



United States Department of the Interior



FISH AND WILDLIFE SERVICE

176 Croghan Spur Road, Suite 200
Charleston, South Carolina 29407

April 17, 2017

Lt. Colonel Matthew W. Luzzatto
District Engineer
U.S. Army Corps of Engineers
69A Hagood Avenue
Charleston, SC 29403-5107

Attn: Warren May

Re: Isle of Palms Beach Renourishment
Charleston County, South Carolina
FWS Log No. 04ES1000-2017-F-0157

Dear Colonel Luzzatto:

This document is the U.S. Fish and Wildlife Service's (Service) Biological Opinion (BO) based on our review of the proposed project, which includes beach renourishment on the Isle of Palms in Charleston County, South Carolina. This BO addresses effects on the green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), Northwest Atlantic population of the loggerhead sea turtle (*Caretta caretta*), piping plover (*Charadrius melodus*) and its critical habitat, red knot (*Calidris canutus rufa*), seabeach amaranth (*Amaranthus pumilus*), and West Indian manatee (*Trichechus manatus*) per section 7 of the Endangered Species Act of 1973, as amended (16 United States Code [U.S.C.] 1531 *et seq.*) (ESA).

Formal consultation was initiated on December 27, 2016. This BO is based on information provided in the December 16, 2016, Charleston District Corps of Engineers (USACE) and South Carolina Department of Health and Environmental Control Office of Ocean and Coastal Resource Management (SCDHEC-OCRM) joint public notice, the Biological Assessment (BA) received on December 27, 2016, and further communication with related parties. A complete administrative record of this consultation is on file at the South Carolina Ecological Services Field Office (SCFO), 176 Croghan Spur Road, Suite 200, Charleston, South Carolina 29407. The Service has assigned FWS Log No. 04ES1000-2017-F-0157 to this consultation.

It is the Service's opinion that this project is not likely to adversely affect (NLAA) the following species: green sea turtle, leatherback sea turtle, piping plover and its designated critical habitat, red knot, seabeach amaranth, and West Indian manatee based on the **Table 1** below.

Table 1. Species and Critical Habitat Evaluated for Effects from the Proposed Action but not discussed further in this Biological Opinion.

SPECIES OR CRITICAL HABITAT	PRESENT IN ACTION AREA	PRESENT IN ACTION AREA BUT “NOT LIKELY TO BE ADVERSELY AFFECTED” BASED ON
Green sea turtle	Yes, but rare. Green sea turtle nests have been documented in low numbers on Garden City and Surfside beaches.	Protection measures in place for the loggerhead sea turtle
Leatherback sea turtle	Possible, but rare. No Leatherback sea turtle nests have been documented on Garden City or Surfside beaches in the past 7 years.	Protection measures in place for the loggerhead sea turtle
Piping plover	Possible, but present in very low numbers during fall and spring migration.	Infrequent use in low numbers during migration, current habitat conditions, and location of sand placement on the island is outside of preferred wintering habitat
Red knot	Possible, but not present or in very low numbers.	Infrequent use in low numbers during migration, current habitat conditions, and no long term adverse impacts to the species’ primary prey item <i>Donax</i> sp., which use exposed intertidal flats, are anticipated
Seabeach amaranth	Possible, within southernmost part of historical range	Absence of documentation of viable plants or seed sources
West Indian manatee	Possible if water temperatures are >68°F	Implementation of Standard Manatee Construction Conditions (Appendix A)

CONSULTATION HISTORY

December 16, 2016 – The Service received the USACE and SCDHEC-OCRM) joint public notice.

December 23, 2016 – The Service provided comments to the USACE regarding the project and noted that we had not received all of the information necessary to initiate formal consultation since we did not receive a biological assessment.

December 27, 2016 – The Service received the supplemental BA from Coastal Science and Engineering (CSE).

January 3, 2017 – The Service sent a letter to the USACE acknowledging receipt of all information necessary to initiate the consultation.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

The proposed action places 2 million cubic yards of sand in 3 reaches along 19,000 linear feet of shoreline on the Isle of Palms (**Figure 1**). A cutterhead pipeline dredge and heavy equipment will be used to construct the project. The construction berm elevation will be placed at +5.5 feet the North American Vertical Datum of 1988 (NAVD) and a small dune and sand berm will be constructed along sections of beach lacking significant dune features at the time of the project. The dune will have a crest elevation of no greater than +10 feet NAVD and a crest width no wider than 15 feet with a seaward slope of 1 on 4. The storm berm will be constructed at +7 feet to +8 feet NAVD and will extend up to 50 feet seaward of the toe of the dune. The seaward slope of the construction berm will be 1 on 20 between +5.5 feet and the mean high water contour. Sand fencing and vegetation will be installed in strategic locations along the landward end of the berm to facilitate natural dune growth. The project will approximately two months to complete.

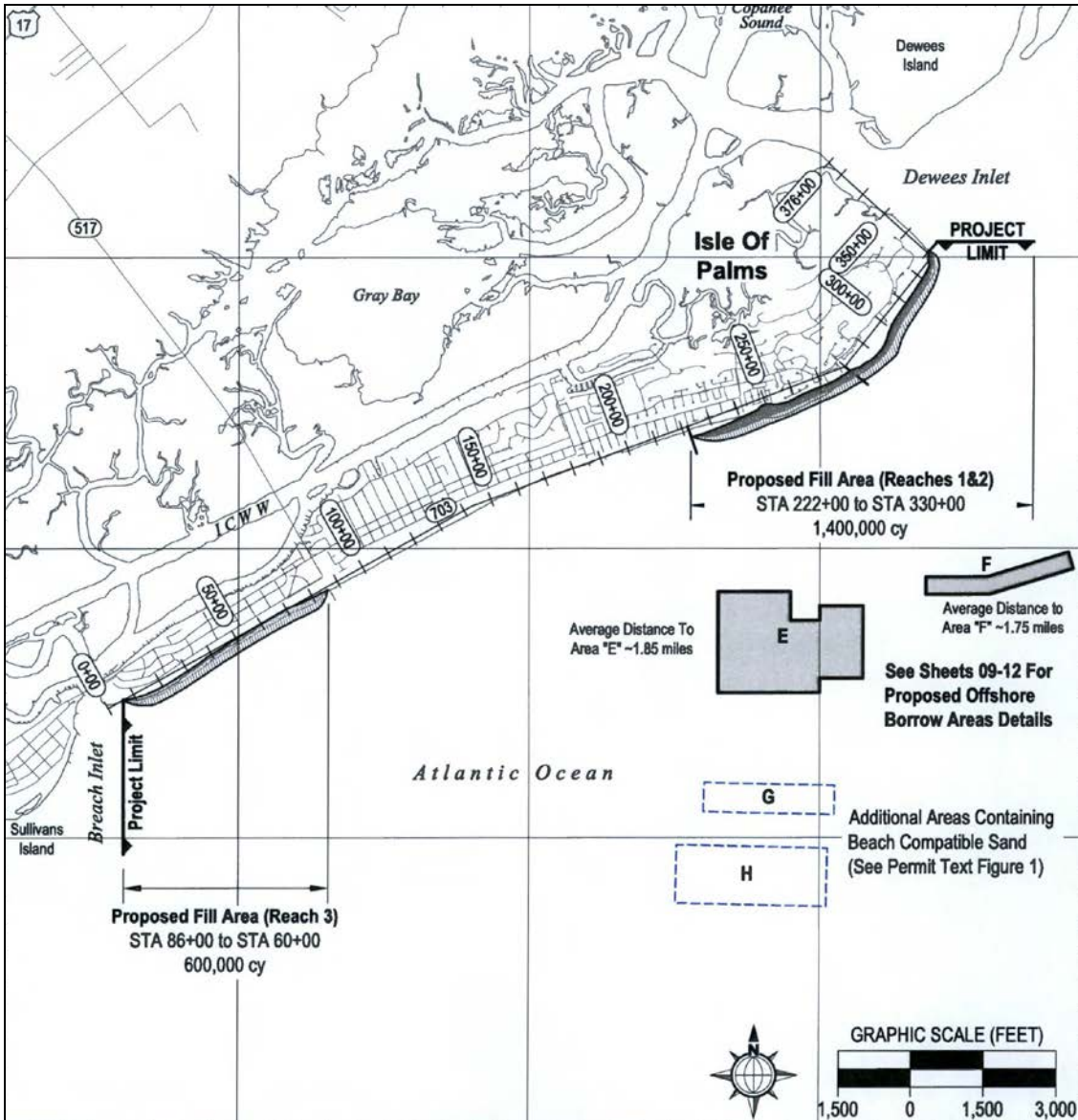


Figure 1. Isle of Palms Project Footprint (CSE 2016)

Conservation Measures

The applicant proposed the following conservation measures to minimize impacts to nesting sea turtles if the projects extend into nesting season (CSE 2016)

- The project will be constructed outside of the sea turtle hatching season (August – October) and if practicable, outside of sea turtle nesting season (May – August). If project construction overlaps with sea turtle nesting season, standard protection and monitoring actions will be completed to minimize impacts to turtles.

- In areas with sufficient storm protection, emergency measures will be removed prior to sand being placed at that location, and the nourishment fill will reach to the escarpment line or as landward as possible. In areas where removal of the emergency measures would leave properties threatened to damage, sand will be placed seaward of the structures and the structures will be removed at the time of sand placement or immediately thereafter.
- The applicant will obtain agreements with the emergency order permit holders prior to construction, which will require removal of all emergency measures prior to or during the renourishment. The agreement will note that failure to remove emergency measures will subject the permit holder to fines or other penalty from SCDHEC-OCRM and/or the USACE.
- Sand will not be placed on top of or landward of emergency structures at any time during the project.
- Removal of emergency measures will be documented photographically as each structure is removed. Records will be checked with existing SCDHEC-OCRM tallies for numbers of sandbags and lengths of wave dissipation systems (WDS). Approval of complete removal of emergency measures will be coordinated between SCDHEC-OCRM and the emergency permit holders.
- The applicant will conduct one lighting survey of the beach during the first May after renourishment following guidelines prepared by the Service.

Refer to the Reasonable and Prudent Measures and Terms and Conditions (page 34) to see how these proposed conservation measures have been modified.

Action Area

The “action area” is defined in 50 CFR 402.02 Interagency Cooperation as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action.

The Service has described the action area to include Sullivan’s Island, the Isle of Palms, and Dewees Island for reasons explained and discussed beginning on page 29 in the “Status of the species within the action area” section of this consultation (**Figure 2**).



Figure 2. Isle of Palms Beach Nourishment Action Area.

Loggerhead Sea Turtle

The Service and National Marine Fisheries Service (NMFS) share Federal jurisdiction for sea turtles under the ESA. The Service has responsibility for sea turtles on the nesting beach. The NMFS has jurisdiction for sea turtles in the marine environment. In accordance with the ESA, the Service completes consultations with all Federal agencies for actions that may adversely affect sea turtles on the nesting beach. The Service’s analysis only addresses activities that may impact nesting sea turtles, their nests and eggs, and hatchlings as they emerge from the nest and crawl to the sea. NMFS assesses and consults with Federal agencies concerning potential impacts to sea turtles in the marine environment, including updrift and downdrift nearshore areas affected by sand placement projects on the beach.

STATUS OF THE SPECIES/CRITICAL HABITAT

Listing

The loggerhead sea turtle, which occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans, was federally listed worldwide as a threatened species on July 28, 1978 (43 Federal Register (FR) 32800). On September 22, 2011, the loggerhead sea turtle’s listing under the ESA was revised from a single threatened species to nine distinct population segments (DPS) listed as either threatened or endangered.

The nine DPSs and their statuses are:

Northwest Atlantic Ocean DPS – threatened
Northeast Atlantic Ocean – endangered
Mediterranean Sea DPS – endangered
South Atlantic Ocean DPS – threatened
North Pacific Ocean DPS – endangered
South Pacific Ocean DPS – endangered
North Indian Ocean DPS – endangered
Southwest Indian Ocean – threatened
Southeast Indo-Pacific Ocean DPS – threatened

The loggerhead sea turtle grows to an average weight of about 200 pounds and is characterized by a large head with blunt jaws. Adults and subadults have a reddish-brown carapace. Scales on the top of the head and top of the flippers are also reddish-brown with yellow on the borders. Hatchlings are a dull brown color (NMFS 2009). The loggerhead feeds on mollusks, crustaceans, fish, and other marine animals.

The loggerhead may be found hundreds of miles out to sea, as well as in inshore areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers. Coral reefs, rocky places, and shipwrecks are often used as feeding areas. Within the Northwest Atlantic, the majority of nesting activity occurs from April through September, with a peak in June and July (Williams-Walls *et al.* 1983, Dodd 1988, Weishampel *et al.* 2006). Nesting occurs within the Northwest Atlantic along the coasts of North America, Central America, northern South America, the Antilles, Bahamas, and Bermuda, but is concentrated in the southeastern U.S. and on the Yucatán Peninsula in Mexico on open beaches or along narrow bays having suitable sand (Sternberg 1981, Ehrhart 1989, Ehrhart *et al.* 2003, NMFS and USFWS 2008).

Designated Critical Habitat

On July 10, 2014, the Service published the final rule to designate critical habitat in the terrestrial environment for the Northwest Atlantic Ocean Distinct Population Segment of the loggerhead sea turtle (79 FR 39755). In total, 1,102.1 kilometers (km) (684.8 miles) of loggerhead sea turtle nesting beaches have been designated as critical habitat in the terrestrial environment in the States of North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi.

Critical Habitat Physical or Biological Features (PBFs)

In accordance with section 3(5)(A)(i) and 4(b)(1)(A) of the ESA and regulations at 50 CFR 424.12, in determining which areas within the geographical area occupied by the species at the time of listing to designate as critical habitat, the Service considers the physical or biological features (PBFs) that are essential to the conservation of the species and which may require special management considerations or protection.

These include, but are not limited to:

- (1) Space for individual and population growth and for normal behavior;
- (2) Food, water, air, light, minerals, or other nutritional or physiological requirements;
- (3) Cover or shelter;
- (4) Sites for breeding, reproduction, or rearing (or development) of offspring; and
- (5) Habitats that are protected from disturbance or are representative of the historical, geographic, and ecological distributions of a species.

The Service derived the specific physical or biological features essential for the loggerhead sea turtle from studies of this species' habitat, ecology, and life history based on the following methods. Shaffer and Stein (2000) identify a methodology for conserving imperiled species known as the "three Rs:" representation, resiliency, and redundancy. Representation, or preserving some of everything, means conserving not just a species but its associated habitats. Resiliency means ensuring that the habitat is adequate for a species and its representative components. Redundancy ensures an adequate number of sites and individuals. Together, resiliency and redundancy ensures that species can survive into the future. This methodology has been widely accepted as a reasonable conservation strategy (Tear *et al.* 2005). In applying this strategy to terrestrial critical habitat for loggerheads, we have determined that it is important to conserve: (1) Beaches that have the highest nesting densities (representation); (2) beaches that have a good geographic spatial distribution to ensure protection of genetic diversity (resiliency and redundancy); (3) beaches that collectively provide a good representation of total nesting (representation); and (4) beaches adjacent to the high density nesting beaches that can serve as expansion areas and provide sufficient habitat to accommodate and provide a rescue effect for nesting females whose primary nesting beach has been lost (resiliency and redundancy). Therefore, we have determined that the following physical or biological features are essential for the loggerhead sea turtle (79 FR 39755):

PBF 1 – Sites for Breeding, Reproduction, or Rearing (or Development) of Offspring

PBF 2 – Habitats Protected From Disturbance or Representative of the Historical, Geographic, and Ecological Distributions of the Species

Critical Habitat Primary Constituent Elements (PCEs)

Under the ESA and its implementing regulations, the Service is required to identify the physical or biological features essential to the conservation of the loggerhead sea turtle in areas occupied at the time of listing, focusing on the features' primary constituent elements (PCEs). We consider primary constituent elements to be those specific elements of the physical or biological features that provide for a species' life-history processes and are essential to the conservation of the species.

Based on our current knowledge of the physical or biological features and habitat characteristics required to sustain the species' life-history processes, we determine that the terrestrial primary constituent elements specific to the Northwest Atlantic Ocean DPS of the loggerhead sea turtle are:

PCE 1 – Suitable nesting beach habitat that has (a) relatively unimpeded nearshore access from the ocean to the beach for nesting females and from the beach to the ocean for both post-nesting females and hatchlings, and (b) is located above mean high water to avoid being inundated frequently by high tides.

PCE 2 – Sand that (a) allows for suitable nest construction, (b) is suitable for facilitating gas diffusion conducive to embryo development, and (c) is able to develop and maintain temperatures and moisture content conducive to embryo development.

PCE 3 – Suitable nesting beach habitat with sufficient darkness to ensure nesting turtles are not deterred from emerging onto the beach and hatchlings and post nesting females orient to the sea.

PCE 4 – Natural coastal processes or artificially created or maintained habitat mimicking natural conditions.

Life history

Loggerheads are long-lived, slow-growing animals that use multiple habitats across entire ocean basins throughout their life history. This complex life history encompasses terrestrial, nearshore, and open ocean habitats. The three basic ecosystems in which loggerheads live are the:

1. Terrestrial zone (supralittoral) - the nesting beach where 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 656 feet. 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 656 feet.
3. Oceanic zone - the vast open ocean environment (from the surface to the sea floor) where water depths are greater than 656 feet.

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, which are 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, 2003, Musick 1999).

The generalized life history of Atlantic loggerheads is shown in **Figure 3** (from Bolten 2003).

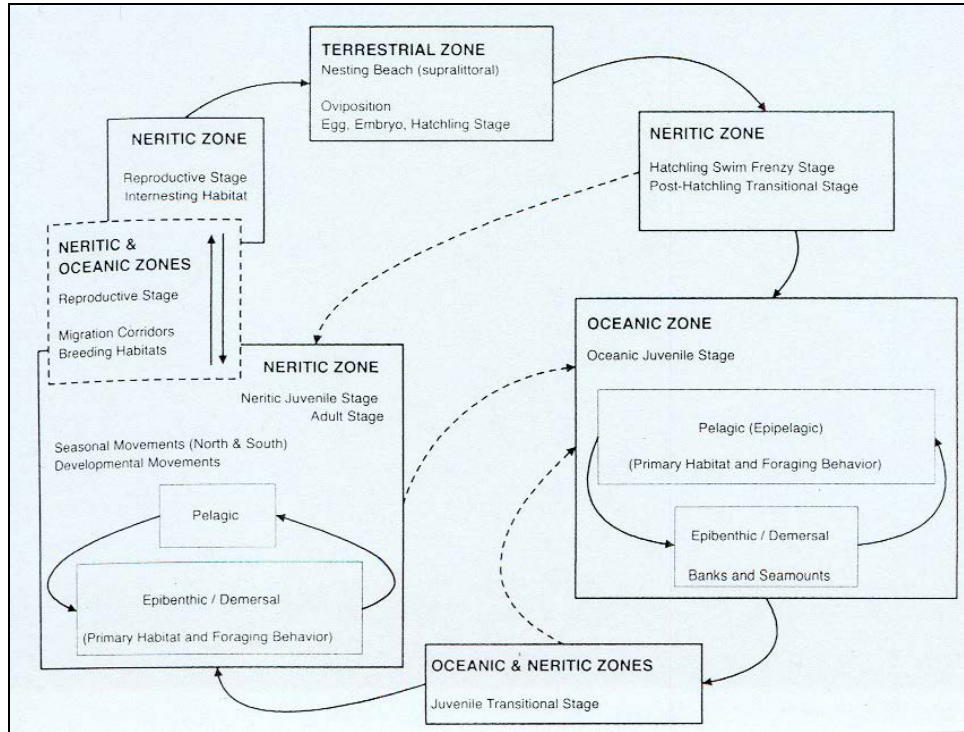


Figure 3. Life history stages of a loggerhead turtle. The boxes represent life stages and the corresponding ecosystems, solid lines represent movements between life stages and ecosystems, and dotted lines are speculative (Bolten 2003).

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). **Table 2** summarizes key life history characteristics for loggerheads nesting in the U.S.

Table 2. Typical values of life history parameters for loggerheads nesting in the U.S. (NMFS and USFWS 2008).

Life History Trait	Data
Clutch size (mean)	100-126 eggs ¹
Incubation duration (varies depending on time of year and latitude)	Range = 42-75 days ^{2,3}
Pivotal temperature (incubation temperature that produces an equal number of males and females)	84°F ⁵
Nest productivity (emerged hatchlings/total eggs) x 100 (varies depending on site specific factors)	45-70 percent ^{2,6}
Clutch frequency (number of nests/female/season)	3-4 nests ⁷
Interesting interval (number of days between successive nests within a season)	12-15 days ⁸
Juvenile (<34 inches Curved Carapace Length) sex ratio	65-70 percent female ⁴
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 Witherington (2006) (information based on nests monitored throughout Florida beaches in 2005, n = 865).

⁴ NMFS (2001); Foley (2005).

⁵ Mrosovsky (1988).

⁶ Witherington (2006) (information based on nests monitored throughout Florida beaches in 2005, n = 1,680).

⁷ Murphy and Hopkins (1984); Frazer and Richardson (1985); Hawkes *et al.* 2005; Scott 2006.

⁸ Dodd (1988).

⁹ Richardson *et al.* (1978); Bjorndal *et al.* (1983).

¹⁰ Snover (2005).

¹¹ Dahlen *et al.* (2000).

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 on a beach in Florida. 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).

The warmer the sand surrounding the egg chamber, the faster the embryos develop (Mrosovsky and Yntema 1980). Sand 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.

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, Houghton and Hays 2001).

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 and Martin 1996, Witherington 1997, Stewart and Wyneken 2004).

Loggerheads in the Northwest Atlantic display complex population structure based on life history stages. Based on mitochondrial deoxyribonucleic acid (mtDNA), oceanic juveniles show no structure, neritic juveniles show moderate structure, and nesting colonies show strong structure (Bowen *et al.* 2005). In contrast, a survey using microsatellite (nuclear) markers showed no significant population structure among nesting populations (Bowen *et al.* 2005), indicating that while females exhibit strong philopatry, males may provide an avenue of gene flow between nesting colonies in this region.

Population dynamics

The loggerhead occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans (Dodd 1988). However, the majority of loggerhead nesting is at the western rims of the Atlantic and Indian Oceans. 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): Peninsular 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 (Bahamas), Sergipe and Northern Bahia (Brazil), Southern Bahia to Rio de Janeiro (Brazil), Tongaland (South Africa), Mozambique, Arabian Sea Coast (Oman), Halaniyat Islands (Oman), Cyprus, Peloponnesus (Greece), Island of Zakynthos (Greece), Turkey, Queensland (Australia), and Japan.

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.

The major nesting concentrations in the U.S. are found in South Florida. However, loggerheads nest from Texas to Virginia. Total estimated nesting in the U.S. has fluctuated between 49,000 and 90,000 nests per year from 1999-2010 (NMFS and Service 2008, FWC/FWRI 2010). About 80 percent 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.* 2008). 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, Bahamas, Greater Antilles, and Yucatán.

From a global perspective, the U.S. nesting aggregation is of paramount importance to the survival of the species as is the population that nests on islands in the Arabian Sea off Oman (Ross 1982, Ehrhart 1989, Baldwin *et al.* 2003). Based on standardized daily surveys of the highest nesting beaches and weekly surveys on all remaining island nesting beaches, approximately 50,000, 67,600, and 62,400 nests, were estimated in 2008, 2009, and 2010, respectively (Conant *et al.* 2009). The status of the Oman loggerhead nesting population, reported to be the largest in the world (Ross 1979), is uncertain because of the lack of long-term standardized nesting or foraging ground surveys and its vulnerability to increasing development pressures near major nesting beaches and threats from fisheries interaction on foraging grounds and migration routes (Possardt 2005). The loggerhead nesting aggregations in Oman and the U.S. account for the majority of nesting worldwide.

Status and distribution

Five recovery units have been identified in the Northwest Atlantic based on genetic differences and a combination of geographic distribution of nesting densities, geographic separation, and geopolitical boundaries (NMFS and USFWS 2008). Recovery units are subunits of a 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. The five recovery units identified in the Northwest Atlantic are:

1. Northern Recovery Unit (NRU) - defined as loggerheads originating from nesting beaches from the Florida-Georgia border through southern Virginia (the northern extent of the nesting range);
2. Peninsula Florida Recovery Unit (PFRU) - 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;
3. Dry Tortugas Recovery Unit (DTRU) - defined as loggerheads originating from nesting beaches throughout the islands located west of Key West, Florida;
4. Northern Gulf of Mexico Recovery Unit (NGMRU) - defined as loggerheads originating from nesting beaches from Franklin County on the northwest Gulf coast of Florida through Texas; and
5. Greater Caribbean Recovery Unit (GCRU) - composed of loggerheads originating from all other nesting assemblages within the Greater Caribbean (Mexico through French Guiana, The Bahamas, Lesser Antilles, and Greater Antilles).

The mtDNA analyses show that there is limited exchange of females among these recovery units (Ehrhart 1989, Foote *et al.* 2000, NMFS 2001, Hawkes *et al.* 2005). Based on the number of haplotypes, the highest level of loggerhead mtDNA genetic diversity in the Northwest Atlantic has been observed in females of the GCRU that nest at Quintana Roo, Mexico (Encalada *et al.* 1999, Nielsen 2010).

Nuclear DNA analyses show that there are no substantial subdivisions across the loggerhead nesting colonies in the southeastern U.S. Male-mediated gene flow appears to be keeping the subpopulations genetically similar on a nuclear DNA level (Francisco-Pearce 2001).

Historically, the literature has suggested that the northern U.S. nesting beaches (NRU and NGMRU) produce a relatively high percentage of males and the more southern nesting beaches (PFRU, DTRU, and GCRU) a relatively high percentage of females (e.g., Hanson *et al.* 1998, NMFS 2001, Mrosovsky and Provanca 1989). The NRU and NGMRU were believed to play an important role in providing males to mate with females from the more

female-dominated subpopulations to the south. However, in 2002 and 2003, researchers studied loggerhead sex ratios for two of the U.S. nesting subpopulations, the northern and southern subpopulations (NGU and PFRU, respectively) (Blair 2005, Wyneken *et al.* 2005). The study produced interesting results. In 2002, the northern beaches produced more females and the southern beaches produced more males than previously believed. However, the opposite was true in 2003 with the northern beaches producing more males and the southern beaches producing more females in keeping with prior literature. Wyneken *et al.* (2005) speculated that the 2002 result may have been anomalous; however, the study did point out the potential for males to be produced on the southern beaches. Although this study revealed that more males may be produced on southern recovery unit beaches than previously believed, the Service maintains that the NRU and NGMRU play an important role in the production of males to mate with females from the more southern recovery units.

The NRU is the second largest loggerhead recovery unit within the Northwest Atlantic Ocean DPS. Annual nest totals from northern beaches averaged 5,215 nests from 1989-2008, a period of near-complete surveys of NRU nesting beaches, representing approximately 1,272 nesting females per year (4.1 nests per female, Murphy and Hopkins 1984) (NMFS and USFWS 2008). Nesting in Georgia reached a new record in 2011 (2,004) followed by another record in 2012 (2,245 nests). South Carolina had the two highest years of nesting in the 2000s in 2011 (4,024 nests) and 2012 (4,628 nests). North Carolina had 967 nests in 2011 and 1103 nests in 2012, which is above the average of 715. The Georgia, South Carolina, and North Carolina nesting data come from the seaturtle.org Sea Turtle Nest Monitoring System, which is populated with data input by the State agencies. The loggerhead nesting trend from daily beach surveys was declining significantly at 1.3 percent annually from 1983 to 2007 (NMFS and Service 2008). Nest totals from aerial surveys conducted by the SCDNR showed a 1.9 percent annual decline in nesting in South Carolina from 1980-2007. Overall, there is strong statistical data to suggest the NRU has experienced a long-term decline (NMFS and USFWS 2008). Currently, however, nesting for the NRU is showing possible signs of stabilizing (76 FR 58868, September 22, 2011).

The PFRU is the largest loggerhead recovery unit within the Northwest Atlantic Ocean DPS and represents approximately 87 percent of all nesting effort in the DPS (Ehrhart *et al.* 2003). A near-complete nest census of the PFRU undertaken from 1989 to 2007 revealed a mean of 64,513 loggerhead nests per year representing approximately 15,735 females nesting per year (4.1 nests per female, Murphy and Hopkins 1984) (FWC 2008, NMFS and USFWS 2008). 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 Survey (INBS) sites surveyed with constant effort over time. In 1979, the Statewide Nesting Beach Survey (SNBS) program was initiated to document the total distribution, seasonality, and abundance of sea turtle nesting in Florida. In 1989, the INBS program was initiated in Florida to measure seasonal productivity, allowing comparisons between beaches and between years (FWC 2009). Of the 190 SNBS surveyed areas, 33 participate in the INBS program (representing 30 percent of the SNBS beach length). Using INBS nest counts, a significant declining trend was documented for the Peninsular Florida Recovery Unit, where nesting declined 26 percent over the 20-year period from 1989–2008, and declined 41

percent over the period 1998-2008 (NMFS and USFWS 2008, Witherington *et al.* 2009). However, with the addition of nesting data through 2010, the nesting trend for the PFRU did not show a nesting decline statistically different from zero (76 FR 58868, September 22, 2011).

The NGMRU is the third largest nesting assemblage among the four U.S. recovery units. Nesting surveys conducted on approximately 186 miles of beach within the NGMRU (Alabama and Florida only) were undertaken between 1995 and 2007 (statewide surveys in Alabama began in 2002). The mean nest count during this 13-year period was 906 nests per year, which equates to about 221 females nesting per year (4.1 nests per female, Murphy and Hopkins 1984, FWC 2008, NMFS and USFWS 2008). Evaluation of long-term nesting trends for the NGMRU is difficult because of changed and expanded beach coverage. Loggerhead nesting trends are best assessed using standardized nest counts made at INBS sites surveyed with constant effort over time. Using Florida INBS data for the NGMRU (FWC 2008), a log-linear regression showed a significant declining trend of 4.7 percent annually from 1997-2008 (NMFS and USFWS 2008).

The DTRU, located west of the Florida Keys, is the smallest of the identified recovery units. A near-complete nest census of the DTRU was undertaken from 1995 to 2004, excluding 2002, (9 years surveyed) revealed 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, FWC 2008, NMFS and USFWS 2008). The nesting trend data for the DTRU are from beaches that are not part of the INBS program, but are part of the SNBS program. A simple linear regression of 1995-2004 nesting data, accounting for temporal autocorrelation, revealed no trend in nesting numbers. Because of the annual variability in nest totals, it was determined that a longer time series is needed to detect a trend (NMFS and USFWS 2008).

The GCRU is composed of all other nesting assemblages of loggerheads within the Greater Caribbean and is the third largest recovery unit within the Northwest Atlantic Ocean DPS, with the majority of nesting at Quintana Roo, Mexico. Statistically valid analyses of long-term nesting trends for the entire GCRU are not available because there are few long-term standardized nesting surveys representative of the region. Additionally, changing survey effort at monitored beaches and scattered and low-level nesting by loggerheads at many locations currently precludes comprehensive analyses. The most complete data are from Quintana Roo and Yucatán, Mexico, where an increasing trend was reported over a 15-year period from 1987-2001 (Zurita *et al.* 2003). However, TEWG (2009) reported a greater than 5 percent annual decline in loggerhead nesting from 1995-2006 at Quintana Roo.

Threats to the Loggerhead Sea Turtle

Anthropogenic (human) factors that impact hatchlings and adult female turtles on land, or the success of nesting and hatching include: beach erosion, armoring and nourishment; artificial lighting; beach cleaning; increased human presence; recreational beach equipment; beach driving; coastal construction and fishing piers; exotic dune and beach vegetation; and poaching. An increased human presence at some nesting beaches or close to nesting beaches

has led to secondary threats such as the introduction of exotic fire ants, feral hogs, dogs, and an increased presence of native species (*e.g.*, raccoons, armadillos, and opossums), which raid and feed on turtle eggs. Although sea turtle nesting beaches are protected along large expanses of the western North Atlantic coast, other areas along these coasts have limited or no protection.

Loggerhead turtles are affected by a completely different set of anthropogenic threats in the marine environment. These include oil and gas exploration and transportation; marine pollution; underwater explosions; hopper dredging, offshore artificial lighting; power plant entrainment and/or impingement; entanglement in debris; ingestion of marine debris; marina and dock construction and operation; boat collisions; poaching, and fishery interactions. In the oceanic environment, loggerheads are exposed to a series of longline fisheries that include the U.S. Atlantic tuna and swordfish longline fisheries, an Azorean longline fleet, a Spanish longline fleet, and various fleets in the Mediterranean Sea (Aguilar *et al.* 1995; Bolten *et al.* 1994; Crouse 1999). There is particular concern about the extensive incidental take of juvenile loggerheads in the eastern Atlantic by longline fishing vessels. In the neritic environment in waters off the coastal U.S., loggerheads are exposed to a suite of fisheries in Federal and State waters including trawl, purse seine, hook and line, gillnet, pound net, longline, dredge, and trap fisheries (NMFS and USFWS 2007).

Coastal Development

Loss of nesting habitat related to coastal development has had the greatest impact on nesting sea turtles. Beachfront development not only causes the loss of suitable nesting habitat, but can result in the disruption of powerful coastal processes accelerating erosion and interrupting the natural shoreline migration (National Research Council 1990b). This may in turn cause the need to protect upland structures and infrastructure by armoring, groin placement, beach emergency berm construction and repair, and beach nourishment, all of which cause changes in, additional loss of, or impact to the remaining sea turtle habitat. Rice (2012a) identified that approximately 856 miles (40%) of sandy beaches from North Carolina to Texas have been developed (**Table 3**).

Table 3. The lengths and percentages of sandy oceanfront beach in each state that are developed, undeveloped, and preserved as of December 2011 (Rice 2012b).

State	Approximate Shoreline Beach Length (miles)	Approximate Miles of Beach Developed (percent of total shoreline length)	Approximate Miles of Beach Undeveloped (percent of total shoreline length) ^a	Approximate Miles of Beach Preserved (percent of total shoreline length) ^b
North Carolina	326	159 (49%)	167 (51%)	178.7 (55%)
South Carolina	182	93 (51%)	89 (49%)	84 (46%)
Georgia	90	15 (17%)	75 (83%)	68.6 (76%)
Florida	809	459 (57%)	351 (43%)	297.5 (37%)
-Atlantic	372	236 (63%)	136 (37%)	132.4 (36%)
-Gulf	437	223 (51%)	215 (49%)	168.0 (38%)
Alabama	46	25 (55%)	21 (45%)	11.2 (24%)
Mississippi barrier island coast	27	0 (0%)	27 (100%)	27 (100%)
Mississippi mainland coast	51 ^c	41 (80%)	10 (20%)	12.6 (25%)
Louisiana	218	13 (6%)	205 (94%)	66.3 (30%)
Texas	370	51 (14%)	319 (86%)	152.7 (41%)
TOTAL	2,119	856 (40%)	1,264 (60%)	901.5 (43%)

^a Beaches classified as “undeveloped” occasionally include a few scattered structures.

^b Preserved beaches include public ownership, ownership by non-governmental conservation organizations, and conservation easements. The miles of shoreline that have been preserved generally overlap with the miles of undeveloped beach but may also include some areas (e.g., in North Carolina) that have been developed with recreational facilities or by private inholdings.

^c The mainland Mississippi coast along Mississippi Sound includes 51.3 miles of sandy beach as of 2010-2011, out of approximately 80.7 total shoreline miles (the remaining portion is non-sandy, either marsh or armored coastline with no sand). See Rice 2012b for details.

Hurricanes

Hurricanes were probably responsible for maintaining coastal beach habitat upon which sea turtles depend through repeated cycles of destruction, alteration, and recovery of beach and dune habitat. Hurricanes generally produce damaging winds, storm tides and surges, and

rain, which can result in severe erosion of the beach and dune systems. Overwash and blowouts are common on barrier islands. Hurricanes and other storms can result in the direct loss of sea turtle nests, either by erosion or washing away of the nests by wave action and inundation or “drowning” of the eggs or pre-emergent hatchlings within the nest, or indirectly by causing the loss of nesting habitat. Depending on their frequency, storms can affect sea turtles on either a short-term basis (nests lost for one season and/or temporary loss of nesting habitat) or long-term, if frequent (habitat unable to recover). The manner in which hurricanes affect sea turtle nesting also depends on their characteristics (winds, storm surge, rainfall), the time of year (within or outside of the nesting season), and where the northeast edge of the hurricane crosses land.

Because of the limited remaining nesting habitat in a natural state with no immediate development landward of the sandy beach, frequent or successive severe weather events could threaten the ability of certain sea turtle populations to survive and recover. Sea turtles evolved under natural coastal environmental events such as hurricanes. The extensive amount of predevelopment coastal beach and dune habitat allowed sea turtles to survive even the most severe hurricane events. It is only within the last 20 to 30 years that the combination of habitat loss to beachfront development and destruction of remaining habitat by hurricanes has increased the threat to sea turtle survival and recovery. On developed beaches, typically little space remains for sandy beaches to become reestablished after periodic storms. While the beach itself moves landward during such storms, reconstruction or persistence of structures at their pre-storm locations can result in a loss of nesting habitat.

Erosion

A critically eroded area is a segment of shoreline where natural processes or human activity have caused or contributed to erosion and recession of the beach or dune system to such a degree that upland development, recreational interests, wildlife habitat, or important cultural resources are threatened or lost. Critically eroded areas may also include peripheral segments or gaps between identified critically eroded areas because, although they may be stable or slightly erosional now, their inclusion is necessary for continuity of management of the coastal system or for the design integrity of adjacent beach management projects (FDEP 2009). It is important to note that for an erosion problem area to be critical there must be an existing threat to or loss of one of four specific interests – upland development, recreation, wildlife habitat, or important cultural resources.

Beachfront Lighting

Artificial lights along a beach can deter females from coming ashore to nest or misdirect females trying to return to the surf after a nesting event. A significant reduction in sea turtle nesting activity has been documented on beaches illuminated with artificial lights (Witherington 1992). Artificial beachfront lighting may also cause disorientation (loss of bearings) and misorientation (incorrect orientation) of sea turtle hatchlings. Visual signs are the primary sea-finding mechanism for hatchlings (Mrosovsky and Carr 1967, Mrosovsky and Shettleworth 1968, Dickerson and Nelson 1989, Witherington and Bjorndal 1991).

Artificial beachfront lighting is a documented cause of hatchling disorientation and misorientation on nesting beaches (Philibosian 1976, Mann 1977, Witherington and Martin 1996). The emergence from the nest and crawl to the sea is one of the most critical periods of a sea turtle's life. Hatchlings that do not make it to the sea quickly become food for ghost crabs, birds, and other predators, or become dehydrated and may never reach the sea. In addition, research has documented significant reduction in sea turtle nesting activity on beaches illuminated with artificial lights (Witherington 1992). During the 2010 sea turtle nesting season in Florida, over 47,000 turtle hatchlings were documented as being disoriented (FWC/FWRI 2011).

Predation

Predation of sea turtle eggs and hatchlings by native and introduced species occurs on almost all nesting beaches. Predation by a variety of predators can considerably decrease sea turtle nest hatching success. The most common predators in the southeastern 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 fire ants (*Solenopsis invicta*) (Dodd 1988, Stancyk 1995). In the absence of nest protection programs in a number of locations throughout the southeast U.S., raccoons may depredate up to 96 percent 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).

Beach Driving

The operation of motor vehicles on the beach affects sea turtle nesting by interrupting or striking a female turtle on the beach, headlights disorienting or misorienting emergent hatchlings, vehicles running over hatchlings attempting to reach the ocean, and vehicle tracks traversing the beach that interfere with hatchlings crawling to the ocean. Hatchlings appear to become diverted not because they cannot physically climb out of the rut (Hughes and Caine 1994), but because the sides of the track cast a shadow and the hatchlings lose their line of sight to the ocean horizon (Mann 1977). The extended period of travel required to negotiate tire tracks and ruts may increase the susceptibility of hatchlings to dehydration and depredation during migration to the ocean (Hosier *et al.* 1981).

Driving on the beach can cause sand compaction, which may result in adverse impacts on nest site selection, digging behavior, clutch viability, and emergence by hatchlings, decreasing nest success and directly killing pre-emergent hatchlings (Mann 1977, Nelson and Dickerson 1987, Nelson 1988).

Additionally, the physical changes and loss of plant cover caused by vehicles on dunes can lead to various degrees of instability, and therefore encourage dune migration. As vehicles move either up or down a slope, sand is displaced downward, lowering the trail. Since the vehicles also inhibit plant growth, and open the area to wind erosion, dunes may become unstable, and begin to migrate. Unvegetated sand dunes may continue to migrate across stable areas as long as vehicle traffic continues. Vehicular traffic through dune breaches or

low dunes on an eroding beach may cause an accelerated rate of overwash and beach erosion (Godfrey *et al.* 1978). If driving is required, the area where the least amount of impact occurs is the beach between the low and high tide water lines. Vegetation on the dunes can quickly reestablish provided the mechanical impact is removed.

Climate Change

The varying and dynamic elements of climate science are inherently long-term, complex, and interrelated. Regardless of the underlying causes of climate change, glacial melting and expansion of warming oceans are causing sea level rise, although its extent or rate cannot as yet be predicted with certainty. At present, the science is not exact enough to precisely predict when and where climate impacts will occur. Although we may know the direction of change, it may not be possible to predict its precise timing or magnitude. These impacts may take place gradually or episodically in major leaps.

Climate change is evident from observations of increases in average global air and ocean temperatures, widespread melting of snow and ice, and rising sea level, according to the Intergovernmental Panel on Climate Change Report (IPCC 2007a). The IPCC Report (2007a) describes changes in natural ecosystems with potential widespread effects on many organisms, including marine mammals and migratory birds. The potential for rapid climate change poses a significant challenge for fish and wildlife conservation. Species' abundance and distribution are dynamic, relative to a variety of factors, including climate. As climate changes, the abundance, and distribution of fish and wildlife will also change. Highly specialized or endemic species are likely to be most susceptible to the stresses of changing climate. Based on these findings and other similar studies, the U.S. Department of the Interior requires agencies under its direction to consider potential climate change effects as part of their long-range planning activities (USFWS 2007c).

In the southeastern U.S., climatic change could amplify current land management challenges involving habitat fragmentation, urbanization, invasive species, disease, parasites, and water management. Global warming will be a particular challenge for endangered, threatened, and other "at risk" species. It is difficult to estimate, with any degree of precision, which species will be affected by climate change or exactly how they will be affected. The Service will use Strategic Habitat Conservation planning, an adaptive science-driven process that begins with explicit trust resource population objectives, as the framework for adjusting our management strategies in response to climate change (USFWS 2006b). As the level of information increases relative to the effects of global climate change on sea turtles and its designated critical habitat, the Service will have a better basis to address the nature and magnitude of this potential threat and will more effectively evaluate these effects to the range-wide status of sea turtles.

Temperatures are predicted to rise from 1.6°F to 9°F for North America by the end of this century (IPCC 2007a, b). Alterations of thermal sand characteristics could result in highly female-biased sex ratios because sea turtles exhibit temperature dependent sex determination (e.g., Glen and Mrosovsky 2004, Hawkes *et al.* 2007).

Along developed coastlines, and especially in areas where shoreline protection 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 or washout by waves and tidal action.

Based on the present level of available information concerning the effects of global climate change on the status of sea turtles and their designated critical habitat, the Service acknowledges the potential for changes to occur in the action area, but presently has no basis to evaluate if or how these changes are affecting sea turtles or their designated critical habitat. Nor does our present knowledge allow the Service to project what the future effects from global climate change may be or the magnitude of these potential effects.

Recreational Beach Use

There is increasing popularity in the southeastern U.S., especially in Florida, for beach communities to carry out beach cleaning operations to improve the appearance of beaches for visitors and residents. Beach cleaning occurs on private beaches and on some municipal or county beaches that are used for nesting by loggerhead sea turtles. Beach cleaning activities effectively remove “seaweed, fish, glass, syringes, plastic, cans, cigarettes, shells, stone, wood, and virtually any unwanted debris” (Barber and Sons 2012). Removal of wrack material (organic material that is washed up onto the beach by surf, tides, and wind) reduces the natural sand-trapping abilities of beaches and contributes to their destabilization. As beach cleaning vehicles and equipment move over the sand, sand is displaced downward, lowering the substrate. Although the amount of sand lost due to single sweeping actions may be small, it adds up considerably over a period of years (Neal *et al.* 2007). In addition, since the beach cleaning vehicles and equipment also inhibit plant growth and open the area to wind erosion, the beach and dunes may become unstable. Beach cleaning “can result in abnormally broad unvegetated zones that are inhospitable to dune formation or plant colonization, thereby enhancing the likelihood of erosion” (Defeo *et al.* 2009). This is also a concern because dunes and vegetation play an important role in minimizing the impacts of artificial beachfront lighting, which causes disorientation of sea turtle hatchlings and nesting turtles, by creating a barrier that prevents residential and commercial business lighting from being visible on the beach.

Human presence on the beach at night during the nesting season can reduce the quality of nesting habitat by deterring or disturbing and causing nesting turtles to avoid otherwise suitable habitat. In addition, human foot traffic can make a beach less suitable for nesting and hatchling emergence by increasing sand compaction and creating obstacles to hatchlings attempting to reach the ocean (Hosier *et al.* 1981).

The use and storage of lounge chairs, cabanas, umbrellas, catamarans, and other types of recreational equipment on the beach at night can also make otherwise suitable nesting habitat unsuitable by hampering or deterring nesting by adult females and trapping or impeding

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.

Sand Placement

Sand placement projects may result in changes in sand density (compaction), beach shear resistance (hardness), beach moisture content, beach slope, sand color, sand grain size, sand grain shape, and sand grain mineral content if the placed sand is dissimilar from the original beach sand (Nelson and Dickerson 1988a). These changes could result in adverse impacts on nest site selection, digging behavior, clutch viability, and hatchling emergence (Nelson and Dickerson 1987, Nelson 1988).

Beach nourishment projects create an elevated, wider, and unnatural flat slope berm. Sea turtles nest closer to the water the first few years after nourishment because of the altered profile (and perhaps unnatural sediment grain size distribution) (Ernest and Martin 1999, Trindell 2005) Rice (2012a) identified that approximately 32% of sandy shorelines from North Carolina to Texas have been modified by sand placement projects (**Table 4**).

Table 4. Approximate shoreline miles of sandy beach that have been modified by sand placement activities for each state in the U.S. continental wintering range of the piping plover as of December 2011. These totals are minimum numbers, given missing data for some areas (Rice 2012b).

State	Known Approximate Miles of Beach Receiving Sand	Proportion of Modified Sandy Beach Shoreline
North Carolina	91.3	28%
South Carolina	67.6	37%
Georgia	5.5	6%
Florida Atlantic coast	189.7	51%
Florida Gulf coast	189.9	43%
Alabama	7.5	16%
Mississippi barrier island coast	1.1	4%
Mississippi mainland coast	43.5	85%
Louisiana	60.4	28%
Texas	28.3	8%
TOTAL	684.8+	32%

Beach compaction and unnatural beach profiles resulting from beach nourishment activities could negatively impact sea turtles regardless of the timing of projects. Very fine sand or the use of heavy machinery can cause sand compaction on nourished beaches (Nelson *et al.* 1987, Nelson and Dickerson 1988a). Significant reductions in nesting success (*i.e.*, false crawls occurred more frequently) have been documented on severely compacted nourished beaches (Fletemeyer 1980, Raymond 1984, Nelson and Dickerson 1987, Nelson *et al.* 1987),

and increased false crawls may result in increased physiological stress to nesting females. Sand compaction may increase the length of time required for female sea turtles to excavate nests and cause increased physiological stress to the animals (Nelson and Dickerson 1988b). Nelson and Dickerson (1988c) concluded that, in general, beaches nourished from offshore borrow sites are harder than natural beaches, and while some may soften over time through erosion and accretion of sand, others may remain hard for 10 years or more.

These impacts can be minimized by using suitable sand and by tilling (minimum depth of 36 inches) compacted sand after project completion. The level of compaction of a beach can be assessed by measuring sand compaction using a cone penetrometer (Nelson 1987). Tilling of a nourished beach with a root rake may reduce the sand compaction to levels comparable to unnourished beaches. However, a pilot study by Nelson and Dickerson (1988c) showed that a tilled nourished beach will remain uncompacted for only up to 1 year. Thus, multi-year beach compaction monitoring and, if necessary, tilling would help to ensure that project impacts on sea turtles are minimized.

A change in sediment color on a beach could change the natural incubation temperatures of nests in an area, which, in turn, could alter natural sex ratios. To provide the most suitable sediment for nesting sea turtles, the color of the nourished sediments should 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 a successful sea turtle nesting season.

In-water and Shoreline Alterations

Many navigable mainland or barrier island tidal inlets or beaches along the Atlantic and Gulf of Mexico coasts are stabilized with jetties or groins. Jetties are built perpendicular to the shoreline and extend through the entire nearshore zone and past the breaker zone to prevent or decrease sand deposition in the channel (Kaufman and Pilkey 1979). Groins are also shore-perpendicular structures that are designed to trap sand that would otherwise be transported by longshore currents and can cause downdrift erosion (Kaufman and Pilkey 1979).

These in-water structures have profound effects on adjacent beaches (Kaufman and Pilkey 1979). Jetties and groins placed to stabilize a beach or inlet prevent normal sand transport, resulting in accretion of sand on updrift beaches and acceleration of beach erosion downdrift of the structures (Komar 1983, Pilkey *et al.* 1984). 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. Rice (2012b) identified over half of inlets from North Carolina to Texas have been modified by some type of structure (**Table 5**).

Table 5. The number of open tidal inlets, inlet modifications, and artificially closed inlets in each state as of December 2011 (Rice 2012a).

State	Existing Inlets							Artificially closed
	Number of Inlets	Total Number of Modified Inlets	Habitat Modification Type					
			structures ^a	dredged	relocated	mined	artificially opened	
North Carolina	20	17 (85%)	7	16	3	4	2	11
South Carolina	47	21 (45%)	17	11	2	3	0	1
Georgia	23	6 (26%)	5	3	0	1	0	0
Florida -Atlantic	21	19 (90%)	19	16	0	3	10	0
Florida -Gulf	48	24 (50%)	20	22	0	6	7	1
Alabama	4	4 (100%)	4	3	0	0	0	2
Mississippi	6	4 (67%)	0	4	0	0	0	0
Louisiana	34	10 (29%)	7	9	1	2	0	46
Texas	18	14 (78%)	10	13	2	1	11	3
TOTAL	221	119 (54%)	89 (40%)	97 (44%)	8 (4%)	20 (9%)	30 (14%)	64 (N/A)

^a Structures include jetties, terminal groins, groin fields, rock or sandbag revetments, seawalls, and offshore breakwaters.

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. In addition to decreasing nesting habitat suitability, construction or repair 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.

Recovery Criteria (only the Demographic Recovery Criteria are presented below; for the Listing Factor Recovery Criteria, see NMFS and USFWS 2008)

1. Number of Nests and Number of Nesting Females
 - a. NRU
 - i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is 2 percent or greater resulting in a total annual number of nests of 14,000 or greater for this recovery unit

(approximate distribution of nests is North Carolina =14 percent [2,000 nests], South Carolina =66 percent [9,200 nests], and Georgia =20 percent [2,800 nests]); and

- ii. 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. PFRU

- i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is statistically detectable (one percent) resulting in a total annual number of nests of 106,100 or greater for this recovery unit; and
- ii. 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. DTRU

- i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is three percent or greater resulting in a total annual number of nests of 1,100 or greater for this recovery unit; and
- ii. 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. NGMRU

- i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is three percent or greater resulting in a total annual number of nests of 4,000 or greater for this recovery unit (approximate distribution of nests (2002-2007) is Florida= 92 percent [3,700 nests] and Alabama =8 percent [300 nests]); and
- ii. 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. GCRU

- i. The total annual number of nests at a minimum of three nesting assemblages, averaging greater than 100 nests annually (e.g., Yucatán, Mexico; Cay Sal Bank, Bahamas) has increased over a generation time of 50 years; and
- ii. 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).

2. Trends in Abundance on Foraging Grounds

A network of in-water sites, both oceanic and neritic across the foraging range is

established and monitoring is implemented to measure abundance. There is statistical confidence (95 percent) 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.

Analysis of the species/critical habitat likely to be affected

The proposed action has the potential to adversely affect nests and hatchlings on the beach. The effects of the proposed action on the loggerhead sea turtle will be considered further in the remaining sections of this BO.

Potential effects include destruction of nests deposited within the boundaries of the proposed project that are not found and relocated out of the project area the nesting season prior to construction. Impacts to nesting females are not expected since the project construction will occur after the egg laying portion of the nesting season. Impacts to hatchlings are not expected since the construction is limited to daylight hours.

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. Because of delayed sexual maturity, reproductive longevity, and low survivorship in early life stages, nesting females are of high value to a population. The loss of a nesting female in a small recovery unit would represent a significant loss to the recovery unit. The reproductive value for a nesting female has been estimated to be approximately 253 times greater than an egg or a hatchling (NMFS and USFWS 2008). However, the proposed action includes avoidance and minimization measures that reduce the possibility of mortality of a nesting female on the beach as a result of the project. Therefore, we do not anticipate the loss of any nesting females on the beach as a result of the project.

During project construction, direct mortality of the developing embryos in nests within the project area may occur for nests that are missed and not relocated. The exact number of these missed nests is not known. However, in two separate monitoring programs on the east coast of Florida where hand digging was performed to confirm the presence of nests and thus reduce the chance of missing nests through misinterpretation, trained observers still missed about 6 to 8 percent of the nests because of natural elements (Martin 1992, Ernest and Martin 1993). This must be considered a conservative number, because missed nests are not always accounted for. In another study, Schroeder (1994) found that even under the best of conditions, about 7 percent of nests can be misidentified as false crawls by highly experienced sea turtle nest surveyors. Missed nests are usually identified by signs of hatchling emergences in areas where no nest was previously documented. Signs of hatchling emergence are very easily obliterated by the same elements that interfere with detection of nests.

However, it is important to note that it is unknown whether nests that would have been laid in a project area had the project not occurred are actually lost from the population or if nesting is simply displaced to adjacent beaches. Regardless, eggs and hatchlings have a low reproductive value; each egg or hatchling has been estimated to have only 0.004 percent of the value of a nesting female (NMFS and USFWS 2008). The Service would not expect this loss to have a significant effect on the recovery and survival of the species, for the following reasons: 1) some nesting is likely just displaced to adjacent non-project beaches, 2) not all eggs will produce hatchlings, and 3) destruction and/or failure of nests will not always result from the construction project. A variety of natural and unknown factors negatively affect incubating egg clutches, including tidal inundation, storm events, and predation.

ENVIRONMENTAL BASELINE

South Carolina barrier beaches are part of a complex and dynamic coastal system that continually respond to inlets, tides, waves, erosion and deposition, longshore sediment transport, and depletion, fluctuations in sea level, and weather events. The location and shape of the coastline perpetually adjusts to these physical forces. Winds move sediment across the dry beach forming dunes and the island interior landscape. The natural communities contain plants and animals that are subject to shoreline erosion and deposition, salt spray, wind, drought conditions, and sandy soils. Vegetative communities include foredunes, primary, and secondary dunes, interdunal swales, sand pine scrub, and maritime forests. However, the protection or persistence of these important natural land forms, processes, and wildlife resources is often in conflict with long-term beach stabilization projects and their indirect effects, i.e., increases in residential development, infrastructure, and public recreational uses.

South Carolina has approximately 182 miles of coastline and approximately 51% (93/182 miles) of the coastline is developed (SC DHEC 2010). Approximately 37% (67.6/182 miles) of the state's coastline has received sand placement via beach nourishment or dredge disposal placement (Rice 2012a). South Carolina currently has 47 tidal inlets open and 36% (17/47 inlets) have been stabilized with some type of hard structure(s) along at least one shoreline (Rice 2012b).

Status of the species within the action area

One of the five recovery units, the NRU, occurs within the proposed action area. The loggerhead sea turtle nesting and hatching season for South Carolina extends from May 1 through October 31. Incubation ranges from about 50 to 60 days.

Sullivan's Island and the Isle of Palms are monitored through a volunteer based nest protection project, which is permitted through SCDNR to conduct daily nesting surveys, nest relocations, predator control measures, and nest inventories. The Isle of Palms has averaged 28.7 nests per season over the past 14 years (**Table 6**), which is a low number compared to other beaches in South Carolina. The nest protection project volunteers relocate over 50%

over their nests in any given season and those numbers have increased to an average of 75% over the past five years. The highest relocation rate (85.1%) to date occurred during the 2016 nesting season. All nests laid within the proposed project areas were relocated due to habitat conditions.

If project construction occurs during the sea turtle nesting season, nesting females may avoid the Isle of Palms and nest on adjacent islands. Dewees Island is the next island north and Sullivan’s Island is the next island south of the Isle of Palms. Therefore, Sullivan’s Island and Dewees Island are considered to be part of the action area.

Table 6. Sea turtle nests and false crawls on Isle of Palms from 2003 through 2016 (SCDNR unpublished data 2003-2016).

Year	Observed Nests	% Nests Relocated	False Crawls
2003	28	64.2%	11
2004	8	62.5%	0
2005	52	69.2%	ND ¹
2006	15	53.3%	0
2007	23	56.5%	ND ¹
2008	27	40.7%	36
2009	19	68.4%	12
2010	23	69.5%	18
2011	42	57.1%	16
2012	62	74.1%	24
2013	34	76.4%	26
2014	11	72.7%	6
2015	31	70.9%	15
2016	27	85.1%	25

¹ND=No Data

Factors affecting the species environment within the action area

Sea turtle nests within the action area are subject to severe erosion, tidal inundation, predation by fox, raccoon, coyote, ghost crabs, and disorientations from artificial beachfront lighting and construction related lighting. All islands within the action areas provide nesting habitat and volunteers carry out nest monitoring and protection efforts, which are overseen by SCDNR.

EFFECTS OF THE ACTION

This section is an analysis of the beneficial, direct, and indirect effects of the proposed action on nesting sea turtles, nests, eggs, and hatchling sea turtles within the action area. The analysis includes effects interrelated and interdependent of the project activities. An

interrelated activity is an activity that is part of a proposed action and depends on the proposed activity. An interdependent activity is an activity that has no independent utility apart from the action.

Factors to be considered

The proposed project will occur within sea turtle nesting habitat and construction may overlap the sea turtle nesting season. Short-term and temporary impacts to sea turtle nesting activities may result from project work occurring on the nesting beach during the nesting season.

Proximity of action: The project will occur within nesting habitat for sea turtles and may potentially impact loggerhead nests and hatchling sea turtles.

Distribution: The project may impact hatchling sea turtles and sea turtle nests that would occur within the project area by discouraging nesting females to nest on the beach due to construction activity or relocating nests that would otherwise be left *in situ* to prevent loss due to burial by construction activities.

Timing: The timing of the project construction may directly and indirectly impact nests and hatchling sea turtles during the nesting season that overlaps with the construction.

Nature of the effect: The effects of the project are not anticipated to result in adverse effects since all nests laid within the vicinity of the project area will be relocated before project construction.

Duration: The projects will take up to two months to complete. Thus, the direct effects would be expected to be short-term in duration.

Disturbance frequency: Sea turtle nests within the project area that are not found and relocated may experience decreased nesting success, hatching success, and hatchling emergence success that could result from the construction activities being conducted during one nesting season.

Disturbance intensity and severity: Project construction may occur during the nesting season. Conservation measures have been incorporated into the project description to minimize impacts.

Analyses for effects of the action

The effects of the proposed project include impacts associated with project construction and maintenance within the action area.

Beneficial Effects

The placement of sand on a beach with reduced dry foredune habitat may increase sea turtle nesting habitat if the placed sand is highly compatible (*i.e.*, grain size, shape, color, etc.) with

naturally occurring beach sediments in the area, and compaction and escarpment remediation measures are incorporated into the project. In addition, a nourished beach that is designed and constructed to mimic a natural beach system may benefit sea turtles more than an eroding beach it replaces.

Adverse Effects

Through many years of research, it has been documented that shoreline stabilization projects can have adverse effects on nesting and hatchling sea turtles and sea turtle nests. Results of monitoring sea turtle nesting provide additional information on how sea turtles respond to these projects, minimization measures, and other factors that influence nesting, hatching, and emerging success.

Direct Effects

The equipment to relocate the inlet will have to traverse the beach portion of the action area, which could result in harm sea turtles nests and emerging hatchlings. While a nest monitoring and egg relocation program would reduce these impacts, nests may be inadvertently missed (when crawls are obscured by rainfall, wind, or tides) or misidentified as false crawls during daily patrols. Even under the best of conditions, about seven percent of the nests can be misidentified as false crawls by experienced sea turtle nest surveyors (Schroeder 1994).

Potential Direct Effects Associated With Project Construction

1. Nest relocation

Besides the potential for missing nests during surveys, there is a potential for eggs to be damaged by nest relocation, particularly if eggs are not relocated within 12 hours of deposition (Limpus *et al.* 1979). Relocated nests can incubate at different temperatures than nests left to incubate in place (*in situ*) (Mrosvosky and Yntema 1980, Hoekert *et al.* 1998, Başkale and Kaska 2005, Tuttle 2007, Bimbi 2009, Tuttle and Rostal 2010, Pintus *et al.* 2009) and cause skewed sex ratios (Morreale *et al.* 1982, Godfrey *et al.* 1997). Relocated nests can also have higher or lower hatch success and hatchling emergence than *in situ* nests (Wyneken *et al.* 1988, Hoekert *et al.* 1998, García *et al.* 2003, Moody 2000, Kornaraki *et al.* 2006, Tuttle 2007, McElroy 2009, Pintus *et al.* 2009) depending on relocation technique and environmental conditions.

Nest relocation can have adverse impacts on gas exchange parameters and the hydric environment of nests (Limpus *et al.* 1979, Ackerman 1980, Parmenter 1980, Spotila *et al.* 1983, McGehee 1990). Nests relocated into sands deficient in oxygen or moisture can result in mortality, morbidity, and reduced behavioral competence of hatchlings. Water availability is known to influence the incubation environment of the embryos and hatchlings of turtles with flexible-shelled eggs, which has been shown to affect nitrogen excretion (Packard *et al.* 1984), mobilization of calcium (Packard and Packard 1986), mobilization of yolk nutrients (Packard *et al.* 1985), hatchling size (Packard *et al.* 1981, McGehee 1990), energy reserves in

the yolk at hatching (Packard *et al.* 1988), and locomotory ability of hatchlings (Miller *et al.* 1987).

2. Equipment during construction

The use of heavy machinery on beaches during a construction project may also have adverse effects on sea turtles. Driving directly above or over incubating egg clutches or on the beach can cause sand compaction, which may result in adverse impacts on nest site selection, digging behavior, clutch viability, and emergence by hatchlings, as well as directly kill pre-emergent hatchlings (Mann 1977, Nelson and Dickerson 1987, Nelson 1988).

Indirect Effects

Many of the direct effects of shoreline stabilization projects may persist over time and become indirect impacts. These indirect effects include increased susceptibility of relocated nests to catastrophic events, the consequences of potential increased beachfront development, changes in the physical characteristics of the beach, the formation of escarpments, and future sand migration.

Increased susceptibility to catastrophic events

Nest relocation within a nesting season may concentrate eggs in an area making them more susceptible to catastrophic events. Hatchlings released from concentrated areas also may be subject to greater predation rates from both land and marine predators, because the predators learn where to concentrate their efforts (Glenn 1998, Wyneken *et al.* 1998).

Species' response to the proposed action

The Service expects a minimal response to the proposed action due to the minimization measures in place and the short duration of project construction.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this BO. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. The Service is not aware of any cumulative effects in the project area at this time.

CONCLUSION

After reviewing the current status of the loggerhead sea turtle, the environmental baseline for the action area, the effects of the proposed project, the cumulative effects, and the proposed conservation measures, it is the Service's biological opinion that the project as proposed, is not likely to jeopardize the continued existence of the loggerhead sea turtle and is not likely to destroy or adversely modify designated critical habitat.

The conservation of the five loggerhead recovery units in the Northwest Atlantic is essential to the recovery of the loggerhead sea turtle. Each individual recovery unit is necessary to conserve genetic and demographic robustness, or other features necessary for long-term sustainability of the entire population. Thus, maintenance of viable nesting in each recovery unit contributes to the overall population. One of the five loggerhead recovery units in the Northwest Atlantic, the NRU, occurs within the action area. Of the available nesting habitat within the NRU, project construction will occur and/or will likely have an effect on approximately 19,000 linear feet of shoreline.

Take of sea turtles will be minimized by implementation of the Reasonable and Prudent Measures, and Terms and Conditions outlined below. These measures have been shown to help minimize adverse impacts to sea turtles.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered or threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, carrying out an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are non-discretionary, and must be implemented by the Corps and/or their contractors so that they become binding conditions of any grant or permit issued, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps and/or their contractors (1) fail(s) to assume and implement the terms and conditions or (2) fail(s) to require the applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps must report the progress of the action and its impacts on the species to the SCFO as specified in the incidental take statement [50 CFR 402.14(i)(3)].

AMOUNT OR EXTENT OF TAKE ANTICIPATED

The Service anticipates 19,000 linear feet of nesting beach habitat could be taken as a result of this proposed action. The take is expected to be in the form of destruction of all nests that may be constructed and eggs that may be deposited and missed by a nest survey and nest relocation program (May 1 – October 31) within the boundaries of the proposed project.

Incidental take is anticipated for only the 19,000 linear feet of beach that have been identified. The Service anticipates incidental take of sea turtles will be difficult to detect for the following reasons: (1) The turtles nest primarily at night and all nests are not found because [a] natural factors, such as rainfall, wind, and tides may obscure crawls and [b] human-caused factors, such as pedestrian and vehicular traffic, may obscure crawls, and result in nests being destroyed because they were missed during a nesting survey and nest mark and avoidance program, (2) The total number of hatchlings per undiscovered nest is unknown.

EFFECT OF THE TAKE

In the accompanying BO, the Service determined that this level of anticipated take is not likely to result in jeopardy to the species. Critical habitat has not been designated in the project area; therefore, the project will not result in destruction or adverse modification of critical habitat. Incidental take of nesting and hatchling sea turtles is anticipated to occur during project construction and during the life of the project. Take will occur on nesting habitat on 19,000 feet of shoreline.

REASONABLE AND PRUDENT MEASURES

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize “take” of the loggerhead sea turtle.

1. Conservation Measures included in the permit application/project plans must be implemented (unless revised below in the Terms and Conditions) in the proposed project.
2. Beach quality sand will be used for sand placement on Isle of Palms.
3. All coastal armoring material including sandbags and both WDS will be removed from the beach prior to or immediately after any material placement.
4. The applicant will hire qualified sea turtle monitors if work will occur during a portion of the nesting season. During the sea turtle nesting season (May 1 – October 31) immediately prior to project construction, surveys for nesting sea turtles must be conducted on the entire island. If nests are constructed in the project footprint, the

- eggs must be relocated to minimize sea turtle nest burial, crushing of eggs, or nest excavation. Nest relocation will be on a selected area of beach that is not expected to experience daily inundation by high tides or known to routinely experience severe erosion and egg loss, predation, or subject to artificial lighting.
5. Construction equipment and materials for project construction must be stored in a manner that will minimize impacts to hatchling sea turtles to the maximum extent practicable.
 6. Predator-proof trash receptacles must be installed and maintained at all beach access points used for project construction to minimize the potential for attracting predators of sea turtles.
 7. The applicant must take actions to minimize sea turtle misorientations/disorientations on the beach caused by the projects' construction-related lighting and artificial lighting associated with oceanfront development adjacent to the project area and within the project limits during the nesting season from May 1 through October 31.
 8. Prior to the beginning of the project, the applicant must submit a lighting plan for the dredge that will be used in this project. The plan must include a description of each light source that will be visible from the beach and the measures implemented to minimize this lighting.
 9. The applicant must hire monitors with sea turtle experience to patrol the beach at night in the project area if nighttime construction activities and equipment occur during the nesting season.
 10. During the sea turtle nesting season, the contractor must not extend the beach fill more than 500 feet along the shoreline and must confine work activities within this area between dusk and the following day's nesting survey unless nighttime monitors patrol the beach to reduce the impacts to emerging sea turtles and burial of new nests.
 11. Sand compaction must be monitored and tilling (non-vegetated areas) must be conducted if needed immediately after completion of the sand placement work and prior to the next three nesting seasons to reduce the likelihood of impacting sea turtle nesting and hatching activities.
 12. Escarpment formation will be monitored and leveling will be conducted if needed immediately after completion of the sand placement project and prior to the next three nesting seasons to reduce the likelihood of impacting nesting and hatchling sea turtles.
 13. Post construction surveys of all artificial lighting visible from the project beach must be completed.

14. During the portion of the nesting season that overlaps with the construction window, on-beach access to the construction site will be restricted to the wet sand below mean high water (MHW).
15. The Service's South Carolina Field Office (SCFO) and South Carolina Department of Natural Resources (SCDNR) must be notified if a sea turtle adult, hatchling, or egg is harmed or destroyed as a direct or indirect result of the project.
16. A meeting/conference call between representatives of the contractor, the SCFO, SCDNR, and the permitted sea turtle monitor(s) must be held prior to the commencement of work on this project.
17. A report describing the actions taken to implement the terms and conditions of this incidental take statement must be submitted to the SCFO following completion of the proposed work.
18. Existing vegetated habitat at each of the beach access points must be protected to the maximum extent practicable and must be delineated by post and rope or other suitable material to ensure vehicles and equipment transport stay within the access corridor. Any vegetated areas impacted must be restored to pre-construction conditions. New beach access locations created for the project work must be approved by the SCFO and SCDNR.
19. Expanded or newly created beach access points must be restored to dune habitat within three months following project completion. The habitat restoration must consist of restoring the dune topography and planting with appropriate native dune vegetation (i.e., native to coastal dunes in South Carolina).

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the ESA, the Corps will include the following terms and conditions, which implement the reasonable and prudent measures (RPM), described above and outline required reporting/monitoring requirements. These terms and conditions (T&Cs) are non-discretionary.

1. Conservation Measures included in the permit application/project plans must be implemented in the proposed project. Construction must be completed by June 30. Based on SCDNR nest emergence dates for Isle of Palms, construction can begin October 1 if the project is not completed by June 30. No construction will occur July 1 – September 30.
2. Daily early morning surveys for sea turtle nests will be required if construction coincides with the sea turtle nesting season. Nesting surveys must be conducted May 1–October 31 in the project area if work will begin before October 31. If nests are constructed in areas where they may be affected by construction activities, the nests must be relocated per the following requirements.

- a. Nesting surveys and nest relocation will only be conducted by personnel with prior experience and training in nesting survey and nest marking procedures. Surveyors must have a valid SCDNR permit. Nesting surveys must be conducted daily between sunrise and 9:00 AM.
 - b. Only those nests that may be affected by sand placement activities will be relocated. Nests requiring relocation will be moved no later than 9:00 AM the morning following deposition to a nearby self-release beach site in a secure setting where artificial lighting will not interfere with hatchling orientation. Relocated nests will not be placed in organized groupings. Relocated nests will be randomly staggered along the length and width of the beach in settings that are not expected to experience daily inundation by high tides or known to routinely experience severe erosion and egg loss, or subject to artificial lighting. Nest relocations in association with construction activities must cease when construction activities no longer threaten nests.
 - c. Nests deposited within areas where construction activities have ceased or will not occur for 75 days or nests laid in the nourished berm prior to tilling must be marked and left in situ unless other factors threaten the success of the nest. The turtle permit holder will install an on-beach marker at the nest site or a secondary marker at a point as far landward as possible to assure that future location of the nest will be possible should the on-beach marker be lost. No activity will occur within this area nor will any activities occur which could result in impacts to the nest. Nest sites will be inspected daily to assure nest markers remain in place and the nest has not been disturbed by the project activity.
3. During the sea turtle nesting season, nighttime storage of construction equipment not in use must be off the beach to minimize disturbance to sea turtle hatching activities.
 4. Staging areas for construction equipment must be located off the beach. Nighttime storage of construction equipment not in use must be off the beach to minimize disturbance to sea turtle nesting and hatching activities. In addition, all construction pipes placed on the beach must be located as far landward as possible without compromising the integrity of the dune system. Pipes placed parallel to the dune must be 5 to 10 feet away from the toe of the dune if the width of the beach allows. Temporary storage of pipes must be off the beach to the maximum extent possible. If the pipes are stored on the beach, they must be placed in a manner that will minimize the impact to nesting habitat and must not compromise the integrity of the dune systems.
 5. Two post-construction surveys must be conducted of all lighting visible from the beach placement area using standard techniques for such a survey (**Appendix B**). The timing of these surveys will be coordinated with the SCFO prior to commencement of the work. Summary reports of both surveys will be provided to the SCFO. The summary report from the post-construction surveys (including the following information: methodology of

the survey, a map showing the position of the lights visible from the beach, a description of each light source visible from the beach, recommendations for remediation, and any actions taken) will be provided to the SCFO within three months after the survey is conducted. After the report is completed, a meeting must be set up with the Corps, the project sponsors, SCDNR, and the Service to discuss the survey report, as well as any documented sea turtle disorientations in or adjacent to the project area. Any action related to artificial beachfront lighting will be addressed by the appropriate project sponsor, as mentioned in RPM #7. If the project is completed during the nesting season and prior to May 1, the lighting surveys may be conducted during the year of construction.

6. Sand compaction must be monitored in the area of sand placement immediately after completion of the project and prior to May 1 for three subsequent years. If tilling is needed, the area must be tilled to a depth of 24 inches. Each pass of the tilling equipment must be overlapped to allow more thorough and even tilling. All tilling activity must be completed at least once prior to nesting season. An electronic copy of the results of the compaction monitoring must be submitted to the SCFO prior to any tilling actions being taken or if a request not to till is made based on compaction results. The requirement for compaction monitoring can be eliminated if the decision is made to till regardless of post construction compaction levels. Additionally, out-year compaction monitoring and remediation are not required if placed material no longer remains on the dry beach.
7. Compaction sampling stations must be located at 500-foot intervals along the sand placement template. One station must be at the seaward edge of the dune/bulkhead line (when material is placed in this area), and one station must be midway between the dune line and the high water line (normal wrack line).
8. At each station, the cone penetrometer must be pushed to a depth of 6, 12, and 18 inches three times (three replicates). Material may be removed from the hole if necessary to ensure accurate readings of successive levels of sediment. The penetrometer may need to be reset between pushes, especially if sediment layering exists. Layers of highly compact material may lie over less compact layers. Replicates must be located as close to each other as possible, without interacting with the previous hole or disturbed sediments. The three replicate compaction values for each depth must be averaged to produce final values for each depth at each station. Reports will include all 18 values for each transect line, and the final six averaged compaction values.
9. If the average value for any depth exceeds 500 pounds per square inch (psi) for any two or more adjacent stations, then that area must be tilled immediately prior to May 1.
10. If values exceeding 500 psi are distributed throughout the project area but in no case do those values exist at two adjacent stations at the same depth, then consultation with the SCFO will be required to determine if tilling is required. If a few values exceeding 500 psi are present randomly within the project area, tilling will not be required.

11. Tilling must occur landward of the wrack line and avoid all vegetated areas three square feet or greater with a three square foot buffer around the vegetated areas.
12. Visual surveys for escarpments along the project area must be made immediately after completion of the sand placement and within 30 days prior to May 1 for three subsequent years if sand in the project area still remains on the dry beach. Escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet must be leveled and the beach profile must be reconfigured to minimize scarp formation by the dates listed above. Any escarpment removal must be reported by location. If the project is completed during the early part of the sea turtle nesting and hatching season, escarpments may be required to be leveled immediately, while protecting nests that have been relocated or left in place. The SCFO must be contacted immediately if subsequent reformation of escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet occurs during the nesting and hatching season to determine the appropriate action to be taken. If it is determined that escarpment leveling is required during the nesting or hatching season, the SCFO will provide a brief written authorization within 30 days that describes methods to be used to reduce the likelihood of impacting existing nests. An annual summary of escarpment surveys and actions taken must be submitted to the SCFO.
13. Prior to the beginning of the project, the applicant must submit a lighting plan for the dredge that will be used in the project. The plan must include a description of each light source that will be visible from the beach and the measures implemented to minimize this lighting. This plan must be reviewed and approved by the SCFO.
14. Direct lighting of the beach and nearshore waters must be limited to the immediate construction area during nesting season and must comply with safety requirements. Lighting on all equipment must be minimized through reduction, shielding, lowering, and appropriate placement to avoid excessive illumination of the water's surface and nesting beach while meeting all Coast Guard, Corps EM 385-1-1, and OSHA requirements. Light intensity of lighting equipment must be reduced to the minimum standard required by OSHA for General Construction areas, in order not to misdirect sea turtles. Shields must be affixed to the light housing and be large enough to block light from all on-beach lamps from being transmitted outside the construction area or to the adjacent sea turtle nesting beach (**Figure 4**). The applicant must monitor compliance with the lighting schematic on a weekly basis by making unscheduled night site visits from May 1 through October 31 to minimize adult and hatchling disorientations. Noncompliance documented twice during this window will result in no construction from 9 PM until 6 AM through October 31.

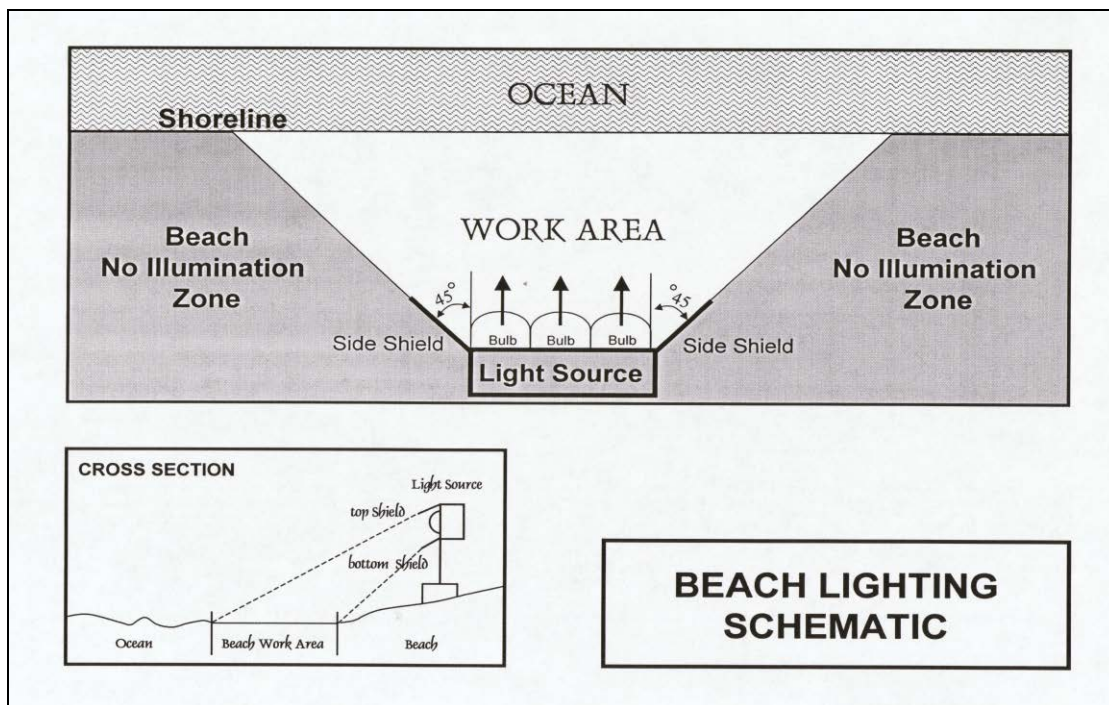


Figure 4. Beach lighting schematic.

15. During the sea turtle nesting season, the contractor must not extend the beach fill more than 500 feet (or other agreed upon length) along the shoreline between dusk and dawn and the following day until the daily nesting survey has been completed and the beach cleared for fill advancement. An exception to this may occur if there is permitted sea turtle surveyor present on-site to ensure no nesting and hatching sea turtles are present within the extended work area. If the 500 feet is not feasible for the project, an agreed upon distance will be decided on during the preconstruction meeting. Once the beach has been cleared and the necessary nest relocations have been completed, the contractor will be allowed to proceed with the placement of fill and work activities during daylight hours until dusk at which time the 500-foot length (or other agreed upon length) limitation must apply. If any nesting turtles are sighted on the beach within the immediate construction area, activities must cease immediately until the turtle has returned to the water and the sea turtle permit holder responsible for nest monitoring has relocated the nest.
16. Predator-proof trash receptacles must be installed and maintained during construction at all beach access points used for the project construction to minimize the potential for attracting predators of sea turtle (**Appendix C**). The contractors conducting the work must provide predator-proof trash receptacles for the construction workers. All contractors and their employees must be briefed on the importance of not littering and keeping the project area trash and debris free.
17. During the nest laying and hatching season, on-beach access to the construction site will be restricted to the wet sand below MHW.

18. A meeting or conference call between representatives of the contractor, SCFO, SCDNR, and the permitted sea turtle surveyor will be held prior to the commencement of work on this project. At least ten business days advance notice will be provided prior to conducting this meeting. The meeting/conference call will provide an opportunity for explanation and/or clarification of the sea turtle protection measures as well as additional guidelines when construction occurs during the sea turtle nesting season, such as storing equipment, minimizing driving, as well as follow up meetings during construction.
19. A report with the information listed below must be submitted to the SCFO within three months of the completion of construction.
 - Project location (latitude and longitude coordinates)
 - Project description (include linear feet of beach, and access points)
 - Dates of actual construction activities
 - Names and qualifications of personnel involved in sea turtle nesting surveys and nest relocation
 - Escarpment formation
 - Remedial action

Monitoring and Reporting

20. A report describing the work conducted during the year and actions taken to implement the reasonable and prudent measures and terms and conditions of this incidental take statement must be submitted to the SCFO within 90 days of completing the proposed work.
21. Upon locating a dead or injured sea turtle adult, hatchling, or egg that may have been harmed or destroyed as a direct or indirect result of the project, the Corps, permittee, and/or local sponsor will be responsible for notifying the SCDNR Hotline (1-800-922-5431) and the SCFO (843-727-4707). Care must be taken in handling injured sea turtles, eggs, or piping plovers to ensure effective treatment or disposition, and in handling dead specimens to preserve biological materials in the best possible state for later analysis.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

1. Educational signs should be placed where appropriate at beach access points explaining the importance of the area to sea turtles and/or the life history of sea turtle species that nest in the area.

Migratory Birds

Nesting season surveys should be conducted in all potential beach-nesting bird habitats within the project boundaries that may be impacted by construction or pre-construction activities during the nesting season. Portions of the project where there is no potential for project-related activity during the nesting season may be excluded.

If shorebird nesting activity is discovered within the project area, the City should establish a 300-foot wide buffer zone around any location where shorebirds have been engaged in nesting behavior, including territory defense. All construction activities, including movement of vehicles, should be prohibited in the buffer zone.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION - CLOSING STATEMENT

This concludes formal consultation on the action outlined in your request for formal consultation for the proposed project. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion or the project has not been completed within five years of the issuance of this BO; (3) the agency action is subsequently modified in a manner, that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

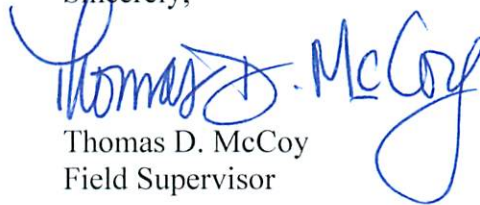
Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered or threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, carrying out an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2) of the ESA, taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are non-discretionary, and must be implemented by the Corps so that they become binding conditions of any grant or permit issued to the Applicant, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps: (1) fails to assume and implement the terms and conditions; or (2) fails to require the Applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps must report the progress of the action and its impacts on the species to the Service as specified in the incidental take statement [50 CFR 402.14(i)(3)].

For this BO, the incidental take will be exceeded when the construction activities associated with this project exceed 19,000 linear feet of beach, which would extend activities beyond the project's authorized boundaries. This BO has exempted an undetermined number of loggerhead sea turtle eggs and hatchlings from the prohibitions of section 9 of the ESA.

The Service appreciates the cooperation of the Corps during this consultation. For further coordination, please contact Ms. Melissa Bimbi at (843) 727-4707, ext. 217. In future correspondence concerning the project, please reference FWS Log Nos. 04ES1000-2017-F-0157.

Sincerely,



Thomas D. McCoy
Field Supervisor

TDM/MKB

Electronic copies to:

- USFWS, Atlanta, GA (Jerry Ziewitz)
- USFWS, Jacksonville, FL (Ann Marie Lauritsen)
- USFWS, Daphne, AL (Dianne Ingram)
- NMFS, Charleston, SC (Pace Wilbur)
- SCDNR, Charleston, SC (Michelle Pate)
- SCDNR, Charleston, SC (Susan Davis)
- SCDHEC-OCRM, Charleston, SC (Matt Slagel)
- CSE, Columbia, SC (Steven Traynum)

LITERATURE CITED

- Ackerman, R.A. 1980. Physiological and ecological aspects of gas exchange by sea turtle eggs. *American Zoologist* 20:575-583.
- Aguilar, R., J. Mas, and X. Pastor. 1995. Impact of Spanish swordfish longline fisheries on the loggerhead sea turtle *Caretta caretta* population in the western Mediterranean. NOAA Technical Memorandum. NMFS-SEFSC-361:1-6.
- Baldwin, R., G.R. Hughes, and R.I.T. Prince. 2003. Loggerhead turtles in the Indian Ocean. Pages 218-232 in Bolten, A.B. and B.E. Witherington (editors). *Loggerhead Sea Turtles*. Smithsonian Books, Washington D.C.
- Barber, H. and Sons. 2012. Beach cleaning equipment and beach cleaning machines. http://www.hbarber.com/Cleaners/Beach_Cleaning_Equipment.html. Accessed August 30, 2012.
- Başkale, E. and Y. Kaska. 2005. Sea turtle nest conservation techniques on southwestern beaches in Turkey. *Israel Journal of Zoology* 51:13-26.
- Bimbi, M.K. 2009. Effects of Relocation and Environmental Factors on Loggerhead Sea Turtle (*Caretta caretta*) Nests on Cape Island. M.S. Thesis. The Graduate School of The College of Charleston, Charleston, South Carolina.
- Bjorndal, K.A., A.B. Meylan, and B.J. Turner. 1983. Sea turtles nesting at Melbourne Beach, Florida, I. Size, growth and reproductive biology. *Biological Conservation* 26:65-77.
- Blair, K. 2005. Determination of sex ratios and their relationship to nest temperature of loggerhead sea turtle (*Caretta caretta*, L.) hatchlings produced along the southeastern Atlantic coast of the United States. Unpublished M.S. thesis. Florida Atlantic University, Boca Raton, Florida.
- Bolten, A.B., K.A. Bjorndal, and H.R. Martins. 1994. Life history model for the loggerhead sea turtle (*Caretta caretta*) populations in the Atlantic: Potential impacts of a longline fishery. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS-SWFC-201:48-55.
- Bolten, Alan B. 2003. Active swimmers-passive drifters: The oceanic juvenile stage of loggerheads in the Atlantic system. Ed. Bolten, Alan B. and Blair E. Witherington. Washington: Smithsonian, 2003. 65 pp.

- Bowen, B. W., A.L. Bass, L. Soares, and R.J. Toonen. 2005. Conservation implications of complex population structure: lessons from the loggerhead turtle (*Caretta caretta*). *Molecular Ecology* 14:2389-2402.
- Carr, A. and L. Ogren. 1960. The ecology and migrations of sea turtles, 4. The green turtle in the Caribbean Sea. *Bulletin of the American Museum of Natural History* 121(1):1-48.
- Chaloupka, M. 2001. Historical trends, seasonality and spatial synchrony in green sea turtle egg production. *Biological Conservation* 101:263-279.
- Christens, E. 1990. Nest emergence lag in loggerhead sea turtles. *Journal of Herpetology* 24(4):400-402.
- Coastal Engineering Research Center. 1984. Shore protection manual, volumes I and II. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.
- Coastal Science and Engineering. 2016. Isle of Palms beach restoration biological assessment and essential fish habitat assessment. Report to USACE. 92 pp.
- Conant, T.A., P.H. Dutton, T. Eguchi, S.P. Epperly, C.C. Fahy, M.H. Godfrey, S.L. MacPherson, E.E. Possardt, B.A. Schroeder, J.A. Seminoff, M.L. Snover, C.M. Uptite, and B.E. Witherington. 2009. Loggerhead sea turtle (*Caretta caretta*) 2009 status review under the U.S. Endangered Species Act. Report to the National Marine Fisheries Service, Silver Spring, Maryland, USA. 219 pp.
- Congdon, J.D., A.E. Dunham, and R.C. van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's turtles (*Emydoidea blandingii*): implications for conservation and management of long-lived organisms. *Conservation Biology* 7(4):826-833.
- Crain, D.A., A.B. Bolten, and K.A. Bjorndal. 1995. Effects of beach nourishment on sea turtles: review and research initiatives. *Restoration Ecology* 3(2):95-104.
- Crouse, D. 1999. Population modeling and implications for Caribbean hawksbill sea turtle management. *Chelonian Conservation and Biology* 3(2):185-188.
- Dahlen, M.K., R. Bell, J.I. Richardson, and T.H. Richardson. 2000. Beyond D-0004: Thirty-four years of loggerhead (*Caretta caretta*) research on Little Cumberland Island, Georgia, 1964-1997. Pages 60-62 in Abreu-Grobois, F.A., R. Briseno-Duenas, R. Marquez, and L. Sarti (compilers). *Proceedings of the Eighteenth International Sea Turtle Symposium*. NOAA Technical Memorandum NMFS-SEFSC-436.
- Daniel, R.S. and K.U. Smith. 1947. The sea-approach behavior of the neonate loggerhead turtle (*Caretta caretta*). *Journal of Comparative and Physiological Psychology* 40(6):413-420.
- Davis, G.E. and M.C. Whiting. 1977. Loggerhead sea turtle nesting in Everglades National Park, Florida, U.S.A. *Herpetologica* 33:18-28.

- Dean, C. 1999. *Against the tide: the battle for America's beaches*. Columbia University Press; New York, New York.
- Defeo, O., A. McLachlan, D.S. Schoeman, T.A. Schlacher, J. Dugan, A. Jones, M. Lastra, and F. Scapini. 2009. Threats to sandy beach ecosystems: a review. *Estuarine, Coastal and Shelf Science* 81:1–12.
- Dickerson, D.D. and D.A. Nelson. 1989. Recent results on hatchling orientation responses to light wavelengths and intensities. Pages 41–43 *in* Eckert, S.A., K.L. Eckert, and T.H. Richardson (compilers). *Proceedings of the 9th Annual Workshop on Sea Turtle Conservation and Biology*. NOAA Technical Memorandum NMFS-SEFC-232.
- Dodd, C.K., Jr. 1988. Synopsis of the biological data on the loggerhead sea turtle *Caretta caretta* (Linnaeus 1758). U.S. Fish and Wildlife Service, Biological Report 88(14).
- Dodd, M.G. and A.H. Mackinnon. 1999. Loggerhead turtle (*Caretta caretta*) nesting in Georgia, 1999: implications for management. Georgia Department of Natural Resources unpublished report. 41 pp.
- Dodd, M.G. and A.H. Mackinnon. 2000. Loggerhead turtle (*Caretta caretta*) nesting in Georgia, 2000: implications for management. Georgia Department of Natural Resources unpublished report. 47 pp.
- Dodd, M.G. and A.H. Mackinnon. 2001. Loggerhead turtle (*Caretta caretta*) nesting in Georgia, 2001. Georgia Department of Natural Resources unpublished report submitted to the U.S. Fish and Wildlife Service for grant E-5-1 “Coastal Endangered Species Management.” 46 pp.
- Dodd, M.G. and A.H. Mackinnon. 2002. Loggerhead turtle (*Caretta caretta*) nesting in Georgia, 2002. Georgia Department of Natural Resources unpublished report submitted to the U.S. Fish and Wildlife Service for grant E-5-2 “Coastal Endangered Species Management.” 46 pp.
- Dodd, M.G. and A.H. Mackinnon. 2003. Loggerhead turtle (*Caretta caretta*) nesting in Georgia, 2003. Georgia Department of Natural Resources unpublished report submitted to the U.S. Fish and Wildlife Service for grant E-5-3 “Coastal Endangered Species Management.” 46 pp.
- Dodd, M.G. and A.H. Mackinnon. 2004. Loggerhead turtle (*Caretta caretta*) nesting in Georgia, 2004. Georgia Department of Natural Resources unpublished report submitted to the U.S. Fish and Wildlife Service for grant E-5-4 “Coastal Endangered Species Management.” 44 pp.
- Ehrhart, L.M. 1989. Status report of the loggerhead turtle. Pages 122-139 *in* Ogren, L., F. Berry, K. Bjorndal, H. Kumpf, R. Mast, G. Medina, H. Reichart, and R. Witham (editors). *Proceedings of the 2nd Western Atlantic Turtle Symposium*. NOAA Technical Memorandum NMFS-SEFC-226.

- Ehrhart, L.M., D.A. Bagley, and W.E. Redfoot. 2003. Loggerhead turtles in the Atlantic Ocean: geographic distribution, abundance, and population status. Pages 157-174 in Bolten, A.B. and B.E. Witherington (editors). *Loggerhead Sea Turtles*. Smithsonian Books, Washington D.C.
- Encalada, S.E., J.C. Zurita, and B.W. Bowen. 1999. Genetic consequences of coastal development: the sea turtle rookeries at X'cacel, Mexico. *Marine Turtle Newsletter* 83:8-10.
- Ernest, R.G. and R.E. Martin. 1993. Sea turtle protection program performed in support of velocity cap repairs, Florida Power & Light Company St. Lucie Plant. Applied Biology, Inc., Jensen Beach, Florida. 51 pp.
- Ernest, R.G. and R.E. Martin. 1999. Martin County beach nourishment project: sea turtle monitoring and studies. 1997 annual report and final assessment. Unpublished report prepared for the Florida Department of Environmental Protection.
- Florida Department of Environmental Protection (FDEP). 2009. Critically eroded beaches in Florida. Bureau of Beaches and Coastal Systems. Tallahassee, Florida
<http://www.dep.state.fl.us/BEACHES/publications/pdf/CritEroRpt09.pdf>.
- Fletemeyer, J. 1980. Sea turtle monitoring project. Unpublished report prepared for the Broward County Environmental Quality Control Board, Florida.
- Foley, A. 2005. Personal communication to Loggerhead Recovery Team. Florida Fish and Wildlife Research Institute.
- Foley, A., B. Schroeder, and S. MacPherson. 2008. Post-nesting migrations and resident areas of Florida loggerheads. Pages 75-76 in Kalb, H., A. Rohde, K. Gayheart, and K. Shanker (compilers). *Proceedings of the Twenty-fifth Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-582.
- Foote, J., J. Sprinkel, T. Mueller, and J. McCarthy. 2000. An overview of twelve years of tagging data from *Caretta caretta* and *Chelonia mydas* nesting habitat along the central Gulf coast of Florida, USA. Pages 280-283 in Kalb, H.J. and T. Wibbels (compilers). *Proceedings of the Nineteenth Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-443.
- Francisco-Pearce, A.M. 2001. Contrasting population structure of *Caretta caretta* using mitochondrial and nuclear DNA primers. Master's thesis, University of Florida, Gainesville, Florida, 71 pp.
- Frazer, N.B. and J.I. Richardson. 1985. Annual variation in clutch size and frequency for loggerhead turtles, *Caretta-caretta*, nesting at Little Cumberland Island, Georgia, USA. *Herpetologica* 41(3):246-251.

- Florida Fish and Wildlife Conservation Commission (FWC). 2007. Sea turtle protection ordinance adopted by counties and municipalities (as of 01/02/2008). http://myfwc.com/seaturtle/Lighting/Light_Ordinance.htm
- Florida Fish and Wildlife Conservation Commission (FWC). 2008. Personal communication to the Loggerhead Recovery Team. Florida Fish and Wildlife Research Institute.
- Florida Fish and Wildlife Conservation Commission (FWC). 2009. Index Nesting Beach Survey Totals. http://research.myfwc.com/features/view_article.asp?id=10690.
- Florida Fish and Wildlife Conservation Commission (FWC). 2011. Manatee Standard Conditions For In-water Work. http://fwcg.myfwc.com/docs/Manatee_StandardConditionsForIn-waterWork_2011.pdf
- Florida Fish and Wildlife Conservation Commission/Florida Fish and Wildlife Research Institute (FWC/FWRI). 2010. A good nesting season for loggerheads in 2010 does not reverse a recent declining trend. http://research.myfwc.com/features/view_article.asp?id=27537
- Florida Fish and Wildlife Conservation Commission/Florida Fish and Wildlife Research Institute (FWC/FWRI). 2011. Personal communication to the U.S. Fish and Wildlife Service.
- García, A., G. Ceballos, R. Adaya. 2003. Intensive beach management as an improved sea turtle conservation strategy in Mexico. *Biological Conservation* 111:253-261.
- Gerrodette, T. and J. Brandon. 2000. Designing a monitoring program to detect trends. Pages 36-39 in Bjorndal, K.A. and A.B. Bolten (editors). *Proceedings of a Workshop on Assessing Abundance and Trends for In-water Sea Turtle Populations*. NOAA Technical Memorandum NMFS-SEFSC-445.
- Glenn, L. 1998. The consequences of human manipulation of the coastal environment on hatchling loggerhead sea turtles (*Caretta caretta*, L.). Pages 58-59 in Byles, R., and Y. Fernandez (compilers). *Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-412.
- Glen, F. and N. Mrosovsky. 2004. Antigua revisited: the impact of climate change on sand and nest temperatures at a hawksbill turtle (*Eretmochelys imbricata*) nesting beach. *Global Change Biology* 10:2036-2045.
- Godfrey, P.J., S.P. Leatherman, and P.A. Buckley. 1978. Impact of off-road vehicles on coastal ecosystems. Pages 581-599 in *Coastal Zone '78 Symposium on Technical, Environmental Socioeconomic and Regulatory Aspects of Coastal Zone Management*. Vol. II, San Francisco, California.
- Godfrey, M.H., R. Barreto, and N. Mrosovsky. 1997. Metabolically-generated heat of developing eggs and its potential effect on sex ratio of sea turtle hatchlings. *Journal of Herpetology* 31(4):616-619.

- Godfrey, M.H. and N. Mrosovsky. 1997. Estimating the time between hatching of sea turtles and their emergence from the nest. *Chelonian Conservation and Biology* 2(4):581-585.
- Gyuris E., 1994. The rate of predation by fishes on hatchlings of the green turtle. *Coral Reefs* 12:137.
- Hailman, J.P. and A.M. Elowson. 1992. Ethogram of the nesting female loggerhead (*Caretta caretta*). *Herpetologica* 48:1-30.
- Hanson, J., T. Wibbels, and R.E. Martin. 1998. Predicted female bias in sex ratios of hatchling loggerhead sea turtles from a Florida nesting beach. *Canadian Journal of Zoology* 76(10):1850-1861.
- Hawkes, L.A., A.C. Broderick, M.H. Godfrey, and B.J. Godley. 2005. Status of nesting loggerhead turtles *Caretta caretta* at Bald Head Island (North Carolina, USA) after 24 years of intensive monitoring and conservation. *Oryx* 39(1):65-72.
- Hawkes, L.A., A.C. Broderick, M.H. Godfrey, and B.J. Godley. 2007. Investigating the potential impacts of climate change on a marine turtle population. *Global Change Biology*. 13:923-932.
- Hays, G.C. 2000. The implications of variable remigration intervals for the assessment of population size in marine turtles. *Journal of Theoretical Biology* 206:221-227.
- Hendrickson, J.R. 1958. The green sea turtle *Chelonia mydas* (Linn.) in Malaya and Sarawak. *Proceedings of the Zoological Society of London* 130:455-535.
- Heppell, S.S. 1998. Application of life-history theory and population model analysis to turtle conservation. *Copeia* 1998(2):367-375.
- Heppell, S.S., L.B. Crowder, and T.R. Menzel. 1999. Life table analysis of long-lived marine species with implications for conservation and management. Pages 137-148 in Musick, J.A. (editor). *Life in the Slow Lane: Ecology and Conservation of Long-lived Marine Animals*. American Fisheries Society Symposium 23, Bethesda, Maryland.
- Heppell, S.S., L.B. Crowder, D.T. Crouse, S.P. Epperly, and N.B. Frazer. 2003. Population models for Atlantic loggerheads: past, present, and future. Pages 225-273 in Bolten, A.B. and B.E. Witherington (editors). *Loggerhead Sea Turtles*. Smithsonian Books, Washington D.C.
- Herren, R.M. 1999. The effect of beach nourishment on loggerhead (*Caretta caretta*) nesting and reproductive success at Sebastian Inlet, Florida. Unpublished Master of Science thesis. University of Central Florida, Orlando, Florida. 138 pages.

- Hoekert, W.E.J., L.H.G. van Tienen, P. van Nugteren, and S. Dench. 1998. The sea turtles of suriname—project comparing relocated nests to undisturbed nests. Pages 192-193 in Byles, R., and Y. Fernandez (compilers). Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-412.
- Hopkins, S.R. and T.M. Murphy. 1980. Reproductive ecology of *Caretta caretta* in South Carolina. South Carolina Wildlife Marine Resources Department Completion Report. 97 pp.
- Hosier, P.E., M. Kochhar, and V. Thayer. 1981. Off-road vehicle and pedestrian track effects on the sea approach of hatchling loggerhead turtles. *Environmental Conservation* 8:158-161.
- Houghton, J.D.R. and G.C. Hays. 2001. Asynchronous emergence by loggerhead turtle (*Caretta caretta*) hatchlings. *Naturwissenschaften* 88:133-136.
- Howard, B. and P. Davis. 1999. Sea turtle nesting activity at Ocean Ridge in Palm Beach County, Florida 1999. Palm Beach County Dept. of Environmental Resources Management, West Palm Beach, Florida. 10 pp.
- Howard, B. and P. Davis. 1999. Sea turtle nesting activity at Ocean Ridge in Palm Beach County, Florida 1999. Palm Beach County Department of Environmental Resources Management, West Palm Beach, Florida.
- Hughes, A.L. and E.A. Caine. 1994. The effects of beach features on hatchling loggerhead sea turtles. in: Proceedings of the 14th Annual Symposium on Sea turtle biology and conservation, March 1-5, 1994, Hilton Head, South Carolina. NOAA, Tech. Memo. NMFS-SEFSC-351.
- Humiston and Moore. 2001. Naples Beach Erosion Control Project 1-Year Post Construction Monitoring Report, prepared for The City of Naples, Florida.
- Intergovernmental Panel on Climate Change. 2007a. Summary for Policymakers. In Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (editors). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom, and New York, New York, USA.
- Intergovernmental Panel on Climate Change. 2007b. Summary for Policymakers. In Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (editors). *Climate Change 2007: Climate Change Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom, and New York, New York, USA.
- Kamezaki, N., Y. Matsuzawa, O. Abe, H. Asakawa, T. Fujii, K. Goto, S. Hagino, M. Hayami, M. Ishii, T. Iwamoto, T. Kamata, H. Kato, J. Kodama, Y. Kondo, I. Miyawaki, K. Mizobuchi, Y. Nakamura, Y. Nakashima, H. Naruse, K. Omuta, M. Samejima, H. Suganuma, H. Takeshita, T. Tanaka, T. Toji, M. Uematsu, A. Yamamoto, T. Yamato, and I. Wakabayashi, 2003.

- Loggerhead turtles nesting in Japan. Pages 210-217 in Bolten, A.B. and B.E. Witherington (editors). *Loggerhead Sea Turtles*. Smithsonian Books, Washington D.C.
- Kaufman, W. and O. Pilkey. 1979. *The Beaches are Moving: The Drowning of America's Shoreline*. Anchor Press/Doubleday, Garden City, New York.
- Komar, P.D. 1983. Coastal erosion in response to the construction of jetties and breakwaters. Pages 191-204 in Komar, P.D. (editor). *CRC Handbook of Coastal Processes and Erosion*. CRC Press. Boca Raton, Florida.
- Kornaraki, E., D.A. Matossian, A.D. Mazaris, Y.G. Matsinos, D. Margaritoulis. 2006. Effectiveness of different conservation measures for loggerhead sea turtle (*Caretta caretta*) nests at Zakynthos Island, Greece. *Biological Conservation* 130:324-330.
- Labisky, R.F., M.A. Mercadante, and W.L. Finger. 1986. Factors affecting reproductive success of sea turtles on Cape Canaveral Air Force Station, Florida, 1985. Final report to the United States Air Force. United States Fish and Wildlife Service Cooperative Fish and Wildlife Research Unit, Agreement Number 14-16-0009-1544, Research Work Order Number 25. 18 pp.
- Leonard, L.A., T.D. Clayton, and O.H. Pilkey. 1990. An analysis of replenished beach design parameters on U.S. East Coast barrier islands. *Journal of Coastal Research* 6(1):15-36.
- Limpus, C.J. 1971. Sea turtle ocean finding behavior. *Search* 2(10):385-387.
- Limpus, C.J. and D.J. Limpus. 2003. Loggerhead turtles in the equatorial and southern Pacific Ocean: a species in decline. Pages 199-209 in Bolten, A.B. and B.E. Witherington (editors). *Loggerhead Sea Turtles*. Smithsonian Books, Washington D.C.
- Limpus, C.J., V. Baker, and J.D. Miller. 1979. Movement induced mortality of loggerhead eggs. *Herpetologica* 35(4):335-338.
- Lohmann, K.J. and C.M.F. Lohmann. 2003. Orientation mechanisms of hatchling loggerheads. Pages 44-62 in Bolten, A.B. and B.E. Witherington (editors). *Loggerhead Sea Turtles*. Smithsonian Books, Washington D.C.
- Lohmann, K. J., Witherington, B. E., Lohmann, C. M. F. and Salmon, M. 1997. Orientation, navigation, and natal beach homing in sea turtles. In *The Biology of Sea Turtles* (ed. P. Lutz and J. Musick), pp. 107-136. Boca Raton: CRC Press.
- Lutcavage, M.E., P. Plotkin, B. Witherington, and P.L. Lutz. 1997. Human impacts on sea turtle survival. Pages 387-409 in Lutz, P.L. and J.A. Musick (editors). *The Biology of Sea Turtles*. CRC Press. Boca Raton, Florida.
- Mann, T.M. 1977. Impact of developed coastline on nesting and hatchling sea turtles in southeastern Florida. M.S. thesis. Florida Atlantic University, Boca Raton, Florida.

- Margaritoulis, D., R. Argano, I. Baran, F. Bentivegna, M.N. Bradai, J.A. Camiñas, P. Casale, G. De Metrio, A. Demetropoulos, G. Gerosa, B.J. Godley, D.A. Haddoud, J. Houghton, L. Laurent, and B. Lazar. 2003. Loggerhead turtles in the Mediterranean Sea: present knowledge and conservation perspectives. Pages 175-198 *in* Bolten, A.B. and B.E. Witherington (editors). *Loggerhead Sea Turtles*. Smithsonian Books, Washington D.C.
- Martin, R.E. 1992. Turtle nest relocation on Jupiter Island, Florida: an evaluation. Presentation to the Fifth Annual National Conference on Beach Preservation Technology, February 12-14, 1992, St. Petersburg, Florida.
- McElroy, M. 2009. The effect of screening and relocation on hatching and emergence success of loggerhead sea turtle nests at Sapelo Island, Georgia. Thesis, University of Georgia, Athens, Georgia, USA.
- McGehee, M.A. 1990. Effects of moisture on eggs and hatchlings of loggerhead sea turtles (*Caretta caretta*). *Herpetologica* 46(3):251-258.
- Meylan, A. 1982. Estimation of population size in sea turtles. Pages 135-138 *in* Bjorndal, K.A. (editor). *Biology and Conservation of Sea Turtles*. Smithsonian Institution Press, Washington, D.C.
- Miller, K., G.C. Packard, and M.J. Packard. 1987. Hydric conditions during incubation influence locomotor performance of hatchling snapping turtles. *Journal of Experimental Biology* 127:401-412.
- Moody, K. 2000. The effects of nest relocation on hatching success and emergence success of the loggerhead turtle (*Caretta caretta*) in Florida. Pages 107-108 *in* Byles, R. and Y. Fernandez (compilers). *Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-412.
- Moran, K.L., K.A. Bjorndal, and A.B. Bolten. 1999. Effects of the thermal environment on the temporal pattern of emergence of hatchling loggerhead turtles *Caretta caretta*. *Marine Ecology Progress Series* 189:251-261.
- Morreale, S.J., G.J. Ruiz, J.R. Spotila, and E.A. Standora. 1982. Temperature-dependent sex determination: Current practices threaten conservation of sea turtles. *Science* 216(4551):1245-1247.
- Mrosovsky, N. 1968. Nocturnal emergence of hatchling sea turtles: control by thermal inhibition of activity. *Nature* 220(5174):1338-1339.
- Mrosovsky, N. 1988. Pivotal temperatures for loggerhead turtles from northern and southern nesting beaches. *Canadian Journal of Zoology* 66:661-669.
- Mrosovsky, N. and A. Carr. 1967. Preference for light of short wavelengths in hatchling green sea turtles (*Chelonia mydas*), tested on their natural nesting beaches. *Behaviour* 28:217-231.

- Mrosovsky, N. and J. Provancha. 1989. Sex ratio of hatchling loggerhead sea turtles: data and estimates from a five year study. *Canadian Journal of Zoology* 70:530-538.
- Mrosovsky, N. and S.J. Shettleworth. 1968. Wavelength preferences and brightness cues in water finding behavior of sea turtles. *Behaviour* 32:211-257.
- Mrosovsky, N. and C.L. Yntema. 1980. Temperature dependence of sexual differentiation in sea turtles: implications for conservation practices. *Biological Conservation* 18:271-280.
- Murphy, T.M. and S.R. Hopkins. 1984. Aerial and ground surveys of marine turtle nesting beaches in the southeast region. Unpublished report prepared for the National Marine Fisheries Service.
- Musick, J.A. 1999. Ecology and conservation of long-lived marine animals. Pages 1-10 in Musick, J.A. (editor). *Life in the Slow Lane: Ecology and Conservation of Long-lived Marine Animals*. American Fisheries Society Symposium 23, Bethesda, Maryland.
- National Marine Fisheries Service (NMFS). 2001. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the Western North Atlantic. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SEFSC-455.
- National Marine Fisheries Service (NMFS). 2009. *Loggerhead Sea Turtles (Caretta caretta)*. National Marine Fisheries Service, Office of Protected Resources. Silver Springs, Maryland. <http://www.nmfs.noaa.gov/pr/species/turtles/loggerhead.htm>
- National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS and USFWS). 1991. Recovery plan for U.S. population of Atlantic green turtle (*Chelonia mydas*). National Marine Fisheries Service, Washington, D.C.
- National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS and USFWS). 1992. Recovery plan for leatherback turtles (*Dermochelys coriacea*) in the U.S. Caribbean, Atlantic, and Gulf of Mexico. National Marine Fisheries Service, Washington, D.C.
- National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS and USFWS). 1993. Recovery plan for hawksbill turtle (*Eretmochelys imbricata*) in the U.S. Caribbean, Atlantic, and Gulf of Mexico. National Marine Fisheries Service, St. Petersburg, Florida.
- National Marine Fisheries Service and U. S. Fish and Wildlife Service (NMFS and USFWS). 2007. Loggerhead sea turtle (*Caretta caretta*) 5-year review: Summary and evaluation. August 65 pp.
- National Marine Fisheries Service and U.S. Fish and Wildlife Service (NMFS and USFWS). 2008. Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (*Caretta caretta*), Second Revision. National Marine Fisheries Service, Silver Spring, MD.

- National Research Council (NRC). 1987. Responding to changes in sea level: Engineering Implications. National Academy Press, Washington, D.C.
- National Research Council (NRC). 1990a. Decline of the sea turtles: causes and prevention. National Academy Press; Washington, D.C.
- National Research Council (NRC). 1990b. Managing coastal erosion. National Academy Press; Washington, D.C.
- National Research Council (NRC). 1995. Beach nourishment and protection. National Academy Press; Washington, D.C.
- Neal, W.J., O.H. Pilkey, and J.T. Kelley. 2007. Atlantic coast beaches: a guide to ripples, dunes, and other natural features of the seashore. Mountain Press Publishing Company, Missoula, Montana. 250 pages.
- Nelson, D.A. 1987. The use of tilling to soften nourished beach sand consistency for nesting sea turtles. Unpublished report of the U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.
- Nelson, D.A. 1988. Life history and environmental requirements of loggerhead turtles. U.S. Fish and Wildlife Service Biological Report 88(23). U.S. Army Corps of Engineers TR EL-86-2 (Rev.).
- Nelson, D.A. and B. Blihovde. 1998. Nesting sea turtle response to beach scarps. Page 113 *in* Byles, R., and Y. Fernandez (compilers). Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-412.
- Nelson, D.A. and D.D. Dickerson. 1987. Correlation of loggerhead turtle nest digging times with beach sand consistency. Abstract of the 7th Annual Workshop on Sea Turtle Conservation and Biology.
- Nelson, D.A. and D.D. Dickerson. 1988a. Effects of beach nourishment on sea turtles. *In* Tait, L.S. (editor). Proceedings of the Beach Preservation Technology Conference '88. Florida Shore & Beach Preservation Association, Inc., Tallahassee, Florida.
- Nelson, D.A. and D.D. Dickerson. 1988b. Hardness of nourished and natural sea turtle nesting beaches on the east coast of Florida. Unpublished report of the U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.
- Nelson, D.A. and D.D. Dickerson. 1988c. Response of nesting sea turtles to tilling of compacted beaches, Jupiter Island, Florida. Unpublished report of the U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

- Nelson, D.A., K. Mauck, and J. Fletemeyer. 1987. Physical effects of beach nourishment on sea turtle nesting, Delray Beach, Florida. Technical Report EL-87-15. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.
- Nielsen, J.T. 2010. Population structure and the mating system of loggerhead turtles (*Caretta caretta*). Open Access Dissertations. Paper 507.
http://scholarlyrepository.miami.edu/oa_dissertations/507
- Packard, M.J. and G.C. Packard. 1986. Effect of water balance on growth and calcium mobilization of embryonic painted turtles (*Chrysemys picta*). *Physiological Zoology* 59(4):398-405.
- Packard, G.C., M.J. Packard, and T.J. Boardman. 1984. Influence of hydration of the environment on the pattern of nitrogen excretion by embryonic snapping turtles (*Chelydra serpentina*). *Journal of Experimental Biology* 108:195-204.
- Packard, G.C., M.J. Packard, and W.H.N. Gutzke. 1985. Influence of hydration of the environment on eggs and embryos of the terrestrial turtle *Terrapene ornata*. *Physiological Zoology* 58(5):564-575.
- Packard, G.C., M.J. Packard, T.J. Boardman, and M.D. Ashen. 1981. Possible adaptive value of water exchange in flexible-shelled eggs of turtles. *Science* 213:471-473.
- Packard G.C., M.J. Packard, K. Miller, and T.J. Boardman. 1988. Effects of temperature and moisture during incubation on carcass composition of hatchling snapping turtles (*Chelydra serpentina*). *Journal of Comparative Physiology B* 158:117-125.
- Parmenter, C.J. 1980. Incubation of the eggs of the green sea turtle, *Chelonia mydas*, in Torres Strait, Australia: the effect of movement on hatchability. *Australian Wildlife Research* 7:487-491.
- Philibosian, R. 1976. Disorientation of hawksbill turtle hatchlings (*Eretmochelys imbricata*) by stadium lights. *Copeia* 1976:824.
- Pilcher, N. J., Enderby, J. S., Stringell, T. and Bateman, L. 2000. Nearshore turtle hatchling distribution and predation. In *Sea Turtles of the Indo-Pacific: Research, Management and Conservation* (ed. N. J. Pilcher and M. G. Ismai), pp.151 -166. New York: Academic Press.
- Pilkey, O.H. and K.L. Dixon. 1996. *The Corps and the shore*. Island Press; Washington, D.C.
- Pilkey, Jr., O.H., D.C. Sharma, H.R. Wanless, L.J. Doyle, O.H. Pilkey, Sr., W. J. Neal, and B.L. Gruver. 1984. *Living with the East Florida Shore*. Duke University Press, Durham, North Carolina.
- Pilkey, O.H. and H.L. Wright III. 1988. Seawalls versus beaches. *Journal of Coastal Research*, Special Issue 4:41-64.

- Pintus, K.J., B.J. Godley, A. McGowan, and A.C. Broderick. 2009. Impact of clutch relocation on green turtle offspring. *Journal of Wildlife Management* 73(7):1151-1157.
- Plant, N.G. and G.B. Griggs. 1992. Interactions between nearshore processes and beach morphology near a seawall. *Journal of Coastal Research* 8(1): 183-200.
- Possardt, E. 2005. Personal communication to Sandy MacPherson, Service.
- Provancha, J.A. and L.M. Ehrhart. 1987. Sea turtle nesting trends at Kennedy Space Center and Cape Canaveral Air Force Station, Florida, and relationships with factors influencing nest site selection. Pages 33-44 *in* Witzell, W.N. (editor). *Ecology of East Florida Sea Turtles: Proceedings of the Cape Canaveral, Florida Sea Turtle Workshop*. NOAA Technical Report NMFS-53.
- Raymond, P.W. 1984. The effects of beach restoration on marine turtles nesting in south Brevard County, Florida. M.S. thesis. University of Central Florida, Orlando, Florida.
- Reina, R.D., P.A. Mayor, J.R. Spotila, R. Piedra, and F.V. Paladino. 2002. Nesting ecology of the leatherback turtle, *Dermochelys coriacea*, at Parque Nacional Marino Las Baulas, Costa Rica: 1988-1989 to 1999-2000. *Copeia* 2002(3):653-664.
- Rice, T.M. 2012a. Inventory of Habitat Modifications to Tidal Inlets in the Continental U.S. Coastal Migration and Wintering Range of the Piping Plover (*Charadrius melodus*). Appendix 1b *in* Comprehensive Conservation Strategy for the Piping Plover (*Charadrius melodus*) in its Coastal Migration and Wintering Range in the Continental United States, U.S. Fish and Wildlife Service, East Lansing, Michigan.
- Rice, T.M. 2012b. The Status of Sandy, Oceanfront Beach Habitat in the Continental U.S. Coastal Migration and Wintering Range of the Piping Plover (*Charadrius melodus*). Appendix 1c *in* Comprehensive Conservation Strategy for the Piping Plover (*Charadrius melodus*) in its Coastal Migration and Wintering Range in the Continental United States, U.S. Fish and Wildlife Service, East Lansing, Michigan.
- Richardson, T.H., J.I. Richardson, C. Ruckdeschel, and M.W. Dix. 1978. Remigration patterns of loggerhead sea turtles (*Caretta caretta*) nesting on Little Cumberland Island and Cumberland Island, Georgia. Pages 39-44 *in* Henderson, G.E. (editor). *Proceedings of the Florida and Interregional Conference on Sea Turtles*. Florida Marine Research Publications Number 33.
- Ross, J.P. 1979. Sea turtles in the Sultanate of Oman. World Wildlife Fund Project 1320. May 1979 report.
- Ross, J.P. 1982. Historical decline of loggerhead, ridley, and leatherback sea turtles. Pages 189-195 *in* Bjorndal, K.A. (editor). *Biology and Conservation of Sea Turtles*. Smithsonian Institution Press; Washington, D.C.

- Routa, R.A. 1968. Sea turtle nest survey of Hutchinson Island, Florida. *Quarterly Journal of the Florida Academy of Sciences* 30(4):287-294.
- Rumbold, D.G., P.W. Davis, and C. Perretta. 2001. Estimating the effect of beach nourishment on *Caretta caretta* (loggerhead sea turtle) nesting. *Restoration Ecology* 9(3):304-310.
- Salmon, M. and J. Wyneken. 1987. Orientation and swimming behavior of hatchling loggerhead turtles *Caretta caretta* L. during their offshore migration. *J. Exp. Mar. Biol. Ecol.* 109: 137–153.
- Salmon, M., J. Wyneken, E. Fritz, and M. Lucas. 1992. Seafinding by hatchling sea turtles: role of brightness, silhouette and beach slope as orientation cues. *Behaviour* 122 (1-2):56-77.
- Schroeder, B.A. 1981. Predation and nest success in two species of marine turtles (*Caretta caretta* and *Chelonia mydas*) at Merritt Island, Florida. *Florida Scientist* 44(1):35.
- Schroeder, B.A. 1994. Florida index nesting beach surveys: are we on the right track? Pages 132-133 in Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar (compilers). *Proceedings of the 14th Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-351.
- Schroeder, B.A. and A.E. Mosier. 1996. Between a rock and a hard place: coastal armoring and marine turtle nesting habitat in Florida. *Proceedings of the 18th International Sea Turtle Symposium (Supplement, 16th Annual Sea Turtle Symposium Addendum)*. NOAA Technical Memorandum.
- Schroeder, B.A., A.M. Foley, and D.A. Bagley. 2003. Nesting patterns, reproductive migrations, and adult foraging areas of loggerhead turtles. Pages 114-124 in Bolten, A.B. and B.E. Witherington (editors). *Loggerhead Sea Turtles*. Smithsonian Books, Washington D.C.
- Scott, J.A. 2006. Use of satellite telemetry to determine ecology and management of loggerhead turtle (*Caretta caretta*) during the nesting season in Georgia. Unpublished Master of Science thesis. University of Georgia, Athens, Georgia. 165 pages.
- South Carolina Department of Health and Environmental Control (SCDHEC). 2010. Adapting to shoreline change: A foundation for improved management and planning in South Carolina. Final report of the Shoreline Change Advisory Committee. 192 p.
- Snover, M. 2005. Personal communication to the Loggerhead Sea Turtle Recovery Team. National Marine Fisheries Service.

- Sobel, D. 2002. A photographic documentation of aborted nesting attempts due to lounge chairs. Page 311 in Mosier, A., A. Foley, and B. Brost (compilers). Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-477.
- Solow, A.R., K.A. Bjorndal, and A.B. Bolten. 2002. Annual variation in nesting numbers of marine turtles: the effect of sea surface temperature on re-migration intervals. Ecology Letters 5:742-746.
- Spotila, J.R., E.A. Standora, S.J. Morreale, G.J. Ruiz, and C. Puccia. 1983. Methodology for the study of temperature related phenomena affecting sea turtle eggs. U.S. Fish and Wildlife Service Endangered Species Report 11.
- Stancyk, S.E. 1995. Non-human predators of sea turtles and their control. Pages 139-152 in Bjorndal, K.A. (editor). Biology and Conservation of Sea Turtles, Revised Edition. Smithsonian Institution Press. Washington, D.C.
- Stancyk, S.E., O.R. Talbert, and J.M. Dean. 1980. Nesting activity of the loggerhead turtle *Caretta caretta* in South Carolina, II: protection of nests from raccoon predation by transplantation. Biological Conservation 18:289-298.
- Steinitz, M.J., M. Salmon, and J. Wyneken. 1998. Beach renourishment and loggerhead turtle reproduction: a seven year study at Jupiter Island, Florida. Journal of Coastal Research 14(3):1000-1013.
- Sternberg, J. 1981. The worldwide distribution of sea turtle nesting beaches. Center for Environmental Education, Washington, D.C., USA.
- Stewart, K.R. and J. Wyneken. 2004. Predation risk to loggerhead hatchlings at a high-density nesting beach in Southeast Florida. Bulletin of Marine Science 74(2):325-335.
- Tait, J.F. and G.B. Griggs. 1990. Beach response to the presence of a seawall. Shore and Beach, April 1990:11-28.
- Talbert, O.R., Jr., S.E. Stancyk, J.M. Dean, and J.M. Will. 1980. Nesting activity of the loggerhead turtle (*Caretta caretta*) in South Carolina I: a rookery in transition. Copeia 1980(4):709-718.
- Terchunian, A.V. 1988. ITPTing coastal armoring structures: can seawalls and beaches coexist? Journal of Coastal Research, Special Issue 4:65-75.
- Trindell, R. 2005. Sea turtles and beach nourishment. Florida Fish and Wildlife Conservation Commission, Imperiled Species Management Section. Invited Instructor, CLE Conference.

- Trindell, R. 2007. Personal communication. Summary of lighting impacts on Brevard County beaches after beach nourishment. Florida Fish and Wildlife Conservation Commission, Imperiled Species Management Section, Tallahassee, Florida to Lorna Patrick, U. S. Fish and Wildlife Service, Panama City, Florida.
- Trindell, R., D. Arnold, K. Moody, and B. Morford. 1998. Post-construction marine turtle nesting monitoring results on nourished beaches. Pages 77-92 in Tait, L.S. (compiler). Proceedings of the 1998 Annual National Conference on Beach Preservation Technology. Florida Shore & Beach Preservation Association, Tallahassee, Florida.
- Turtle Expert Working Group (TEWG). 2009. An assessment of the loggerhead turtle population in the Western North Atlantic Ocean. NOAA Technical Memorandum NMFS-SEFSC-575.
- Tuttle, J.A. 2007. Loggerhead sea turtle (*Caretta caretta*) nesting on a Georgia barrier island: effects of nest relocation. Thesis, Georgia Southern University, Statesboro, Georgia, USA.
- Tuttle, J.A. and D. Rostal. 2010. Effects of nest relocation on nest temperature and embryonic development of loggerhead sea turtles (*Caretta caretta*). Chelonian Conservation and Biology 9:1-7.
- U.S. Fish and Wildlife Service (USFWS). 2006. Strategic Habitat Conservation. Final Report of the National Ecological Assessment Team to the U.S. Fish and Wildlife Service and U.S. Geologic Survey.
- U.S. Fish and Wildlife Service (USFWS). 2007. Draft communications plan on the U.S. Fish and Wildlife Service's Role in Climate Change.
- Weishampel, J.F., D.A. Bagley, and L.M. Ehrhart. 2006. Intra-annual loggerhead and green turtle spatial nesting patterns. Southeastern Naturalist 5(3):453-462.
- Whelan, C.L. and J. Wyneken. 2007. Estimating predation levels and site-specific survival of hatchling loggerhead sea turtles (*Caretta caretta*) from south Florida beaches. Copeia (3):745-754.
- Williams-Walls, N., J. O'Hara, R.M. Gallagher, D.F. Worth, B.D. Peery, and J.R. Wilcox. 1983. Spatial and temporal trends of sea turtle nesting on Hutchinson Island, Florida, 1971-1979. Bulletin of Marine Science 33(1):55-66.
- Witherington, B.E. 1986. Human and natural causes of marine turtle clutch and hatchling mortality and their relationship to hatching production on an important Florida nesting beach. Unpublished M.S. thesis. University of Central Florida, Orlando, Florida.
- Witherington, B. E. 1991. Orientation of hatchling loggerhead turtles at sea off artificially lighted and dark beaches. Journal of Experimental Marine Biology and Ecology. 149:1-11.

- Witherington, B.E. 1992. Behavioral responses of nesting sea turtles to artificial lighting. *Herpetologica* 48:31-39.
- Witherington, B.E. 1997. The problem of photopollution for sea turtles and other nocturnal animals. Pages 303-328 in Clemmons, J.R. and R. Buchholz (editors). *Behavioral Approaches to Conservation in the Wild*. Cambridge University Press, Cambridge, United Kingdom.
- Witherington, B.E. 2006. Personal communication to Loggerhead Recovery Team on nest monitoring in Florida during 2005. Florida Fish and Wildlife Research Institute.
- Witherington, B.E., K.A. Bjorndal, and C.M. McCabe. 1990. Temporal pattern of nocturnal emergence of loggerhead turtle hatchlings from natural nests. *Copeia* 1990(4):1165-1168.
- Witherington, B.E. and K.A. Bjorndal. 1991. Influences of artificial lighting on the seaward orientation of hatchling loggerhead turtles (*Caretta caretta*). *Biological Conservation* 55:139-149.
- Witherington, B.E. and M. Salmon. 1992. Predation on loggerhead turtle hatchlings after entering the sea. *Journal of Herpetology*. 26(2):226-228.
- Witherington, B.E. and R.E. Martin. 1996. Understanding, assessing, and resolving light pollution problems on sea turtle nesting beaches. Florida Marine Research Institute Technical Report TR-2. 73 pp.
- Witherington, B.E., L. Lucas, and C. Koepfel. 2005. Nesting sea turtles respond to the effects of ocean inlets. Pages 355-356 in Coyne, M.S. and R.D. Clark (compilers). *Proceedings of the Twenty-first Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-528.
- Witherington, B., P. Kubilis, B. Brost, and A. Meylan. 2009. Decreasing annual nest counts in a globally important loggerhead sea turtle population. *Ecological Applications* 19:30-54.
- Wood, D.W. and K.A. Bjorndal. 2000. Relation of temperature, moisture, salinity, and slope to nest site selection in loggerhead sea turtles. *Copeia* 2000(1):119-128.
- Wyneken, J. 2000. The migratory behavior of hatchling sea turtles beyond the beach. Pages 121-142 in N.J. Pilcher and G. Ismail, eds. *Sea turtles of the Indo-Pacific*. ASEAN Academic Press, London.
- Wyneken, J. and M. Salmon. 1996. Aquatic predation, fish densities, and potential threats to sea turtle hatchlings from open-beach hatcheries: final report. Technical Report 96-04, Florida Atlantic University, Boca Raton, Florida.
- Wyneken, J., T.J. Burke, M. Salmon, and D.K. Pedersen. 1988. Egg failure in natural and relocated sea turtle nests. *Journal of Herpetology* 22(1):88-96.

Wyneken, J., Salmon, M. and K. J. Lohmann. 1990. Orientation by hatchling loggerhead sea turtles *Caretta caretta* in a wave tank. *Journal of Experimental Marine Biology and Ecology* 139:43–50.

Wyneken, J., L. DeCarlo, L. Glenn, M. Salmon, D. Davidson, S. Weege., and L. Fisher. 1998. On the consequences of timing, location and fish for hatchlings leaving open beach hatcheries. Pages 155-156 *in* Byles, R. and Y. Fernandez (compilers). *Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-412.

Wyneken, J., L.B. Crowder, and S. Epperly. 2005. Final report: evaluating multiple stressors in loggerhead sea turtles: developing a two-sex spatially explicit model. Final Report to the U.S. Environmental Protection Agency National Center for Environmental Research, Washington, DC. EPA Grant Number: R829094.

Zurita, J.C., R. Herrera, A. Arenas, M.E. Torres, C. Calderón, L. Gómez, J.C. Alvarado, and R. Villavicencio. 2003. Nesting loggerhead and green sea turtles in Quintana Roo, Mexico. Pages 125-127 *in* Seminoff, J.A. (compiler). *Proceedings of the Twenty-second Annual Symposium on Sea Turtle Biology and Conservation*. NOAA Technical Memorandum NMFS-SEFSC-503.

APPENDIX A: Standard Manatee Construction Conditions

To reduce potential construction-related impacts to the manatee to discountable and insignificant levels, the Service recommends implementing the *Standard Manatee Construction Conditions* (FWC 2011), which are as follows:

The permittee will comply with the following manatee protection construction conditions:

- a. The permittee will instruct all personnel associated with the project of the potential presence of manatees and the need to avoid collisions with manatees. All construction personnel are responsible for observing water-related activities for the presence of manatee(s).
- b. The permittee will advise all construction personnel that there are civil and criminal penalties for harming, harassing, or killing manatees, which are protected under the Marine Mammal Protection Act of 1972, the Endangered Species Act of 1973, and the Florida Manatee Sanctuary Act.
- c. Siltation barriers must be made of material in which manatees cannot become entangled, are properly secured, and are regularly monitored to avoid manatee entrapment. Barriers must not block manatee entry to or exit from essential habitat.
- d. All vessels associated with the construction project must operate at “no wake/idle” speeds at all times while in the construction area and while in water where the draft of the vessel provides less than a four-foot clearance from the bottom. All vessels will follow routes of deep water whenever possible.
- e. If manatee(s) are seen within 100 yards of the active daily construction/dredging operation or vessel movement, all appropriate precautions must be implemented to ensure protection of the manatee. These precautions must include the operation of all moving equipment no closer than 50 feet to a manatee. Operation of any equipment closer than 50 feet to a manatee will necessitate immediate shutdown of that equipment. Activities will not resume until the manatee(s) has departed the project area of its own volition.
- f. Any collision with and/or injury to a manatee must be reported immediately to the SCDNR Hotline at 1-800-922-5431. Collision and/or injury should also be reported to the U.S. Fish and Wildlife Service (843-727-4707).

APPENDIX B

ASSESSMENTS: DISCERNING PROBLEMS CAUSED BY ARTIFICIAL LIGHTING

EXCERPT FROM:

UNDERSTANDING, ASSESSING, AND RESOLVING LIGHT-POLLUTION PROBLEMS ON SEA TURTLE
NESTING BEACHES
FLORIDA WILDLIFE RESEARCH INSTITUTE TECHNICAL REPORT TR-2
REVISED 2003

LIGHTING INSPECTIONS

WHAT ARE LIGHTING INSPECTIONS?

During a lighting inspection, a complete census is made of the number, types, locations, and custodians of artificial light sources that emit light visible from the beach. The goal of lighting inspections is to locate lighting problems and to identify the property owner, manager, caretaker, or tenant who can modify the lighting or turn it off.

WHICH LIGHTS CAUSE PROBLEMS?

Although the attributes that can make a light source harmful to sea turtles are complex, a simple rule has proven to be useful in identifying problem lighting under a variety of conditions:

An artificial light source is likely to cause problems for sea turtles if light from the source can be seen by an observer standing anywhere on the nesting beach.

If light can be seen by an observer on the beach, then the light is reaching the beach and can affect sea turtles. If any glowing portion of a luminaire (including the lamp, globe, or reflector) is directly visible from the beach, then this source is likely to be a problem for sea turtles. But light may also reach the beach indirectly by reflecting off buildings or trees that are visible from the beach. Bright or numerous sources, especially those directed upward, will illuminate sea mist and low clouds, creating a distinct glow visible from the beach. This “urban skyglow” is common over brightly lighted areas. Although some indirect lighting may be perceived as nonpoint-source light pollution, contributing light sources can be readily identified and include sources that are poorly directed or are directed upward. Indirect lighting can originate far from the beach.

Although most of the light that sea turtles can detect can also be seen by humans, observers should realize that some sources, particularly those emitting near-ultraviolet and violet light (e.g., bug-zapper lights, white electric-discharge lighting) will appear brighter to sea turtles than to humans. A human is also considerably taller than a hatchling; however, an observer on the dry beach who crouches to the level of a hatchling may miss some lighting that will affect turtles. Because of the way that some lights are partially hidden by the dune, a standing observer is more likely to see light that is visible to hatchlings and nesting turtles in the swash zone.

HOW SHOULD LIGHTING INSPECTIONS BE CONDUCTED?

Lighting inspections to identify problem light sources may be conducted either under the purview of a lighting ordinance or independently. In either case, goals and methods should be similar.

GATHER BACKGROUND INFORMATION

Before walking the beach in search of lighting, it is important to identify the boundaries of the area to be inspected. For inspections that are part of lighting ordinance enforcement efforts, the jurisdictional boundaries of the sponsoring local government should be determined. It will help

to have a list that includes the name, owner, and address of each property within inspection area so that custodians of problem lighting can be identified. Plat maps or aerial photographs will help surveyors orient themselves on heavily developed beaches.

PRELIMINARY DAYTIME INSPECTIONS

An advantage to conducting lighting inspections during the day is that surveyors will be better able to judge their exact location than they would be able to at night. Preliminary daytime inspections are especially important on beaches that have restricted access at night. Property owners are also more likely to be available during the day than at night to discuss strategies for dealing with problem lighting at their sites.

A disadvantage to daytime inspections is that fixtures that are not directly visible from the beach will be difficult to identify as problems. Moreover, some light sources that can be seen from the beach in daylight may be kept off at night and thus present no problems. For these reasons, daytime inspections are not a substitute for nighttime inspections. Descriptions of light sources identified during daytime inspections should be detailed enough so that anyone can locate the lighting. In addition to a general description of each luminaire (e.g., HPS floodlight directed seaward at top northeast corner of the building at 123 Ocean Street), photographs or sketches of the lighting may be necessary. Descriptions should also include an assessment of how the specific lighting problem can be resolved (e.g., needs turning off; should be redirected 90° to the east). These detailed descriptions will show property owners exactly which luminaires need what remedy.

NIGHTTIME INSPECTIONS

Surveyors orienting themselves on the beach at night will benefit from notes made during daytime surveys. During nighttime lighting inspections, a surveyor walks the length of the nesting beach looking for light from artificial sources. There are two general categories of artificial lighting that observers are likely to detect:

1. **Direct lighting.** A luminaire is considered to be direct lighting if some glowing element of the luminaire (e.g., the globe, lamp [bulb], reflector) is visible to an observer on the beach. A source not visible from one location may be visible from another farther down the beach. When direct lighting is observed, notes should be made of the number, lamp type (discernable by color), style of fixture, mounting (pole, porch, *etc.*), and location (street address, apartment number, or pole identification number) of the luminaire(s). If exact locations of problem sources were not determined during preliminary daytime surveys, this should be done during daylight soon after the nighttime survey. Photographing light sources (using long exposure times) is often helpful.
2. **Indirect lighting.** A luminaire is considered to be indirect lighting if it is not visible from the beach but illuminates an object (e.g., building, wall, tree) that is visible from the beach. Any object on the dune that appears to glow is probably being lighted by an indirect source. When possible, notes should be made of the number, lamp type, fixture style, and mounting of an indirect-lighting source. Minimally, notes should be taken that would allow a surveyor to find the

lighting during a follow-up daytime inspection (for instance, which building wall is illuminated and from what angle?).

WHEN SHOULD LIGHTING INSPECTIONS BE CONDUCTED?

Because problem lighting will be most visible on the darkest nights, lighting inspections are ideally conducted when there is no moon visible. Except for a few nights near the time of the full moon, each night of the month has periods when there is no moon visible. Early-evening lighting inspections (probably the time of night most convenient for inspectors) are best conducted during the period of two to 14 days following the full moon. Although most lighting problems will be visible on moonlit nights, some problems, especially those involving indirect lighting, will be difficult to detect on bright nights.

A set of daytime and nighttime lighting inspections before the nesting season and a minimum of three additional nighttime inspections during the nesting-hatching season are recommended. The first set of day and night inspections should take place just before nesting begins. The hope is that managers, tenants, and owners made aware of lighting problems will alter or replace lights before they can affect sea turtles. A follow-up nighttime lighting inspection should be made approximately two weeks after the first inspection so that remaining problems can be identified. During the nesting-hatching season, lighting problems that seemed to have been remedied may reappear because owners have been forgetful or because ownership has changed. For this reason, two midseason lighting inspections are recommended. The first of these should take place approximately two months after the beginning of the nesting season, which is about when hatchlings begin to emerge from nests. To verify that lighting problems have been resolved, another follow-up inspection should be conducted approximately one week after the first midseason inspection.

WHO SHOULD CONDUCT LIGHTING INSPECTIONS?

Although no specific authority is required to conduct lighting inspections, property managers, tenants, and owners are more likely to be receptive if the individual making recommendations represent a recognized conservation group, research consultant, or government agency. When local ordinances regulate beach lighting, local government code-enforcement agents should conduct lighting inspections and contact the public about resolving problems.

WHAT SHOULD BE DONE WITH INFORMATION FROM LIGHTING INSPECTIONS?

Although lighting surveys serve as a way for conservationists to assess the extent of lighting problems on a particular nesting beach, the principal goal of those conducting lighting inspections should be to ensure that lighting problems are resolved. To resolve lighting problems, property managers, tenants, and owners should be give the information they need to make proper alterations to light sources. This information should include details on the location and description of problem lights, as well as on how the lighting problem can be solved. One should also be prepared to discuss the details of how lighting affects sea turtles. Understanding the nature of the problem will motivate people more than simply being told what to do.

APPENDIX C

EXAMPLES OF PREDATOR PROOF TRASH RECEPTACLES



Example of predator proof trash receptacle at Gulf Islands National Seashore. Lid must be tight fitting and made of material heavy enough to stop animals such as raccoons.



Example of trash receptacle anchored into the ground so it is not easily turned over.



Example of predator proof trash receptacle at Perdido Key State Park. Metal trash can is stored inside. Cover must be tight fitting and made of material heavy enough to stop animals such as raccoons.