feasibility and provide incentives to reduce the amount of non-fisheries related marine debris that causes loggerhead injury and mortality.	Ongoing	NMFS	Academia, NGOs, USCG, State Resource Agencies	TBD	TBD	TBD	TBD	TBD	TBD	
3	656	Maintain or implement marine debris cleanup programs in coastal waters.	Ongoing	State Resource Agencies, Local Govts	NOAA, USCG, NGOs	375	75	75	75	75	75	
2	661	Develop a comprehensive GIS database to assess vessel interactions with loggerheads.	5	NMFS, State Resource Agencies	USCG, Academics, DOD	250	50	50	50	50	50	Linked to 141
1	662	Develop and implement a strategy to reduce vessel interactions with loggerheads.	5	NMFS, State Resource Agencies	DOD, USCG	500	100	100	100	100	100	

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				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
3	671	Assess effects of new technologies for channel dredge equipment on loggerhead captures.	3	COE	NMFS	TBD	TBD	TBD	TBD			
2	672	Incorporate effective channel dredge equipment modifications into future operations.	Ongoing	COE	NMFS	TBD	TBD	TBD	TBD	TBD	TBD	
2	673	Maintain current requirements for channel dredging activities in the southeast U.S. Atlantic and Gulf of Mexico and evaluate whether additional measures are required to minimize loggerhead mortality.	Ongoing	COE, NMFS	State Resource Agencies	0	0	0	0	0	0	
2	674	Implement regional requirements for channel dredging activities north of North Carolina to minimize loggerhead mortality.	3	COE, NMFS	State Resource Agencies	0	0	0	0			
3	711	Develop a video about the impacts of beachfront lighting on loggerheads and ways to minimize impacts.	3	FWS-ES	FFWCC, GDNR, SCDNR, NCWRC, ADCNR, NGOs	150	50	50	50			

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				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
3	712	Maintain websites with comprehensive information about loggerheads.	Ongoing	FWS-ES, NMFS, State Resource Agencies, Academia, NGOs		500	100	100	100	100	100	
3	713	Develop an educational curriculum for students and the public about loggerhead demography and ecological roles.	3	Academia, NGOs	FWS-ES, NMFS, State Resource Agencies	225	75	75	75			
3	714	Use computer gaming technologies to engage young people in sea turtle conservation.	3	NGOs		150	50	50	50			
3	72	Facilitate international scientific communication and information sharing.	Ongoing	FWS-ES, NMFS, Academia, NGOs		250	50	50	50	50	50	
3	73	Ensure facilities permitted to hold and display captive loggerheads have appropriate informational displays.	Ongoing	FWS-ES, FFWCC, GDNR, SCDNR, NCWRC, ADCNR	Aquaria, NGOs	0	0	0	0	0	0	
3	74	Ensure standard criteria and recommendations for sea turtle nesting interpretive walks are followed.	Ongoing	FFWCC, GDNR, SCDNR, NCWRC, ADCNR	FWS-ES	0	0	0	0	0	0	
3	75	Develop guidelines for and encourage interpretive daytime turtle walks.	3	FFWCC, GDNR, SCDNR, NCWRC, ADCNR	FWS-ES	15	5	5	5			

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Priority	**Action Number**	**Action Description**	**Action Duration (Years)**	**Responsible Party**		**Total Cost ($1000s) for FY1-FY5**	**Cost Estimate by FY (by $1,000s)**					**Comments**
				Lead	**Others**		**FY1**	**FY2**	**FY3**	**FY4**	**FY5**	
3	76	Place educational signs at public access points on nesting beaches.	Ongoing	FWS-Refuges, NPS, FFWCC, FDEP, GDNR, SCDNR, NCWRC, NCDENR, ADCNR, Local Govts, NGOs		125	25	25	25	25	25	
2	77	Conduct a contingent valuation study to measure the economic value of sea turtle related ecotourism.	3	Academia	FWS-ES, NMFS	150	50	50	50			

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PART V. APPENDICES

APPENDIX 1: LOGGERHEAD THREATS ANALYSIS

A comprehensive assessment of recovery plans indicated that the analysis of threats has received insufficient attention (Clark *et al*. 2002) and that this lack of knowledge regarding the nature of threats facing a species is likely to contribute to the failure of recovery plans (Lawler *et al*. 2002). Based on these assessments, the Loggerhead Recovery Team undertook a detailed analysis of threats to assist in prioritizing recovery actions. The following steps describe the process used to identify, categorize, quantify, and prioritize threats to the Northwest Atlantic population of the loggerhead. The annotated threats tables are posted on the FWS Loggerhead Recovery Plan website [http://www.fws.gov/northflorida].

(1) Threats affecting loggerheads are often specific to life stages and the habitats in which they occur. The Team identified and evaluated eight life stages (see Figure 8) in the threats analysis: egg, hatchling, hatchling swim frenzy and transitional stage, juvenile oceanic stage, juvenile neritic stage, adult oceanic stage, adult neritic stage, and nesting female.

(2) The three ecosystems inhabited by loggerheads (terrestrial, neritic, and oceanic) were then associated with the life stages occurring in those ecosystems as the first step in developing the threats analysis matrix as shown:

Lifestage	Ecosystem
Nesting female	Terrestrial Zone
Egg	Terrestrial Zone
Hatchling stage	Terrestrial Zone
Hatchling swim frenzy, transitional stage	Neritic Zone
Juvenile stage	Oceanic Zone
Adult stage	Oceanic Zone
Juvenile stage	Neritic Zone
Adult stage	Neritic Zone

(3) All identified threats to the Northwest Atlantic population of the loggerhead sea turtle were grouped into 7 categories (see Table A1-1): fisheries bycatch, resource use [non-fisheries], construction and development, ecosystem alterations, pollution, species interactions, and other factors.

(4) To facilitate quantifying and presenting the threats affecting the Northwest Atlantic population of the loggerhead sea turtle, the three elements (life stage, ecosystem, and specific categories of threats) were combined into a matrix using MS Excel (Table A1-2). A separate worksheet was developed for each of the 7 threat categories (see Table A1-1) with each specific threat within the threat categories identified as a separate column.

(5) Annual mortality for each life stage/ecosystem for each specific threat was estimated as a "category" of mortality using a color-coded $\log_{10}$ scale (Table A1-3). The log midpoint for that color-coded category was used for calculations of the annual mortality (see #9 and #10 below) to be consistent with the logarithmic scale of categories of mortality. When quantitative data were not available, the Team assigned a category of mortality based on best available information. The <**COMMENT**> feature of Excel was used to document the data source, calculations, and justification for each estimate of mortality presented in each cell of the matrix. The annotated threats tables with <**COMMENT**> fields are posted on the FWS Loggerhead Recovery Plan website [http://www.fws.gov/northflorida].

The Team identified a number of threats where mortality has been documented or is likely to occur. However, for these threats, data are insufficient at this time to allow for an estimation of mortality. For these threats where mortality is known but not quantified, the cell is shaded gray and assigned a value of 1 (= annual mortality of 1 individual in that category) so that these potentially important threats would appear in the summary tables.

(6) For each threat category, the total annual mortality for each life stage/ecosystem for all specific threats within that threat category was calculated by summing across the row (see column "Sum" in Table A1-4). To compare annual mortality among life stages, the annual mortality for each life stage was adjusted by the reproductive value of each life stage. This adjustment is necessary because some individuals in a population are more "valuable" than others in terms of the number of offspring they are expected to produce. An individual's potential for contributing offspring to future generations is its reproductive value (RV, Table A1-5). The reproductive values were developed using a stage-based demographic model (see #7 below) for the Northwest Atlantic loggerhead sea turtle population (Table A1-6; M. Snover, unpublished data). The reproductive values were converted to "relative reproductive values" based on the reproductive value of a nesting female, which is 1 (Table A1-5). The summed annual mortality for each life stage/ecosystem for all specific threats within a threat category was adjusted by the relative reproductive value for each life stage in the column "Total Estimated Adjusted Annual Mortality (number of adult females)" (see Table A1-4).

Several assumptions were made in calculating the relative reproductive values and need to be recognized when interpreting the results of this threats analysis. Table A1-6 suggests that there is a knife-edge ontogenetic change from the oceanic juvenile stage to the neritic juvenile stage. In reality, this ontogenetic change occurs over ages 7-12 (Bjorndal *et al*. 2000, 2003a). In addition, the neritic juvenile stage spans years 8-33, which combines small and large juveniles into this single life stage and results in an overestimate of adjusted mortality for threats affecting small juveniles and an underestimate of adjusted mortality for threats affecting large juveniles.

(7) The stage-based demographic model that was used to develop the reproductive values had the following parameters:

We assumed 34 years to first reproduction, a total of 7 years in the oceanic state (Bjorndal *et al*. 2000), with the first year identified as hatchlings. For survival rates we followed NMFS (2001) with adult annual survival rate = 0.812, neritic juvenile annual survival rate = 0.893, and oceanic juvenile annual survival rate was adjusted to 0.725 to result in $\lambda = 0.98$. For the first year survival rate, we used the smallest value reported for potential oceanic annual survival rates for small, similar-sized Kemp's ridleys, 0.25 (Heppell *et al*. 2005). Fecundity values were 4.1 nests per year, 115 eggs per nest, and a 0.50 sex ratio (NMFS 2001). NMFS (2001) used a nest survival rate of 0.675 which is the value from Wassaw Island, Georgia. As this beach is monitored and protected, we assumed a lower value would be more representative of the entire nesting region and used the value of 0.50. An age-based matrix model was used that cycled adult females between breeding and nonbreeding years (NMFS 2001, Heppell *et al*. 2003b). The matrix differed slightly from those of NMFS (2001) and Heppell *et al*. (2003b) in that we did not incorporate first year survival into the fecundity (i.e., we used a post-breed rather than a pre-breed model).

(8) The threats tables for each of the threats categories are presented on the FWS Loggerhead Recovery Plan website [http://www.fws.gov/northflorida; also see Appendix 2].

(9) Two types of summary tables were developed. First, a summary table was developed by combining the row totals for the specific threats within a threat category adjusted for relative reproductive values (step #6 above), for each of the 7 threat categories (Table A1-7). Values are not presented in this summary table, only categories of annual estimates of mortality based on the color-coded log scale. Summary Table A1-7 presents the relative importance of each threat category by life stage/ecosystem.

(10) A second summary table was developed to present the annual mortality for each specific threat within a threat category summed for all life stages/ecosystems and adjusted for relative reproductive values for each life stage/ecosystem (Table A1-8).

(11) The summary tables allowed the Recovery Team to evaluate the relative importance of each threat category by life stage/ecosystem and by specific threat. The Recovery Team used these summary tables to identify and prioritize recovery actions (see Recovery Narrative and Implementation Schedule).

(12) In addition to prioritizing recovery actions, the summary tables identify gaps in our knowledge (gray-shaded cells) where further research is needed. Although these gray-shaded cells could not be quantified, they may represent significant threats to the recovery of the Northwest Atlantic population of the loggerhead sea turtle.

(13) Sublethal effects have been identified for certain threats and life stages and are identified by stippling in the appropriate cells of the threats tables. These sublethal effects are likely to affect individual fitness (e.g., reduced somatic growth, egg production, hatchling production, nesting range, foraging range).

Table A1-1. Threat categories and description.

Category	Threat	Description
Fisheries Bycatch	Bottom trawl	Includes bottom trawl fisheries for blue crab, flounder, general finfish, scallop, shrimp, whelk, and the North Carolina flynet fishery for weakfish
	Top/midwater trawl	Includes trawls for sargassum and cannonball jellyfish
	Dredge	Includes dredge fisheries for scallops and whelks
	Pelagic longline	Includes longline fisheries for shark, swordfish, tuna, and wahoo
	Demersal longline	Includes longline fisheries for black scabbard and shark
	Demersal, large mesh gillnet	Includes gillnet fisheries for black drum, dogfish, monkfish, shark, and southern flounder
	Demersal, small mesh gillnet	Includes gillnet fisheries for general finfish
	Drift gillnet	Includes drift gillnet fisheries for shark, swordfish, and tuna
	Pound nets and weirs	
	Pot/trap fisheries	Includes pot fisheries for blue crab, lobster, stone crab, and whelk
	Haul seine	
	Channel net	
	Purse seine	Includes purse seines for menhaden and tuna
	Recreational hook and line	
	Commercial hook and line	Includes commercial hook and line fisheries for snapper/grouper, Gulf reef fish, king and Spanish mackerel, and sharks

Table A1-1. Threat categories and description, continued.

Category	Threat	Description
Resource Use (non-fisheries)	Legal harvest	
	Illegal harvest	
	Oil and gas activities	
	Vessel strikes	
	Beach cleaning	
	Human presence	
	Recreational beach equipment	
	Beach vehicular driving	
	Power generating activities	
	Conservation/research activities	Includes harassment of nesting females and hatchlings, handling of eggs, etc.
	Military activities	
Construction and Development (Although light pollution is associated with construction and development, that threat is captured under the "Pollution" category.)	Beach sand placement	Includes beach nourishment, beach restoration, and inlet sand bypassing
	Beach armoring	Includes bulkheads, seawalls, soil retaining walls, rock revetments, sandbags, and geotextile tubes
	Other shoreline stabilizations	Includes groins, jetties, mesh groins (nets), and offshore breakwaters
	Sand fences	
	Dredging	
	Stormwater outfalls	
	Coastal construction	Refers to buildings on the coast
	Channel blasting	
	Bridge blasting	
Ecosystem Alterations	Trophic changes from fishing	Refers to trophic changes from fishing-related activities (e.g., bottom trawling)
	Trophic changes from benthic habitat alteration	
	Beach erosion (washouts) and accretion	
	Aquaculture	
	Eutrophication	

Table A1-1. Threat categories and description, continued.

Category	Threat	Description
Pollution	Marine debris ingestion	
	Marine debris entanglement in derelict fishing gear	
	Marine debris entanglement in non-fishing gear	
	Beach debris	Includes large items that can impede or trap hatchlings and/or nesting females
	Oil pollution	
	Light pollution	
	Noise pollution	
	Thermal pollution	Includes thermal pollution from power plants
	Toxins	
Species Interactions	Predation	
	Disease and parasites	
	Harmful algal blooms	
	Predation by exotic species	
	Exotic dune and beach vegetation	
Other Factors	Climate change	
	Natural catastrophes	
	Cold water	
	Other (egg stage only)	Includes root damage, disease events, infertile eggs, relocation mortality, and inundation

Table A1-2. Threats matrix.

Life Stage	Ecosystem	Threats					
Nesting female	Terrestrial Zone						
Egg	Terrestrial Zone						
Hatchling stage	Terrestrial Zone						
Hatchling swim frenzy, transitional stage	Neritic Zone						
Juvenile stage	Oceanic Zone						
Adult stage	Oceanic Zone						
Juvenile stage	Neritic Zone						
Adult stage	Neritic Zone						

Table A1-3. Key used to assign estimated annual mortality to each threat category.

KEY		
Estimated Annual Mortality	**Color code**	**Value**
No evidence of mortality, based on best available information		
Sublethal effects occur at this stage and may result in reduced fitness (e.g., reduced somatic growth rates, reduced hatchling production, reduced prey abundance, reduced quality of nesting and/or foraging habitats)	(stippled grey)	
> 0 Mortality has been documented or is likely to occur; however, data are insufficient to allow estimation of mortality	(light grey)	**1**
1-10	(yellow)	**3**
11-100	(light orange)	**30**
101-1000	(orange)	**300**
1001-10,000	(red)	**3,000**
10,001-100,000	(dark red)	**30,000**
100,001-1,000,000	(black)	**300,000**

Table A1-4. Estimated annual mortality calculations.

Table A2-1. Results of threats analyses for threat category FISHERIES BYCATCH.

LIFE STAGE	ECOSYSTEM	TRAWL (BOTTOM)	TRAWL (TOP/ MID-WATER)	DREDGE FISHERIES	LONGLINE (PELAGIC)	LONGLINE (DEMERSAL)	GILLNET (DEMERSAL, LG. MESH)	GILLNET (DEMERSAL, SM. MESH)	GILLNET (DRIFT)	POUND NETS AND WEIRS	POT/TRAP FISHERIES	HAUL SEINES	CHANNEL NET	PURSE SEINE	HOOK & LINE (RECREA-TIONAL)	HOOK & LINE (COMM-ERCIAL)	SUM	RRV	TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)
Nesting female	Terrestrial Zone																0	1.000	0
Egg	Terrestrial Zone																0	0.004	0
Hatchling stage	Terrestrial Zone																0	0.004	0
Swim frenzy, transitional stage	Neritic Zone		1														1	0.004	0
Juvenile stage	Oceanic Zone				30,000	1			1								30,002	0.029	870
Adult stage	Oceanic Zone				1				1								2	0.789	2
Juvenile stage	Neritic Zone	30,000	1	300	1	3,000	3,000	300	30	30	30	1	1	1	30	30	36,755	0.235	8637
Adult stage	Neritic Zone	3,000	1	30	1	300	300	30	3	3	30	1	1	1	3	3	3,707	0.789	2925
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		9417	1	94	872	942	942	94	10	9	31	1	1	1	9	9			

Table A1-5. Reproductive values and relative reproductive values.

Lifestage	Ecosystem	Reproductive Values	Relative Reproductive Values
Nesting female	Terrestrial Zone	253.1	1.000
Egg	Terrestrial Zone	1	0.004
Hatchling stage	Terrestrial Zone	1	0.004
Hatchling swim frenzy, transitional stage	Neritic Zone	1	0.004
Juvenile stage	Oceanic Zone	7.3	0.029
Adult stage	Oceanic Zone	199.8	0.789
Juvenile stage	Neritic Zone	59.6	0.235
Adult stage	Neritic Zone	199.8	0.789

Table A1-6. Calculations for reproductive values.

Lifestage	Age	Stable Age Distribution	Stable Age Distribution, eliminating eggs/hatchlings stage	Reproductive Values (RV)	Weighted mean of RV for each stage
Eggs/Hatchlings	1	0.439		1	1
	2	0.112	0.199207793	3.915	7.3287694
	3	0.083	0.147627204	5.294	
	4	0.061	0.108497102	7.16	
	5	0.045	0.080038846	9.683	
	6	0.034	0.060473794	13.095	
Oceanic Juveniles	7	0.025	0.044466025	17.71	
	8	0.018	0.032015538	23.95	59.565532
	9	0.017	0.030236897	26.223	
	10	0.015	0.026679615	28.712	
	11	0.014	0.024900974	31.438	
	12	0.013	0.023122333	34.422	
	13	0.012	0.021343692	37.689	
	14	0.011	0.019565051	41.267	
	15	0.009709	0.017268826	45.184	
	16	0.008868	0.015772988	49.473	
	17	0.008099	0.014405214	54.169	
	18	0.007397	0.013156608	59.311	
	19	0.006756	0.012016499	64.941	
	20	0.00617	0.010974215	71.105	
	21	0.005635	0.010022642	77.854	
	22	0.005146	0.009152887	85.244	
	23	0.0047	0.008359613	93.336	
	24	0.004293	0.007635706	102.195	
	25	0.003921	0.006974051	111.896	
	26	0.003581	0.006369313	122.517	
	27	0.00327	0.005816156	134.146	
	28	0.002987	0.005312801	146.88	
	29	0.002728	0.004852133	160.822	
	30	0.002491	0.004430595	176.087	
	31	0.002275	0.004046408	192.801	
	32	0.002078	0.003696016	211.102	
Neritic Juveniles	33	0.001898	0.003375861	231.14	
Breeding Adults	34	0.003851	0.006849547	253.081	253.081
Non-Breeding Adults	35	0.006374	0.011337058	167.563	167.563
Adults					199.771

Table A1-7. Annual mortality for each lifestage/ecosystem for each threat category adjusted by relative reproductive equivalents (does not include sub-lethal effects, see individual threats tables in Appendix 2). Numeric values are not presented in this summary table, only categories of annual estimates of mortality based on the color-coded log scale (Table A1-3).

		CATEGORIES OF THREATS						
LIFE STAGE	ECOSYSTEM	FISHERIES BYCATCH	RESOURCE USE (NON-FISHERIES)	CONSTRUCTION AND DEVELOPMENT	ECOSYSTEM ALTERATIONS	POLLUTION	SPECIES INTERACTIONS	OTHER FACTORS
Nesting female	Terrestrial Zone							
Egg	Terrestrial Zone							
Hatchling stage	Terrestrial Zone							
Swim frenzy, transitional stage	Neritic Zone							
Juvenile stage	Oceanic Zone							
Adult stage	Oceanic Zone							
Juvenile stage	Neritic Zone							
Adult stage	Neritic Zone							

Table A1-8. Annual mortality for each threat within a threat category summed for all lifestages/ecosystems and adjusted for relative reproductive values for each lifestage/ecosystem (does not include sub-lethal effects, see individual threats tables in Appendix 2). Numeric values are not presented in this summary table, only categories of annual estimates of mortality based on the color-coded log scale (Table A1-3).

THREAT CATEGORY	SPECIFIC THREAT WITHIN A THREAT CATEGORY														
Other Factors	Climate change	Natural catastrophes	Cold water	Other (egg stage only)											
Species Interactions	Predation by native species	Disease and parasites	Red tide	Predation by exotic species	Exotic dune and beach vegetation										
Ecosystem Alterations	Trophic changes from fishery harvest	Trophic changes from benthic habitat alteration	Beach erosion (washouts) and accretion	Aquaculture	Eutrophication										
Pollution	Marine debris ingestion	Marine debris entanglement in derelict fishing gear	Marine debris entanglement in non-fishing gear	Beach debris	Oil pollution	Light pollution	Noise pollution	Thermal pollution	Toxins						
Construction and Development	Beach sand placement	Beach armoring	Other shoreline stabilizations	Sand fences	Dredging	Stormwater outfalls	Coastal construction	Channel blasting	Bridge blasting						
Resource Use (non-fisheries)	Legal harvest	Illegal harvest	Oil and gas activities	Vessel strikes	Beach cleaning	Human presence	Recreational beach equipment	Beach vehicular driving	Power plant entrainment	Management/ research activities	Military activities				
Fisheries Bycatch	Trawl (bottom)	Trawl (top/ midwater)	Dredge fisheries	Longline (pelagic)	Longline (demersal)	Gillnet (demersal, lg. mesh)	Gillnet (demersal, sm. mesh)	Gillnet (drift)	Pound nets and weirs	Pot/trap fisheries	Haul seines	Channel net	Purse seine	Hook & line (recreational)	Hook & line (commercial)

APPENDIX 2: THREATS TABLES

The following seven tables are the result of the loggerhead threats analysis described in Appendix 1. Please consult the excel file posted on the FWS Loggerhead Recovery Plan website [http://www.fws.gov/northflorida] to access detailed information used to derive the estimated annual mortality.

Table A2-1. Results of threats analyses for threat category FISHERIES BYCATCH.

LIFE STAGE	ECOSYSTEM	TRAWL (BOTTOM)	TRAWL (TOP/ MID-WATER)	DREDGE FISHERIES	LONGLINE (PELAGIC)	LONGLINE (DEMERSAL)	GILLNET (DEMERSAL, LG. MESH)	GILLNET (DEMERSAL, SM. MESH)	GILLNET (DRIFT)	POUND NETS AND WEIRS	POT/TRAP FISHERIES	HAUL SEINES	CHANNEL NET	PURSE SEINE	HOOK & LINE (RECREA-TIONAL)	HOOK & LINE (COMM-ERCIAL)	SUM	RRV	TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)
Nesting female	Terrestrial Zone																0	1.000	0
Egg	Terrestrial Zone																0	0.004	0
Hatchling stage	Terrestrial Zone																0	0.004	0
Swim frenzy, transitional stage	Neritic Zone		1														1	0.004	0
Juvenile stage	Oceanic Zone				30,000	1			1								30,002	0.029	870
Adult stage	Oceanic Zone				1				1								2	0.789	2
Juvenile stage	Neritic Zone	30,000	1	300	1	3,000	3,000	300	30	30	30	1	1	1	30	30	36,755	0.235	8637
Adult stage	Neritic Zone	3,000	1	30	1	300	300	30	3	3	30	1	1	1	3	3	3,707	0.789	2925
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		9417	1	94	872	942	942	94	10	9	31	1	1	1	9	9			

Table A2-2. Results of threats analyses for threat category RESOURCE USE (NON-FISHERIES).

Life Stage	Ecosystem	LEGAL HARVEST	ILLEGAL HARVEST	OIL AND GAS ACTIVITIES	VESSEL STRIKES	BEACH CLEANING	HUMAN PRESENCE	RECREA-TIONAL BEACH EQUIPMENT	BEACH VEHICULAR DRIVING	POWER PLANT ENTRAIN-MENT	MANAGE-MENT/ RESEARCH ACTIVITIES	MILITARY ACTIVITIES	SUM	RRV	TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)
Nesting female	Terrestrial Zone								3			1	4	1.000	4
Egg	Terrestrial Zone		3,000			1		1	1		300	1	3,304	0.004	13
Hatchling stage	Terrestrial Zone					1	1	1	1		1	1	6	0.004	0
Swim frenzy, transitional stage	Neritic Zone											1	1	0.004	0
Juvenile stage	Oceanic Zone	30	30	1	1								62	0.029	2
Adult stage	Oceanic Zone			1	1								2	0.789	2
Juvenile stage	Neritic Zone	3,000	300	30	300					3		1	3,634	0.235	854
Adult stage	Neritic Zone	300	30	3	300					3		1	637	0.789	503
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		943	107	10	308	0	0	0	3	3	1	2			

Table A2-3. Results of threats analyses for threat category CONSTRUCTION AND DEVELOPMENT.													
Life Stage	**Ecosystem**	BEACH SAND PLACEMENT	BEACH ARMORING	OTHER SHORELINE STABILIZ-ATIONS	SAND FENCES	DREDGING	STORM-WATER OUTFALLS	COASTAL CONSTRUC-TION	CHANNEL BLASTING	BRIDGE BLASTING	**SUM**	**RRV**	TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)
Nesting female	Terrestrial Zone	1	3	1				1			6	1.000	6
Egg	Terrestrial Zone	3,000	[illegible]	1			1	3,000			36,002	0.004	144
Hatchling stage	Terrestrial Zone	3,000	1	1	1			1			3,004	0.004	12
Swim frenzy, transitional stage	Neritic Zone			1							1	0.004	0
Juvenile stage	Oceanic Zone										0	0.029	0
Adult stage	Oceanic Zone										0	0.789	0
Juvenile stage	Neritic Zone					30					30	0.235	7
Adult stage	Neritic Zone					3					3	0.789	2
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		25	123	1	0	9	0	13	0	0			

Table A2-4. Results of threats analyses for threat category ECOSYSTEM ALTERATIONS.									
Life Stage	**Ecosystem**	**TROPHIC CHANGES FROM FISHERY HARVEST**	**TROPHIC CHANGES FROM BENTHIC HABITAT ALTERATION**	**BEACH EROSION (WASHOUTS) AND ACCRETION**	**AQUACULTURE**	**EUTROPHI-CATION**	**SUM**	**RRV**	**TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)**
Nesting female	Terrestrial Zone						0	1.000	0
Egg	Terrestrial Zone			300,000			300,000	0.004	1,200
Hatchling stage	Terrestrial Zone						0	0.004	0
Swim frenzy, transitional stage	Neritic Zone						0	0.004	0
Juvenile stage	Oceanic Zone						0	0.029	0
Adult stage	Oceanic Zone						0	0.789	0
Juvenile stage	Neritic Zone						0	0.235	0
Adult stage	Neritic Zone						0	0.789	0
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		0	0	1,200	0	0			

Table A2-5. Results of threats analyses for threat category POLLUTION.													
Life Stage	**Ecosystem**	MARINE DEBRIS INGESTION	MARINE DEBRIS ENTANGLE-MENT IN DERELICT FISHING GEAR	MARINE DEBRIS ENTANGLE-MENT IN NON-FISHING GEAR	BEACH DEBRIS	OIL POLLUTION	LIGHT POLLUTION	NOISE POLLUTION	THERMAL POLLUTION	TOXINS	**SUM**	**RRV**	TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)
Nesting female	Terrestrial Zone						3				3	1.000	3
Egg	Terrestrial Zone					1				1	2	0.004	0
Hatchling stage	Terrestrial Zone				1	1	300,000				300,002	0.004	1200
Swim frenzy, transitional stage	Neritic Zone	[illegible]	1	1		[illegible]	1			1	60,004	0.004	240
Juvenile stage	Oceanic Zone	1	1	1		1				1	5	0.029	0
Adult stage	Oceanic Zone	1	1	1		1				1	5	0.789	4
Juvenile stage	Neritic Zone	1	300	30		30				1	362	0.235	85
Adult stage	Neritic Zone	1	30	30		3				1	65	0.789	51
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		122	95	32	0	130	1203	0	0	2			

Table A2-6. Results of threats analyses for threat category SPECIES INTERACTIONS.

Life Stage	Ecosystem	PREDATION BY NATIVE SPECIES	DISEASE AND PARASITES	RED TIDE	PREDATION BY EXOTIC SPECIES	EXOTIC DUNE AND BEACH VEGETATION	SUM
Nesting female	Terrestrial Zone						0
Egg	Terrestrial Zone	300,000	see comment		30,000	1	330,001
Hatchling stage	Terrestrial Zone	3,000			1	1	3,002
Swim frenzy, transitional stage	Neritic Zone	300,000					300,000
Juvenile stage	Oceanic Zone	1	1				2
Adult stage	Oceanic Zone	1	1				2
Juvenile stage	Neritic Zone	1	1	30			32
Adult stage	Neritic Zone	1	1	30			32
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		2414	0	31	120	0	

Table A2-7. Results of threats analyses for threat category OTHER FACTORS.								
Life Stage	**Ecosystem**	**CLIMATE CHANGE**	**NATURAL CATASTROPHES**	**COLD WATER**	**OTHER (EGG STAGE ONLY)**	**SUM**	**RRV**	**TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)**
Nesting female	Terrestrial Zone					0	1.000	0
Egg	Terrestrial Zone	1	1		300,000	300,002	0.004	1200
Hatchling stage	Terrestrial Zone	1	1			2	0.004	0
Swim frenzy, transitional stage	Neritic Zone		1	1		2	0.004	0
Juvenile stage	Oceanic Zone			1		1	0.029	0
Adult stage	Oceanic Zone					0	0.789	0
Juvenile stage	Neritic Zone			30		30	0.235	7
Adult stage	Neritic Zone					0	0.789	0
TOTAL ESTIMATED ADJUSTED ANNUAL MORTALITY (# OF ADULT FEMALES)		0	0	7	1200			

APPENDIX 3: LEGAL HARVEST TABLE

Table A3-1. Legal Harvest of Loggerheads in the North Atlantic, Caribbean, and Gulf of Mexico.

Caribbean Islands

Country	Legal Turtle Harvest	Legal Egg Harvest	Season	Size Limit	Source Legislation	Citation
Anguilla (United Kingdom)	No[1]	No[1]			Fisheries Protection Act, Revised Statutes of Anguilla, Chapter F-40	Godley *et al*. 2004
Antigua & Barbuda	Yes	No	Sep 1-Apr 30	> 73 kg (160 lb.)	1990 Fishery Regulations, promulgated under the authority of the Fisheries Act (1983), Section 21	Fuller *et al*. 1992
Aruba (Netherlands)	No	No			Nests/Eggs are protected by the Marine Environment Ordinance (Marien Milieuverordening Aruba A.B. 1980 Nr. 18); Turtles are protected under this law by Decree No. 51 of 1987	K. Eckert, WIDECAST, personal communication, 2006
The Bahamas	Yes[2]	No	Aug 1-Mar 31	≥ 76 cm (30 in) back length	Fisheries Resources Regulations, 3 March 1986, Part IV, Sections 29-33	Fleming 2001
Barbados	No	No			Fisheries (Management) Regulations of 1998, promulgated under the authority of the Fisheries Act (1993)	Horrocks *et al*. 1992
Bonaire (Netherlands	No	No			Marine Environment Ordinance (Verordening Marien Milieu A.B.	K. Eckert, WIDECAST, personal communication,

[1] Harvest is prohibited until 2021.
[2] Harvest quota is 1,200 kg per year.

Country	Legal Turtle Harvest	Legal Egg Harvest	Season	Size Limit	Source Legislation	Citation
Antilles)					1991 Nr. 8), Article 14	2006
British Virgin Islands (United Kingdom)	Yes	No	Dec 1-Mar 31	≥ 9 kg (20 lb.)	The Turtles Ordinance 1959 as amended in 1986, Fisheries Act 1997	Fleming 2001, Godley *et al*. 2004
Cayman Islands (United Kingdom)	Yes	No	Nov 1-Mar 31	≤ 60 cm	Marine Conservation Law 1978, The Marine Conservation (Turtle Protection) (Amendment) 2007	Fleming 2001, Godley *et al*. 2004
Cuba	No	No			Ministry of Fishing Industries (MIP) Resolution 9 (2008)	
Curacao (Netherlands Antilles)	No	No			Eilandsbesluit bescherming zeeschildpadden (A.B. 1996 Nr.8), promulgated under the authority of the Reef Management Ordinance (A.B. 1976 nr. 48)	K. Eckert, WIDECAST, personal communication, 2006
Dominica	Yes	No			Forestry and Wildlife Act, Ch 60:02, Act 12 of 1990, Section 21	K. Eckert, WIDECAST, personal communication, 2006
Dominican Republic	No	No			Decree No. 34-96, 1996	Fleming 2001
Guadeloupe (France)	No	No			l'Arrêté fixant la liste des tortues marines protégées dans le département de la Guadeloupe (1991)	K. Eckert, WIDECAST, personal communication, 2006
Grenada	Yes	No	Sep 1-Apr 30	≥ 25 lb	Fisheries Amendment Regulations 1996 SRO24 Section 16(5) and Fisheries Amendment Regulation 2001 SRO2 Section 17	Grazette *et al*. 2007
Haiti	Yes	No	Oct 1-Apr 30		Fisheries Law 27, Oct. 1978, Article 97	Fleming 2001

Country	Legal Turtle Harvest	Legal Egg Harvest	Season	Size Limit	Source Legislation	Citation
Jamaica	No	No			Wildlife Protection Act (145), amended 1991	Fleming 2001
Martinique (France)	No	No			l'Arrêté fixant la liste des tortues marines protégées dans le département de la Martinique (1993)	K. Eckert, WIDECAST, personal communication, 2006
Montserrat (United Kingdom)	Yes	Yes	Oct 1-Apr 1	$\geq$ 20 lb (9.07 kg)	Laws of Montserrat 1962, Chapter 112	Godley *et al*. 2004
Puerto Rico (United States)	No	No			Endangered Species Act (1973)	Fleming 2001
Saba (Netherlands Antilles)	No	No			2001 Nature Conservation Ordinance (Landsverordening grondslagen natuurbeheer en bescherming)	K. Eckert, WIDECAST, personal communication, 2006
St. Eustatius (Netherlands Antilles)	No	No			2001 Nature Conservation Ordinance (Landsverordening grondslagen natuurbeheer en bescherming)	K. Eckert, WIDECAST, personal communication, 2006
St. Kitts & Nevis	Yes	No	Mar 1-Sep 30	> 72.6 kg (160 lb)	1995 Fishery Regulations (Art.19) promulgated under the authority of the Fisheries Act (No.4) of 1984	K. Eckert, WIDECAST, personal communication, 2006
St. Lucia	Yes	No	Oct 2-Feb 27	> 35 kg (75 lb)	Fisheries Regulations (1994), promulgated under the authority of the Fisheries Act (1986)	K. Eckert, WIDECAST, personal communication, 2006
St. Maarten (Netherlands Antilles)	No	No			2001 Nature Conservation Ordinance (Landsverordening grondslagen natuurbeheer en bescherming)	K. Eckert, WIDECAST, personal communication, 2006
St. Vincent & Grenadines	Yes	No	Aug 1-Feb 28	> 72 kg (160 lb)	1987 Fisheries Regulations (Part VI), promulgated under the authority of the Fisheries Act (1986)	K. Eckert, WIDECAST, personal communication, 2006

Country	**Legal Turtle Harvest**	**Legal Egg Harvest**	**Season**	**Size Limit**	**Source Legislation**	**Citation**
Tobago/ Trinidad	Yes	No	Oct 1-Feb 28		The Conservation of Wildlife Act (Chapter 67:01) and Fisheries Act (Chapter 67:51)	J. Frazier, Smithsonian Institution, personal communication, 2005
Turks and Caicos (United Kingdom)	Yes	No	Year-round	≥ 9 kg (20 lb)	Fisheries Protection Ordinance 1995	Fleming 2001
U.S. Virgin Islands (United States)	No	No			Endangered Species Act (1973)	Fleming 2001

Mexico and Central America

Country	Legal Turtle Harvest	Legal Egg Harvest	Season	Size Limit	Source Legislation	Citation
Belize	No	No			Section 13 of the Fisheries Act, Chapter 210 of the Substantive Laws of Belize Revised Edition 2003 Statutory Instrument No. 66 0f 2002	J. Frazier, Smithsonian Institution, personal communication, 2005
Costa Rica	No	No			Decreto Nº 8325 Ley de Protección, Conservación y Recuperación de las Poblaciones de Tortugas Marinas (2002)	K. Eckert, WIDECAST, personal communication, 2006
El Salvador	No	No			Resolution de Servicio de Parques Nacionales y Vida Silvestre de la Direccion General de Recursos Naturales Renovables, 21 July 1997	J. Frazier, Smithsonian Institution, personal communication, 2005
Guatemala	No	No			Ley General de Pesca y Acuicultura Decreto Nº 80 (2002)	K. Eckert, WIDECAST, personal communication,

Country	Legal Turtle Harvest	Legal Egg Harvest	Season	Size Limit	Source Legislation	Citation
						2006
Honduras	No	No			Ley del Ambiente 1993	J. Frazier, Smithsonian Institution, personal communication, 2005
Mexico	No	No			Acuerdo por el que se Establece Veda para las Especies y Subspecies de Tortuga Marina en aguas de Jurisdiccion Federal del Golfo de Mexico y Mar Caribe, asi como las del Oceano Pacifico, Incluyendo el Golfo de California (31 May 1990)	Fleming 2001
Nicaragua	No	No			2004 Ley de Pesca y Acuicultura Nº489	K. Eckert, WIDECAST, personal communication, 2006
Panama	No	No			Wildlife Law (Ley de Vida Silvestre No. 24), 1995 and Environment Law (Ley General de Ambiente No. 41), 1998	K. Eckert, WIDECAST, personal communication, 2006

South America

Country	Legal Turtle Harvest	Legal Egg Harvest	Season	Size Limit	Source Legislation	Citation
Brazil	No	No			Order n. 5 (31 January 1986)	Marcovaldi and Marcovaldi 1999
Colombia	No	No			Resolucion No. 002879 de 21 noviembre 1995	J. Frazier, Smithsonian Institution, personal communication, 2005
French Guiana (France)	No	No			l’Arrêté fixant la liste des tortues marines protégées dans le département de la Guyane (Ministere de l' environment), 17 July 1991	J. Frazier, Smithsonian Institution, personal communication, 2005
Guyana	Yes	No			Eggs are protected under Fisheires Regulations 1973 Section 4.21, and turtles are harvested by permit under Section 33, Chapter 71.098	J. Frazier, Smithsonian Institution, personal communication, 2005
Suriname	No	No			Game law of 1954. Government Publication of Suriname No. 25. Resolution 104, October 1970.	Reichart and Fretey 1993
Venezuela	No	No			1979 Resolution to the 1970 Ley de Protección a la Fauna Silvestre (Gaceta Oficial Nº 29.289)	Guada and Sole 2000

Atlantic Islands

Country	Legal Turtle Harvest	Legal Egg Harvest	Season	Size Limit	Source Legislation	Citation
Azores	No	No			The conservation of loggerhead turtles is ruled by ratification of the Convention on Migratory Species (11/1/1983)	Fretey 2001; M. Santos and H.R. Martins, University of the Azores, personal communications, 2006
Bermuda	No	No			Protected Species Act 2003	
Canary Islands	No	No			Ley 4/1989 (27/03/1989) sobre Proteccion de los Espacious Naturales y la Flora y Fauna Silvestres; Loi 12/1994 du 19 Decembre 1994 sur les Espaces naturaels des Canaries; Decreto 161/97 de Delegaciones en Materia de Medio Ambiente a lod Cabildos Insulares	Fretey 2001
Cape Verde	No				Decretee Law 7/2002 from December 30 Official Bulletin 37	L. Hawkes, University of Exeter in Cornwall, personal communication, 2006
Madeira	No	No			Decreto Legislativo Regional n.o 18/85/M of 07/09/1985	Fretey 2001

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Appendix 4: Conservation Lands Table

Table A4-1. U.S. Loggerhead Nesting Beaches in Conservation Lands (approximate length and ownership), 2007. Conservation lands are defined as public ownership (Federal, state, or local government) and privately owned lands (e.g., non-profit conservation foundations). Most of these lands are generally managed in a way that benefits sea turtle conservation. Public lands that have lighted development, armoring, or other profound threats to sea turtle nesting have not been included. In compiling the list of conservation lands, human visitation was not considered a profound threat to sea turtle nesting. Therefore, public lands designated for human recreation have been included. F=Federal, S=State, C=County, M=Municipal, N=NGO Conservation Lands, P=Private Conservation Lands, T=Special Taxing District of the State.

Conservation Land Name	Length (km)	Ownership
VIRGINIA (north to south)		
Chincoteague NWR (Assateague Island)	20.60	F
Wallops Island	10.60	F
Chincoteague NWR (Assawoman Island)	8.10	F
Chincoteague NWR (Metompkin Island)	1.20	F
Metompkin Island	10.90	N
Cedar Sandbar	1.60	S
Cedar Island (Chincoteague NWR/The Nature Conservancy/private)	6.00	F, N, Private
Parramore Island Natural Area Preserve	15.00	N
Hog Island	16.10	N, Private
Cobb Island	11.10	N
Little Cobb Island	1.10	N
Wreck Island	6.90	S
Ship Shoal Island	4.50	N
Myrtle Island	6.00	N
Smith Island	13.30	N
Fishermans Island NWR	9.70	F
Fort Story Military Reservation	5.80	F
Virginia Beach Resort Strip	9.70	M
Croatan Beach	1.60	M
Dam Neck Naval Base	5.20	F
Sandbridge Beach (includes Little Island District Park)	8.10	M
Back Bay NWR	7.60	F
False Cape State Park	6.80	S
VIRGINIA TOTAL	187.50	

NORTH CAROLINA (north to south)		
Currituck NWR (Swan Island Unit)	3.60	F
Currituck NWR (Monkey Island Unit)	1.60	F
The Nature Conservancy (unnamed parcel)	2.00	N
Currituck Banks National Estuarine Research Reserve	2.00	S
Pea Island NWR	19.50	F
Cape Hatteras National Seashore	80.00	F
Cape Lookout National Seashore	93.30	F
Fort Macon State Park	3.20	S
Hammocks Beach State Park	6.00	S
Onslow Beach	18.30	F
Lea and Huttaf Islands (Audubon)	3.22	N
Masonboro Island	12.00	S
Fort Fisher State Recreation Area	4.83	S
Bird Island	1.60	S
NORTH CAROLINA TOTAL	251.15	
SOUTH CAROLINA (north to south)		
Waites Island (Coastal Carolina University segment)	2.00	S
Myrtle Beach State Park	2.00	S
Huntington Beach State Park	4.80	S
North Island (Tom Yawkey Wildlife Center Heritage Preserve)	15.00	S
Sand/South Island (Tom Yawkey Wildlife Center Heritage Preserve)	8.00	S
Cedar Island (SCDNR Santee Coastal Reserve)	4.30	S
Murphy Island (SCDNR Santee Coastal Reserve)	9.00	S
Cape Romain NWR (Cape/Lighthouse Islands)	13.50	F
Cape Romain NWR (Raccoon Key)	9.00	F
Cape Romain NWR (Bull Island)	10.00	F
Capers Island (SCDNR Heritage Preserve)	5.20	S
Isle of Palms County Park	0.18	C
Folly Beach County Park (north end, no facilities)	0.80	C
Folly Beach County Park (south end, facilities)	0.76	C
Beachwalker County Park at Kiawah Island	1.00	C
Botany Bay Island	2.80	P
Botany Bay Plantation (Edisto Island)	3.50	S
Edisto Beach State Park	2.30	S
Pine Island (SCDNR)	0.50	S
Otter Island (SCDNR Heritage Preserve)	7.60	S
Hunting Island State Park	6.40	S

Pritchards Island (University of South Carolina)	4.00	S
St. Phillips Island	1.00	P
Turtle Island (SCDNR Heritage Preserve)	1.00	S
SOUTH CAROLINA TOTAL	114.64	
GEORGIA (north to south)		
Little Tybee Island	8.70	S
Wassaw NWR	10.80	F
Pine Island	1.80	F
Ossabaw Island	17.70	S
Blackbeard Island NWR	14.40	F
Sapelo Island	9.90	S
Wolf Island NWR	4.00	F
Old Coast Guard Station/Bruce Tract	1.00	C
Massengale Park	0.50	C
Jekyll Island	14.70	S
Little Cumberland Island	4.90	P
Cumberland Island National Seashore	28.40	F
GEORGIA TOTAL	116.80	
FLORIDA ATLANTIC COAST (north to south)		
Fort Clinch State Park	3.70	S
Main Beach Park (aka Dr. G. Ralph Wolff Beach Park)	0.40	M
North Beach Park	0.40	M
Seaside Park	0.40	M
Peters Point Park	0.27	C
Burney Park	0.18	C
Little Talbot Island State Park	9.70	S
Huguenot Memorial Park	2.82	M
Mayport Naval Station	1.80	F
Kathryn Abbey Hanna Park	2.40	M
Guana River State Park	6.80	S
South Ponte Vedra Park	0.03	C
Surfside Park	0.05	C
Anastasia State Park	7.20	S
Franklin B. Butler Park	0.33	C
Crescent Beach Park	0.07	C
Fort Matanzas National Monument	1.61	F
River to Sea Preserve	0.16	C
Washington Oaks Gardens State Park	1.10	S
Malacompra Park	0.80	C

Old Salt Road Park (16th Road Beach Access)	0.10	C
Jungle Hut Road Park	0.10	C
Varn Park	0.40	C
Gamble Rogers Memorial State Recreation Area	1.80	S
North Peninsula State Recreation Area	3.99	S
Bicentenial Park	0.19	C
Tom Renick Park	0.06	C
Birth Place of Speed Park	0.06	M
Dahlia Park	0.12	M
Ponce Preserve	0.29	M
Winterhaven Park	0.03	C
Lighthouse Point Park	0.52	C
Smyrna Dunes Park	0.94	C
North Beach Community Park	0.14	M
Canaveral National Seashore	38.20	F
Merritt Island NWR	9.80	F
Cape Canaveral Air Force Station	21.00	F
Jetty Park	0.31	T
Cherie Down Park	0.13	C
Alan Shepard Park	0.38	M
Sidney Fischer Park	0.09	M
Lori Wilson Park	0.35	C
Robert P. Murkshe Memorial Park	0.13	C
Cresent Beach	0.08	M
Patrick Air Force Base	7.00	F
Seagull Park	0.06	C
S.P.R.A. Park	0.06	C
Hightower Beach Park	0.86	S/C
Pelican Beach Park	0.46	M
Richard G. Edgeton Bicentennial Park	0.05	M
Millenium Park	0.08	M
Irene H. Canova Park	0.13	C
Canova Beach Park	0.34	C
Howard E. Futch Memorial Park (Paradise Beach Park)	0.41	C
Sunrise Park	0.08	M
James H. Nance Park	0.21	M
Indialantic Beach	0.46	M
Wave Crest Park	0.06	M
Ocean Park	0.11	M
Loggerhead Park Preserve	0.07	M
Spessard Holland North Beach Park	0.41	C

Spessard Holland South Beach Park	0.44	C
Archie Carr NWR (Brevard County)	3.88	F/S/C
Sea Oats Park	0.09	S
Coconut Point Park	0.46	S
Juan Ponce de Leon Landing	0.70	S
Twin Shores Park	0.27	S
Judith Resnick Memorial Park	0.47	S
Brevard County Fire Rescue Property	0.04	C
Bonsteel Park	0.07	S
Sebastian Inlet State Park	4.80	S
Archie Carr NWR (Indian River County)	0.72	F/S
Ambersand Beach Park	0.03	C
Treasure Shores Park	0.50	C
North Treasure Shores Parcel	0.59	S
South Treasure Shores Parcel	0.15	S
Spallone Tract	0.03	S
Golden Sands Park	0.23	C
Wabasso Beach Park	0.11	C
Jungle Trail Conservation Area - North	0.16	C
Jungle Trail Conservation Area - South	0.30	C
Tracking Station Beach Park	0.33	C
Jaycee Park	0.16	C
Humiston Park	0.15	C
South Beach Park	0.17	C
Round Island Park	0.10	C
Avalon State Park	1.83	S
Pepper Park	0.63	S/C
Fort Pierce Inlet State Park	0.57	S
South Jetty Park	0.05	C
South Beach Boardwalk Park	0.38	S
Kimberly Bergalis Park	0.55	S
Surfside Park	0.18	M
Coconut Drive Park	0.15	M
Exchange Park	0.07	C
Green Turtle Beach Park	0.38	S
Frederick Douglass Park	0.31	C
Blind Creek Park	0.10	C
Turtle Beach Nature Trail	0.55	P
St. Lucie Power Plant	2.50	P
Walton Rocks Park	1.03	C/P
Dollman Park	0.57	C

Waveland Park	0.10	C/P
Glasscock Beach Park	0.03	S
Sea Turtle Beach Park	0.40	S/C
Jensen Beach Park	0.44	C
Muscara	0.26	S
Bob Graham Beach Park	0.61	S/C
Bob Graham Beach Addition	0.10	C
Curtis Beach Park	0.09	S
Pasley Beach Park	0.09	C
Dubner	0.03	S
Beachwalk Park	0.13	C
Alex’s Beach Park	0.12	S
Bryn Mawr Park	0.03	C
Stokes Park	0.003	C
Virginia Forrest Beach Park	0.03	S
Tiger Shores Beach Park	0.04	C
Stuart Beach Park	0.41	C
Santa Lucea	0.25	S
Fletcher Beach Park	0.04	S
House of Refuge Park	0.63	C
Chastain Beach Park	0.03	C
Bathtub Reef Beach Park	0.31	S/C
St. Lucie Inlet Preserve State Park	4.30	S
Hobe Sound NWR	5.30	F
Hobe Sound Beach Park	0.08	C
Blowing Rocks Preserve	1.20	N
Coral Cove Park (incorporated)	0.29	C
Coral Cove (unincorporated - future park)	0.61	C
Jupiter Beach Park	0.57	C
Carlin Park	1.02	C
Diamondhead/Radnor (future park)	1.10	C
Ocean Cay Park	0.21	C
Juno Beach Park	0.09	C
Juno Dunes Natural Area	0.82	C
Loggerhead Park	0.34	C
John D. MacArthur Beach State Park	2.90	S
Ocean Reef Park	0.22	C
Riviera Municipal Beach	0.31	M
Palm Beach Municipal Beach	0.79	M
Phipps Ocean Park	0.37	M
R.G. Kreusler Park	0.16	C

Lake Worth Municipal Beach	0.40	M
Lantana Municipal Beach	0.21	M
Ocean Hammock Park	0.33	C
Boynton Beach Oceanfront Park	0.30	M
Gulfstream Park	0.18	C
Delray Beach Municipal Beach	1.67	M
Atlantic Dunes	0.16	M
Milani (future park)	0.12	C
Spanish River Park	1.00	M
Red Reef Park	0.73	M
Red Reef Golf Course	0.36	M
South Beach Park	0.84	M
South Inlet Park	0.29	C
Southbeach Park	0.76	C
Hollywood North Beach Park	1.60	C
John U. Lloyd Beach State Park	3.90	S
North Shore Ocean Front Park	0.94	C
North Shore Park	0.24	C
64th Street Park	0.12	C
Indian Beach Park	0.17	C
Collins Park	0.16	C
Lummus Park	1.34	C
Ocean Front Park	0.16	C
Pier Park / South Pointe Park	0.43	M
Haulover Park	2.40	C
Crandon Park	3.98	C
Bill Baggs Cape Florida State Park	1.90	S
Biscayne National Park	3.10	F
Long Key State Park	4.00	S
Little Crawl Key State Park	0.30	S
Bahia Honda State Park	4.70	S
Fort Zachary Taylor Historic State Park	0.20	S
Florida Keys NWRs (Boca Grand and Woman Keys)	2.59	F
Dry Tortugas National Park	3.70	F
FLORIDA ATLANTIC COAST TOTAL	223.21	

FLORIDA GULF COAST (west to east, north to south)

Perdido Key State Park	2.30	S
Fort Pickens Gate Park	0.27	C
Gulf Islands National Seashore (Florida District)	35.60	F
Casino Beach	0.30	C

Pensacola Beach Park East	0.09	C
Beach Accesses (2 adjacent unnamed parcels)	1.46	C
Navarre Beach State Park	1.93	S
Eglin Air Force Base	27.40	F
Newman C. Brackin Wayside Park and Boardwalk	0.20	C
John Beasley Park	0.20	C
City of Destin (unnamed parcel)	0.03	M
Henderson Beach State Park	2.10	S
James Lee Park	0.28	C
Miramar Regional Beach Access	0.33	C
Topsail Hill Preserve State Park	5.30	S
Stallworth Lake	0.08	C
Dune Allen/Fort Panic Regional Beach Access	0.11	C
Ed Walline Regional Beach Access	0.06	C
Gulfview Heights Regional Beach Access	0.03	C
Blue Mountain Regional Beach Access	0.03	C
Grayton Dunes Regional Beach Access	0.10	C
Garfield Addition	0.06	C
Grayton Beach State Park	3.10	S
St. Joe Property Regional Beach Access	0.04	C
Gulf Shore Manor (Santa Clara) Regional Beach Access	0.05	C
One Seagrove Neighborhood Beach Access	0.10	C
Deer Lake State Park	0.11	S
Walton Dunes Regional Beach Access	0.12	C
Inlet Beach Regional Beach Access	0.44	C
Camp Helen State Park	0.80	S
M.B. Miller Park	0.71	C
Rick Seltzer Park	0.05	C
St. Andrews State Park	9.00	S
Tyndall Air Force Base	28.50	F
St. Joseph Peninsula State Park	14.50	S
Cape Palms Park	0.03	C
Eglin Air Force Base (Cape San Blas parcel)	4.80	F
Salinas Park	0.38	C
St. Vincent NWR	16.10	F
Little St. George Island (aka Cape St. George Island)	14.50	S
St. George Island County Park	0.16	C
St. George Island State Park	14.50	S
Jeff Lewis Wilderness Preserve	15.44	N
John S. Phipps Preserve	4.25	N
Bald Point State Park	5.50	S

Anclote Key Preserve State Park	9.70	S
Fred H. Howard Park	0.30	C
Sunset Beach Park	0.10	M
Honeymoon Island State Park	6.40	S
Caladesi Island State Park	4.00	S
Indian Rocks Beach Access Park	0.09	C
Sand Key Park	0.80	C
Tiki Gardens/Indian Shores Beach Access Park	0.01	C
Redington Shores Beach Access Park	0.11	C
Archibald Memorial Beach	0.18	M
Madeira Beach Access Park	0.14	C
Kitty Stewart Park	0.02	M
John's Pass Beach and Park	0.06	M
Treasure Island Beach Access Park	0.08	C
St. Pete Beach Access Park	0.09	C
Fort Desoto County Park (North and East Beach)	9.60	C
Egmont Key NWR (and State Park)	5.20	F
Anna Maria Bayfront Park	0.32	M
Holmes Beach	0.97	M
Manatee Beach	0.64	C
Cortez Beach	0.81	C
Coquina Beach	1.45	C
Beer Can Island/Greer Island	0.37	S
North Lido Park	0.92	M
Lido Beach	0.95	M
South Lido Park	1.26	M
Siesta Key Public Beach	0.73	C
Point of Rocks	0.12	C
Turtle Beach	0.76	C
Palmer Point Park	0.73	C
Nokomis Beach	0.52	C
North Jetty Park	0.27	C
Venice Beach	0.27	M
Service Club Park	0.43	M
Brohard Beach	1.46	M
Caspersen Beach	2.79	C
Blind Pass Beach	0.90	C
Manasota Beach	0.43	C
Stump Pass Beach State Park	2.40	S
Chadwick Park (Englewood Beach)	0.59	C
Don Pedro Island State Park	2.40	S

Gasparilla Island State Park	2.40	S
Cayo Costa State Park	10.90	S
North Captiva State Park	4.80	S
Little Estero Island Critical Wildlife Area	2.41	S
Lovers Key State Park	4.00	S
Bowditch Point Regional Park	0.18	C
Lynn Hall Memorial Park	0.18	C
Bonita Beach Park	0.18	C
Lely Barefoot Beach Preserve	2.30	C
Delnor-Wiggins Pass State Park	2.40	S
Vanderbilt Beach County Park	0.10	C
Clam Pass Conservation and Park	3.00	C
Lowdermilk City Park	0.20	C
Tigertail Beach County Park	0.80	C
Ten Thousand Islands NWR	5.00	F
FLORIDA GULF COAST TOTAL	309.65	
ALABAMA (west to east)		
Dauphin Island Public Beach	1.40	C
Dauphin Island Campground	0.80	C
Fort Gaines State Historic Site	1.00	C
Fort Morgan State Historic Site	2.40	S
Bureau of Land Management (unnamed parcels)	1.00	F
ADCNR (unnamed park in Baldwin County)	0.40	S
Bon Secour NWR	4.60	F
Gulf Shores Public Beach	0.40	M
Gulf State Park	5.60	S
ALABAMA TOTAL	17.60	
MISSISSIPPI		
Gulf Islands National Seashore (Mississippi District)	42.90	F
MISSISSIPPI TOTAL	42.90	
LOUISIANA (west to east)		
Breton NWR (Breton Island)	6.50	F
South Gosier	2.10	S
North Gosier (Grand)	0.80	S
Curlew	0.50	S
Freemason Island	2.20	S
North Island	1.60	S
Breton NWR (Chandeleur Islands)	41.70	F

LOUISIANA TOTAL	55.40	
TEXAS (north to south)		
Sea Rim State Park	9.00	S
Rollover Fish Pass Wildlife Management Area	0.20	S
Bolivar Flats	4.80	S
Fort Travis Seashore	0.80	S
Mad Island Wildlife Management Area	21.80	S
Stewart Beach Park	1.70	M
Galveston Island State Park	2.50	S
Peach Point-Bryan Beach Wildlife Management Area	2.30	S
San Bernard NWR	8.80	F
Matagorda Island Wildlife Management Area/State Park/NWR	48.80	F/S
Mustang Island State Park	8.00	S
Padre Balli Park	2.00	C
Padre Island National Seashore	111.70	F
Andy Bowie Park	1.20	C
Laguna Atascosa NWR-Padre Island Preserve	31.70	F
Lower Rio Grande Valley NWR	6.50	F
Boca Chica State Park	1.00	S
TEXAS TOTAL	262.80	
GRAND TOTAL	**1,581.66**	