**United States Department of the Interior**

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

April 1, 2014

Henry Wicker
U.S. Army Corps of Engineers
69 Darlington Avenue
Wilmington, North Carolina 28403

Dear Mr. Wicker:

This document transmits the U.S. Fish and Wildlife Service's (Service) Biological Opinion based on our review of the proposed NC 12 Emergency Beach Nourishment Project in Dare County, North Carolina and its effects on the federally endangered leatherback sea turtle (*Dermochelys coriacea*), federally endangered Kemp's ridley sea turtle (*Lepidochelys kempii*), federally threatened Northwest Atlantic population of loggerhead sea turtle (*Caretta caretta*), and federally threatened green sea turtle (*Chelonia mydas*). This Biological Opinion is provided in accordance with Section 7(a)(2) of the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 *et seq*.). Your February 28, 2014 request for formal consultation was received on February 28, 2014.

If you have any questions concerning this Biological Opinion, please contact me at (919) 856-4520 (Ext. 11).

Sincerely,

Pete Benjamin
Field Supervisor

Electronic copy:

Bill Biddlecome, USACE, Washington, NC
Kathy Herring, NCDOT, Raleigh, NC
Neil Medlin, NCDOT, Raleigh, NC
Clay Willis, NCDOT, Edenton, NC
Mike Bryant, USFWS, Manteo, NC

Scott Lanier, USFWS, Manteo, NC
Dennis Stewart, USFWS, Manteo, NC
AnnMarie Lauritsen, USFWS, Saint Petersburg, FL
Jerry Ziewitz, USFWS, Tallahassee, FL
Thayer Broili, NPS, Manteo, NC
Fritz Rhode, NMFS, Beaufort, NC
Travis Wilson, NCWRC, Creedmoor, NC
Matthew Godfrey, NCWRC, Beaufort, NC
Cathy Brittingham, NCDCM, Raleigh, NC
David Wainwright, NCDWR, Raleigh, NC

This Biological Opinion (BO) is based on information provided in the Updated March 2014 Biological Assessment (BA), meetings, telephone conversations, emails, field investigations, and other sources of information. A complete administrative record of this consultation is on file at this office.

## CONSULTATION HISTORY

February 14, 2013 – The U.S. Army Corps of Engineers (USACE) and the North Carolina Department of Transportation (NCDOT) met with the Service and other agencies to discuss the need for the proposed project. The Service provided information on the need for formal Section 7 consultation.

May 7-8, 2013 – The USACE and NCDOT again met with the Service and other agencies to discuss regulatory requirements for the project.

January 16, 2014 – NCDOT meets with Service to discuss Section 7 consultation for the project.

February 4, 2014 – The Service provides comments on a draft BA to NCDOT.

February 6, 2014 – The Service provides comments on a revised draft BA to NCDOT.

February 28, 2014 – The Service received a letter from the USACE, dated February 28, 2014, with the attached BA, requesting formal consultation for the NC 12 Emergency Beach Nourishment Project.

March 5, 2014 – The Service sent a letter to USACE stating that all information required for initiation of formal consultation was either included with their February 28, 2014 letter or was otherwise available.

March 13, 2014 – The Service provided USACE and NCDOT with a draft BO.

March 31, 2014 – The Service received a revised BA from the USACE, dated March 2014.

# BIOLOGICAL OPINION

## I. DESCRIPTION OF PROPOSED ACTION

On October 28, 2012, Hurricane Sandy impacted the North Carolina coast in the Outer Banks. The storm caused severe beach erosion, dune loss, and damage to NC 12. After repairing NC 12, the NCDOT installed protective sandbags and reconstructed a dune adjacent to the highway. Despite these protective measures, NC 12 is still vulnerable to ocean overwash during storms and high tides. Although Phase IIb of the NC 12 Transportation Management Plan will ultimately place NC 12 on a bridge in this area (previously addressed in a July 10, 2008 BO), the

NCDOT proposes a one-time temporary beach nourishment project in order to protect NC 12 for approximately three years until the permanent project is completed.

The area of beach fill will be approximately 12,000 feet long along the eastern side of NC 12. The area of beach fill will consist of four zones. Beginning at the northern end, there will be a 2,000 feet long transition area. South of this transition area will be a 2,000 feet long zone with a 100 feet wide berm and a reconstructed dune. South of this zone is a 6,000 feet long zone with a 120 feet wide berm. The southernmost zone will be another 2,000 feet long transition zone (see Figure 1).

The estimated volume of sand to be placed on the beach is 1.7 million cubic yards. The sand will be obtained by ocean dredging from offshore borrow sources within the Wimble Shoals area (see Figure 2). The sand sources have been identified and sampled for compatibility with the receiving beach. The material placed on the beach will be in compliance with sand suitability standards as specified in the terms and conditions of Pea Island National Wildlife Refuge (PINWR) Special Use Permit # 2013-005.

A pipeline and/or hopper dredge will be utilized to place the sand within the 12,000 feet long project area. Heavy equipment will then move the sand on the beach and create the designed beach profile. Equipment typically used in this operation will likely include an ocean dredge, barges, pipelines, pumps, bulldozers, front end loaders, and excavators. The equipment will be moored offshore of the project area and staged on land at approved sites. The location of equipment will be coordinated with the staff of the PINWR and the village of Rodanthe.

The sand will be placed on the beach so as to maximize sand placement on the beach face and reduce runoff from the slurry. At the south end of the project within the Mirlo Beach community, sand will not be placed under any private homes or structures. The nourished beach profile will remain seaward of any private residence. All work will be conducted 24 hours per day, seven days a week. The project is estimated to take 60-90 days to complete.

**Action Area**

The action area lies within the North Carolina Outer Banks and is comprised of a dynamic barrier island system formed by wind and wave action. The barrier islands that make up the Outer Banks are sand ridges with underlying layers of limestone, sand, and clay. The action area begins within the PINWR approximately 1.5 miles north of the southern PINWR boundary and extends south from that point approximately 2.27 miles, ending within the community of Mirlo Beach in Rodanthe (see Figure 1). For the purposes of this BO, the action area includes all of the beach up to and including NC 12 within the 12,000 beach nourishment area. Most of the action area is within the PINWR. Though mostly undeveloped, the portion of the action area within PINWR consists of natural vegetation communities that have been influenced by past and present human disturbances. The construction and maintenance of an artificial sand berm along the seaward side of NC 12 has significantly interrupted the natural barrier island ecosystem processes (e.g. limiting overwash and disrupting island migration). The southernmost portion of the action area consists of the community of Mirlo Beach, which is an area lacking any dunes and with private residences located between NC 12 and the Atlantic Ocean.

For the purposes of this BO, the sand borrow area within Wimble Shoals and the ocean between the borrow area and the nourishment area are not considered part of the action area. The USACE and/or NCDOT will consult separately with the National Marine Fisheries Service (NMFS) for federally listed species that utilize these areas.

**Conservation Measures**

Conservation measures represent actions, pledged in the project description, that the action agency will implement to minimize the effects of the proposed action and further the recovery of the species under review. Such measures should be closely related to the action and should be achievable within the authority of the action agency. Since conservation measures are part of the proposed action, their implementation is required under the terms of the consultation. The USACE and NCDOT have proposed the following conservation measures.

- A dredge pipeline route will be selected that avoids nesting shorebird areas.
- Compatible beach sand will be utilized and compaction limited so as to maintain appropriate habitat for swash zone invertebrates, thereby maintaining a food source for shorebirds.
- The project area will be monitored daily from mid-April through June for shorebird site selection and nesting behavior.
- NCDOT will coordinate with the Service and the North Carolina Wildlife Resources Commission (NCWRC) regarding any observations of protected shorebird species within the project area and take necessary actions to avoid any potential negative impact to these species.
- Beginning May 1, NCDOT will establish a turtle monitoring program in the action area to ensure that the area to receive sediment is clear of incubating sea turtle nests. Monitors will survey the beach every morning at sunrise from May through September to look for nesting activity. If nesting activity is detected (false crawl or nest), the monitor will contact either the PINWR biologist or the National Park Service (NPS) biologist, depending on the activity location. After the PINWR and the NPS begin their monitoring programs in late May, the NCDOT will only monitor the part of the action area located outside the PINWR that is not monitored by the NPS or their volunteers.
- Only sand that is determined by the PINWR manager to be comparable to native beach sand will be placed on the project area.
- During and after construction, the beach will be measured for compaction. If there is extreme compaction that would limit the ability of sea turtles to successfully construct a nest cavity, tilling of the disposal material would occur if specified by the PINWR Refuge Manager (if located on the refuge).
- Any work on the beach at night will be done with directional LED lights with a predominant wavelength of about 650nm. Amber colored construction lights are preferred. Lighting on the beach shall be minimized to only what is necessary for safe operations. If bulldozers and

other equipment are used on the beach at night without the proper LED lights, they will operate under the acceptable lights without the traditional lights.

- If nourishment activity occurs on the beach during the nesting season, nighttime monitors will be utilized to detect any turtles that may attempt to nest on the project area beach.
- NCDOT will work with the PINWR biologist to implement any necessary modifications to the current physical and biological sand monitoring project on Pea Island.

## II. STATUS OF THE SPECIES/CRITICAL HABITAT

### A. Species/critical habitat description

#### Northwest Atlantic Ocean population of loggerhead sea turtle

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 DPS – 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 DPS – 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 2009a). 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 ship wrecks 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 United

States 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).

On March 25, 2013, the Service proposed to designate critical habitat for the Northwest Atlantic Ocean Distinct Population Segment of the loggerhead sea turtle (78 FR 18000). In total, 1,189.9 kilometers (739.3 miles) of loggerhead sea turtle nesting beaches have been proposed for designation as critical habitat in the states of North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi. The final rule is expected to be published in June 2014.

**Green sea turtle**

The green sea turtle was federally listed on July 28, 1978 (43 FR 32800). Breeding populations of the green sea turtle in Florida and along the Pacific Coast of Mexico are listed as endangered; all other populations are listed as threatened. The green sea turtle has a worldwide distribution in tropical and subtropical waters.

The green sea turtle grows to a maximum size of about 4 feet and a weight of 440 pounds. It has a heart-shaped shell, small head, and single-clawed flippers. The carapace is smooth and colored gray, green, brown, and black. Hatchlings are black on top and white on the bottom (NMFS 2009b). Hatchling green turtles eat a variety of plants and animals, but adults feed almost exclusively on seagrasses and marine algae.

Major green sea turtle nesting colonies in the Atlantic occur on Ascension Island, Aves Island, Costa Rica, and Surinam. Within the U.S., green sea turtles nest in small numbers in the U.S. Virgin Islands and Puerto Rico, and in larger numbers along the east coast of Florida, particularly in Brevard, Indian River, St. Lucie, Martin, Palm Beach, and Broward Counties (NMFS and USFWS 1991). Nests have been documented, in smaller numbers, north of these Counties, from Volusia through Nassau Counties in Florida, as well as in Georgia, South Carolina, North Carolina, and as far north as Delaware in 2011. Nests have been documented in smaller numbers south of Broward County in Miami-Dade. Nesting also has been documented along the Gulf coast of Florida from Escambia County through Franklin County in northwest Florida and from Pinellas County through Monroe County in southwest Florida (FWC/FWRI 2010b).

Green sea turtles are generally found in fairly shallow waters (except when migrating) inside reefs, bays, and inlets. The green turtle is attracted to lagoons and shoals with an abundance of marine grass and algae. Open beaches with a sloping platform and minimal disturbance are required for nesting.

Critical habitat for the green sea turtle has been designated for the waters surrounding Culebra Island, Puerto Rico, and its outlying keys.

## Leatherback sea turtle

The leatherback sea turtle was federally listed as an endangered species on June 2, 1970 (35 FR 8491). Leatherbacks have the widest distribution of the sea turtles with nonbreeding animals recorded as far north as the British Isles and the Maritime Provinces of Canada and as far south as Argentina and the Cape of Good Hope (Pritchard 1992). Foraging leatherback excursions have been documented into higher-latitude subpolar waters. They have physiological and anatomical adaptations that allow them to exploit waters far colder than any other sea turtle species would be capable of surviving (Frair *et al.* 1972, Greer *et al.* 1973).

The adult leatherback can reach 4 to 8 feet in length and weigh 500 to 2,000 pounds. The carapace is distinguished by a rubber-like texture, about 1.6 inches thick, made primarily of tough, oil-saturated connective tissue. Hatchlings are dorsally mostly black and are covered with tiny scales; the flippers are edged in white, and rows of white scales appear as stripes along the length of the back (NMFS 2009c). Jellyfish are the main staple of its diet, but it is also known to feed on sea urchins, squid, crustaceans, tunicates, fish, blue-green algae, and floating seaweed. This is the largest, deepest diving of all sea turtle species.

Leatherback turtle nesting grounds are distributed worldwide in the Atlantic, Pacific, and Indian Oceans on beaches in the tropics and subtropics. The Pacific Coast of Mexico historically supported the world's largest known concentration of nesting leatherbacks.

The leatherback turtle regularly nests in the U.S. Caribbean in Puerto Rico and the U.S. Virgin Islands. Along the U.S. Atlantic coast, most nesting occurs in Florida (NMFS and USFWS 1992). Leatherback nesting has also been reported on the northwest coast of Florida (LeBuff 1990, FWC 2009a); and in southwest Florida a false crawl (nonnesting emergence) has been observed on Sanibel Island (LeBuff 1990). Nesting has also been reported in Georgia, South Carolina, and North Carolina (Rabon *et al.* 2003) and in Texas (Shaver 2008).

Adult females require sandy nesting beaches backed with vegetation and sloped sufficiently so the distance to dry sand is limited. Their preferred beaches have proximity to deep water and generally rough seas.

Marine and terrestrial critical habitat for the leatherback sea turtle has been designated at Sandy Point on the western end of the island of St. Croix, U.S. Virgin Islands (50 Code of Federal Regulations (CFR) 17.95).

## Kemp's ridley sea turtle

The Kemp's ridley sea turtle was federally listed as endangered on December 2, 1970 (35 FR 18320). The Kemp's ridley, along with the flatback sea turtle (*Natator depressus*), has the most geographically restricted distribution of any sea turtle species. The range of the Kemp's ridley includes the Gulf coasts of Mexico and the U.S., and the Atlantic coast of North America as far north as Nova Scotia and Newfoundland.

Adult Kemp's ridleys and olive ridleys are the smallest sea turtles in the world. The weight of an adult Kemp's ridley is generally between 70 to 108 pounds with a carapace measuring approximately 24 to 26 inches in length (Heppell *et al.* 2005). The carapace is almost as wide as it is long. The species' coloration changes significantly during development from the grey-black dorsum and plastron of hatchlings, a grey-black dorsum with a yellowish-white plastron as post-pelagic juveniles and then to the lighter grey-olive carapace and cream-white or yellowish plastron of adults. Their diet consists mainly of swimming crabs, but may also include fish, jellyfish, and an array of mollusks.

Nesting is mainly limited to the beaches of the western Gulf of Mexico, primarily in Tamaulipas, Mexico (NMFS *et al.* 2011). Nesting also occurs in Veracruz and a few historical records exist for Campeche, Mexico (Marquez-Millan 1994). Nesting also occurs regularly in Texas and infrequently in a few other U.S. states. However, historic nesting records in the U.S. are limited to south Texas (Werler 1951, Carr 1961, Hildebrand 1963).

Most Kemp's ridley nests located in the U.S. have been found in south Texas, especially Padre Island (Shaver and Caillouet 1998; Shaver 2002, 2005). Nests have been recorded elsewhere in Texas (Shaver 2005, 2006a, 2006b, 2007), and in Florida (Johnson *et al.* 1999, Foote and Mueller 2002, Hegna *et al.* 2006, FWC/FWRI 2010b), Alabama (J. Phillips, Service, personal communication, 2007 cited in NMFS *et al.* 2011; J. Isaacs, Service, personal communication, 2008 cited in NMFS *et al.* 2011), Georgia (Williams *et al.* 2006), South Carolina (Anonymous 1992), and North Carolina (Godfrey 2014), but these events are less frequent. Kemp's ridleys inhabit the Gulf of Mexico and the Northwest Atlantic Ocean, as far north as the Grand Banks (Watson *et al.* 2004) and Nova Scotia (Bleakney 1955). They occur near the Azores and eastern north Atlantic (Deraniyagala 1938, Brongersma 1972, Fontaine *et al.* 1989, Bolten and Martins 1990) and Mediterranean (Pritchard and Marquez 1973, Brongersma and Carr 1983, Tomas and Raga 2007, Insacco and Spadola 2010).

Hatchlings, after leaving the nesting beach, are believed to become entrained in eddies within the Gulf of Mexico. Most Kemp's ridley post-hatchlings likely remain within the Gulf of Mexico. Others are transported into the northern Gulf of Mexico and then eastward, with some continuing southward in the Loop Current, then eastward on the Florida Current into the Gulf Stream (Collard and Ogren 1990, Putman *et al.* 2010). Juvenile Kemp's ridleys spend on average two years in the oceanic zone (NMFS SEFSC unpublished preliminary analysis, July 2004, as cited in NMFS *et al.* 2011) where they likely live and feed among floating algal communities. They remain here until they reach about 7.9 inches in length (approximately two years of age), at which size they enter coastal shallow water habitats (Ogren 1989); however, the time spent in the oceanic zone may vary from one to four years or perhaps more (Turtle Expert Working Group (TEWG) 2000, Baker and Higgins 2003, Dodge *et al.* 2003).

No critical habitat has been designated for the Kemp's ridley sea turtle.

## B. Life History

### Loggerhead sea turtle

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 both oviposition (egg laying) and embryonic development and hatching occur.

2. Neritic zone - the inshore marine environment (from the surface to the sea floor) where water depths do not exceed 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 (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).

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). The following table summarizes key life history characteristics for loggerheads nesting in the U.S.

**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] |
| Internesting 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 Caldwell (1962), 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, presumably using decreasing sand temperature as a cue (Hendrickson 1958, Mrosovsky and Shettleworth 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.

### Green sea turtle

Green sea turtles deposit from one to nine clutches within a nesting season, but the overall average is about 3.3 nests. The interval between nesting events within a season varies around a mean of about 13 days (Hirth 1997). Mean clutch size varies widely among populations. Average clutch size reported for Florida was 136 eggs in 130 clutches (Witherington and Ehrhart 1989). Only occasionally do females produce clutches in successive years. Usually two or more years intervene between breeding seasons (NMFS and USFWS 1991). Age at sexual maturity is believed to be 20 to 50 years (Hirth 1997).

### Leatherback sea turtle

Leatherbacks nest an average of five to seven times within a nesting season, with an observed maximum of 11 nests (NMFS and USFWS 1992). The interval between nesting events within a season is about 9 to 10 days. Clutch size averages 80 to 85 yolked eggs, with the addition of usually a few dozen smaller, yolkless eggs, mostly laid toward the end of the clutch (Pritchard 1992). Nesting migration intervals of 2 to 3 years were observed in leatherbacks nesting on the Sandy Point National Wildlife Refuge, St. Croix, U.S. Virgin Islands (McDonald and Dutton 1996). Leatherbacks are believed to reach sexual maturity in 13 to 16 years (Dutton *et al.* 2005, Jones *et al.* 2011).

### Kemp's ridley sea turtle

Kemp's ridley sea turtles nest primarily from April into July. Nesting often occurs in synchronized emergences, known as "arribadas" or "arribazones," which may be triggered by high wind speeds, especially north winds, and changes in barometric pressure (Jimenez *et al.* 2005). Nesting occurs primarily during daylight hours. Clutch size averages 100 eggs, and eggs typically take 45 to 58 days to hatch depending on incubation conditions, especially temperatures (Marquez-Millan 1994, Rostal 2007).

Females lay an average of 2.5 clutches within a season (TEWG 1998) and inter-nesting interval generally ranges from 14 to 28 days (Miller 1997; Donna Shaver, Padre Island National Seashore, personal communication, 2007 as cited in NMFS et al. 2011). The mean remigration interval for adult females is 2 years, although intervals of 1 and 3 years are not uncommon (Marquez *et al.* 1982; TEWG 1998, 2000). Males may not be reproductively active on an annual basis (Wibbels *et al.* 1991). Age at sexual maturity is believed to be between 10 to 17 years (Snover *et al.* 2007).

## C. Population Dynamics

### Loggerhead sea turtle

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 2003a, 2003b; 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. 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 Janerio (Brazil), Tongaland (South Africa), Mozambique, Arabian Sea Coast (Oman), Halaniyat Islands (Oman), Cyprus, Peloponnesus (Greece), Island of Zakynthos (Greece), Turkey, Queensland (Australia), and Japan.

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 USFWS 2008, FWC/FWRI 2010a). 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.

**Green sea turtle**

There are an estimated 150,000 females that nest each year in 46 sites throughout the world (NMFS and USFWS 2007a). In the U.S. Atlantic, there are about 100 to 1,000 females estimated to nest on beaches in Florida annually (FWC 2009c). In the U.S. Pacific, over 90 percent of nesting throughout the Hawaiian archipelago occurs at the French Frigate Shoals, where about 200 to 700 females nest each year (NMFS and USFWS 1998). Elsewhere in the U.S. Pacific, nesting takes place at scattered locations in the Commonwealth of the Northern Marianas, Guam, and American Samoa. In the western Pacific, the largest green turtle nesting aggregation in the world occurs on Raine Island, Australia, where thousands of females nest nightly in an average nesting season (Limpus *et al.* 1993). In the Indian Ocean, major nesting beaches occur in Oman where 30,000 females are reported to nest annually (Ross and Barwani 1995).

**Leatherback sea turtle**

A dramatic drop in nesting numbers has been recorded on major nesting beaches in the Pacific. Spotila *et al.* (2000) have highlighted the dramatic decline and near extirpation of leatherbacks in the Pacific.

The East Pacific and Malaysia leatherback populations have collapsed. Spotila *et al.* (1996) estimated that only 34,500 females nested annually worldwide in 1995, which is a dramatic decline from the 115,000 estimated in 1980 (Pritchard 1982). In the eastern Pacific, the major nesting beaches occur in Costa Rica and Mexico. At Playa Grande, Costa Rica, considered the most important nesting beach in the eastern Pacific, numbers have dropped from 1,367 leatherbacks in 1988-1989 to an average of 188 females nesting between 2000-2001 and 2003-2004. In Pacific Mexico, 1982 aerial surveys of adult female leatherbacks indicated this area had become the most important leatherback nesting beach in the world. Tens of thousands of nests were laid on the beaches in 1980s, but during the 2003-2004 seasons a total of 120 nests were recorded. In the western Pacific, the major nesting beaches lie in Papua New Guinea; Papua, Indonesia; and the Solomon Islands. These are some of the last remaining significant nesting assemblages in the Pacific. Compiled nesting data estimated approximately 5,000 to 9,200 nests annually with 75 percent of the nests being laid in Papua, Indonesia.

However, the most recent population size estimate for the North Atlantic alone is a range of 34,000 to 94,000 adult leatherbacks (TEWG 2007). During recent years in Florida, the total number of leatherback nests counted as part of the SNBS program ranged from 540 to 1,797 from 2006-2010 (FWC/FWRI 2010a). Assuming a clutch frequency (number of nests/female/season) of 4.2 in Florida (Stewart 2007), these nests were produced by a range of 128 to 428 females in a given year.

Nesting in the Southern Caribbean occurs in the Guianas (Guyana, Suriname, and French Guiana), Trinidad, Dominica, and Venezuela. The largest nesting populations at present occur in the western Atlantic in French Guiana with nesting varying during 1967 to 2005 between a low of 5,029 nests in 1980 to a high of 63,294 nests in 1988 (TEWG 2007). Trinidad supports an estimated 6,000 leatherbacks nesting annually, which represents more than 80 percent of the nesting in the insular Caribbean Sea. Leatherback nesting along the Caribbean Central American coast takes place between Honduras and Colombia. In Atlantic Costa Rica, at Tortuguero, the number of nests laid annually between 1995 and 2006 was estimated to range from 199 to 1,623.

Modeling of the Atlantic Costa Rica data indicated that the nesting population has decreased by 67.8 percent over this time period.

In Puerto Rico, the main nesting areas are at Fajardo (Northeast Ecological Corridor) and Maunabo on the main island of Puerto Rico and on the islands of Culebra and Vieques. Between 1993 and 2010, the number of nests in the Fajardo area ranged from 51 to 456. In the Maunabo area, the number of nests recorded between 2001 and 2010 ranged from a low of 53 in 2002 to a high of 260 in 2009 (Diez 2011). On the island of Culebra, the number of nests ranged from a low 41 in 1996 to a high of 395 in 1997 (Diez 2011). On beaches managed by the Commonwealth of Puerto Rico on the island of Vieques, the Puerto Rico Department of Natural and Environmental Resources recorded annually 14-61 leatherback nests between 1991 and 2000; 145 nests in 2002; 24 in 2003; and 37 in 2005 (Diez 2011). The number of leatherback sea turtle nests recorded on Vieques Island beaches managed by the Service ranged between 13 and 163 during 2001-2010. Using the numbers of nests recorded in Puerto Rico between 1984 and 2005, the Turtle Expert Working Group (2007) estimated a population growth of approximately 10 percent per year. Recorded leatherback nesting on the Sandy Point National Wildlife Refuge on the island of St. Croix, U.S. Virgin Islands, between 1982 and 2010, ranged from a low of 82 in 1986 to a high of 1,008 in 2001 (Garner and Garner 2010). Using the number of observed females at Sandy Point from 1986 to 2004, the Turtle Expert Working Group (2007) estimated a population growth of approximately 10 percent per year. In the British Virgin Islands, annual nest numbers have increased in Tortola from zero to six nests per year in the late 1980s to 35 to 65 nests per year in the 2000s (TEWG 2007).

The most important nesting beach for leatherbacks in the eastern Atlantic lies in Gabon, Africa. It was estimated there were 30,000 nests along 60 miles of Mayumba Beach in southern Gabon during the 1999-2000 nesting season (Billes *et al.* 2000). Some nesting has been reported in Mauritania, Senegal, the Bijagos Archipelago of Guinea-Bissau, Turtle Islands and Sherbro Island of Sierra Leone, Liberia, Togo, Benin, Nigeria, Cameroon, Sao Tome and Principe, continental Equatorial Guinea, Islands of Corisco in the Gulf of Guinea, Democratic Republic of the Congo, and Angola. In addition, a large nesting population is found on the island of Bioko (Equatorial Guinea) (Fretey *et al.* 2007).

**Kemp's ridley sea turtle**

Most Kemp's ridleys nest on the beaches of the western Gulf of Mexico, primarily in Tamaulipas, Mexico. Nesting also occurs in Veracruz and Campeche, Mexico, although a small number of Kemp's ridleys nest consistently along the Texas coast (NMFS *et al.* 2011). In addition, rare nesting events have been reported in Alabama, Florida, Georgia, South Carolina, and North Carolina. Historical information indicates that tens of thousands of ridleys nested near Rancho Nuevo, Mexico, during the late 1940s (Hildebrand 1963). The Kemp's ridley population experienced a devastating decline between the late 1940s and the mid-1980s. The total number of nests per nesting season at Rancho Nuevo remained below 1,000 throughout the 1980s, but gradually began to increase in the 1990s. In 2009, 16,273 nests were documented along the 18.6 miles of coastline patrolled at Rancho Nuevo, and the total number of nests documented for all the monitored beaches in Mexico was 21,144 (USFWS 2010). In 2011, a total of 20,570 nests were documented in Mexico, 81 percent of these nests were documented in the Rancho Nuevo beach (Burchfield and Peña 2011). In addition, 153 and 199 nests were recorded during 2010 and 2011, respectively, in the United States, primarily in Texas.

### D. Status and Distribution

#### Loggerhead sea turtle

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. Peninsular 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. 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;

4. Dry Tortugas Recovery Unit (DTRU) - defined as loggerheads originating from nesting beaches throughout the islands located west of Key West, Florida; 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 Provancha 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. The overall NRU loggerhead nesting trend from daily beach surveys was declining significantly at 1.3 percent annually from 1983 to 2007 (NMFS and USFWS 2008). However, current data indicates an increasing trend. Georgia has had continuous increases in nesting from 2009 (998 nests) to 2013 (2,282 nests). South Carolina has had continuous increases in nesting from 2009 (2,182 nests) to 2013 (5,194 nests). The Georgia and South Carolina nesting data come from the seaturtle.org Sea Turtle Nest Monitoring System, which is populated with data input by the state agencies. North Carolina had 1258 nests in 2013, which is above the 10-year average of 791 (Godfrey 2014).

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 2009b).

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 loggerhead recovery unit within the Northwest Atlantic Ocean DPS. 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).

In the DTRU, a near-complete nest census undertaken from 1995 to 2004 (excluding 2002) 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, 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.

*Recovery Criteria (only the Demographic Recovery Criteria are presented below)*

1. Number of Nests and Number of Nesting Females
   a. Northern Recovery Unit
      i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is two 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. Peninsular Florida Recovery Unit
      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. Dry Tortugas Recovery Unit
      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. Northern Gulf of Mexico Recovery Unit
      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. Greater Caribbean Recovery Unit
   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.

**Green sea turtle**

Annual nest totals documented as part of the Florida SNBS program from 1989-2010 have ranged from 435 nests laid in 1993 to 13,225 in 2010. Nesting occurs in 26 counties with a peak along the east coast, from Volusia through Broward Counties. Although the SNBS program provides information on distribution and total abundance statewide, it cannot be used to assess trends because of variable survey effort. Therefore, green turtle nesting trends are best assessed using standardized nest counts made at INBS sites surveyed with constant effort over time (1989-2010). Green sea turtle nesting in Florida is increasing based on 22 years (1989-2010) of INBS data from throughout the state (FWC/FWRI 2010b). The increase in nesting in Florida is likely a result of several factors, including: (1) a Florida statute enacted in the early 1970s that prohibited the killing of green turtles in Florida; (2) the species listing under the ESA afforded complete protection to eggs, juveniles, and adults in all U.S. waters; (3) the passage of Florida's constitutional net ban amendment in 1994 and its subsequent enactment, making it illegal to use any gillnets or other entangling nets in state waters; (4) the likelihood that the majority of Florida green turtles reside within Florida waters where they are fully protected; (5) the protections afforded Florida green turtles while they inhabit the waters of other nations that have enacted strong sea turtle conservation measures (e.g., Bermuda); and (6) the listing of the species on Appendix I of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which stopped international trade and reduced incentives for illegal trade from the U.S (NMFS and USFWS 2007a).

*Recovery Criteria*

The U.S. Atlantic population of green sea turtles can be considered for delisting if, over a period of 25 years, the following conditions are met:

1. The level of nesting in Florida has increased to an average of 5,000 nests per year for at least six years. Nesting data must be based on standardized surveys;

2. At least 25 percent (65 miles) of all available nesting beaches (260 miles) is in public ownership and encompasses at least 50 percent of the nesting activity;

3. A reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds; and

4. All priority one tasks identified in the recovery plan have been successfully implemented.

**Leatherback sea turtle**

Pritchard (1982) estimated 115,000 nesting females worldwide, of which 60 percent nested along the Pacific coast of Mexico. Declines in leatherback nesting have occurred over the last two decades along the Pacific coasts of Mexico and Costa Rica. The Mexican leatherback nesting population, once considered to be the world's largest (historically estimated to be 65 percent of the worldwide population), is now less than one percent of its estimated size in 1980. Spotila *et al.* (1996) estimated the number of leatherback sea turtles nesting on 28 beaches throughout the world from the literature and from communications with investigators studying those beaches. The estimated worldwide population of leatherbacks in 1995 was about 34,500 females on these beaches with a lower limit of about 26,200, and an upper limit of about 42,900. This is less than one-third the 1980 estimate of 115,000. Leatherbacks are rare in the Indian Ocean and in very low numbers in the western Pacific Ocean. The most recent population size estimate for the North Atlantic is a range of 34,000 to 94,000 adult leatherbacks (TEWG 2007). The largest population is in the western Atlantic. Using an age-based demographic model, Spotila *et al.* (1996) determined that leatherback populations in the Indian Ocean and western Pacific Ocean cannot withstand even moderate levels of adult mortality and that the Atlantic populations are being exploited at a rate that cannot be sustained. They concluded that leatherbacks are on the road to extinction and further population declines can be expected unless action is taken to reduce adult mortality and increase survival of eggs and hatchlings.

In the western Atlantic, the U.S. nesting populations primarily occur in Florida, Puerto Rico, and the U.S. Virgin Islands. In Florida, the SNBS program documented an increase in leatherback nesting numbers from 98 nests in 1989 to between 453 and 1,747 nests per season in the early 2000s (FWC 2009a, Stewart and Johnson 2006). Although the SNBS program provides information on distribution and total abundance statewide, it cannot be used to assess trends because of variable survey effort. Therefore, leatherback nesting trends are best assessed using standardized nest counts made at INBS sites surveyed with constant effort over time (1989-2010). Under the INBS program, approximately 30 percent of Florida's SNBS beach length is surveyed. The INBS nest counts represent approximately 34 percent of known leatherback nesting in Florida. An analysis of the INBS data has shown an exponential increase in leatherback sea turtle nesting in Florida since 1989. From 1989 through 2010, the annual number of leatherback sea turtle nests at the core set of index beaches ranged from 27 to 615 (FWC 2010b). Using the numbers of nests recorded from 1979 through 2009, Stewart *et al.* (2011) estimated a population growth of approximately 10.2 percent per year. In Puerto Rico, the main nesting areas are at Fajardo (Northeast Ecological Corridor) and Maunabo on the main island and on the islands of Culebra and Vieques. Nesting ranged from 51 to 456 nests between 2001 and 2010 (Diez 2011). In the U.S. Virgin Islands, leatherback nesting on Sandy Point National Wildlife Refuge on the island of St. Croix ranged from 143 to 1,008 nests between 1990 and 2005 (TEWG 2007, NMFS and USFWS 2007b).

*Recovery Criteria*

The U.S. Atlantic population of leatherbacks can be considered for delisting if the following conditions are met:

1. The adult female population increases over the next 25 years, as evidenced by a statistically significant trend in the number of nests at Culebra, Puerto Rico, St. Croix, U.S. Virgin Islands, and along the east coast of Florida;

2. Nesting habitat encompassing at least 75 percent of nesting activity in U.S. Virgin Islands, Puerto Rico, and Florida is in public ownership; and

3. All priority one tasks identified in the recovery plan have been successfully implemented.

**Kemp's ridley sea turtle**

Nesting aggregations of Kemp's ridleys at Rancho Nuevo, Mexico were discovered in 1947, and the adult female population was estimated to be 40,000 or more individuals based on a film by Andres Herrera (Hildebrand 1963, Carr 1963). Within approximately 3 decades, the population had declined to 924 nests and reached the lowest recorded nest count of 702 nests in 1985. Since the mid-1980s, the number of nests observed at Rancho Nuevo and nearby beaches has increased 15 percent per year (Heppell et al. 2005), allowing cautious optimism that the population is on its way to recovery. This increase in nesting can be attributed to full protection of nesting females and their nests in Mexico resulting from a bi-national effort between Mexico and the U.S. to prevent the extinction of the Kemp's ridley, the requirement to use Turtle Excluder Devices (TEDs) in shrimp trawls both in the U.S. and Mexico, and decreased shrimping effort (NMFS *et al.* 2011, Heppell *et al.* 2005).

*Recovery Criteria (only the Demographic Recovery Criteria are presented below)*

The recovery goal is to conserve and protect the Kemp's ridley sea turtle so that protections under the ESA are no longer necessary and the species can be removed from the List of Endangered and Threatened Wildlife. Biological recovery criteria form the basis from which to gauge whether the species should be reclassified to threatened (i.e., downlisted) or delisted, whereas the listing factor criteria ensure that the threats affecting the species are controlled or eliminated.

Downlisting Criteria

1. A population of at least 10,000 nesting females in a season (as estimated by clutch frequency per female per season) distributed at the primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) in Mexico is attained. Methodology and capacity to implement and ensure accurate nesting female counts have been developed.

2. Recruitment of at least 300,000 hatchlings to the marine environment per season at the three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) in Mexico is attained to ensure a minimum level of known production through *in situ* incubation, incubation in corrals, or a combination of both.

Delisting Criteria

1. An average population of at least 40,000 nesting females per season (as measured by clutch frequency per female per season and annual nest counts) over a 6-year period distributed among nesting beaches in Mexico and the U.S. is attained. Methodology and capacity to ensure accurate nesting female counts have been developed and implemented.

2. Ensure average annual recruitment of hatchlings over a 6-year period from *in situ* nests and beach corrals is sufficient to maintain a population of at least 40,000 nesting females per nesting season distributed among nesting beaches in Mexico and the U.S into the future. This criterion may rely on massive synchronous nesting events (i.e., arribadas) that will swamp predators as well as rely on supplemental protection in corrals and facilities.

## E. Analysis of the Species/Critical Habitat Likely to be Affected

The Service and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) share federal jurisdiction for sea turtles under the ESA. 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.

The proposed action has the potential to adversely affect nesting females, nests, and hatchlings within the action area. 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 beach nourishment 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. The effects of the proposed action on sea turtles will be considered further in the remaining sections of this biological opinion.

Critical habitat has not been designated for sea turtles in the continental United States; therefore, the proposed action would not result in an adverse modification. On March 25, 2013, the Service proposed to designate critical habitat for the Northwest Atlantic Ocean Distinct Population Segment of the loggerhead sea turtle (78 FR 18000). The final rule is expected to be published in June 2014. However, the action area does not occur in or near the proposed critical habitat.

**Other Species**

In addition to the four species that are the subject of this formal consultation, the USACE has determined that, based on lack of habitat, the project will have no effect on the federally listed red-cockaded woodpecker (*Picoides borealis*), roseate tern (*Sterna dougallii*), and red wolf (*Canis rufus*). The Service concurs with these conclusions. The USACE has determined that there will be no effect on designated critical habitat for the piping plover (*Charadrius melodus*). The Service concurs with this conclusion. Also, the USACE has determined that the project may affect, but is not likely to adversely affect the West Indian manatee (*Trichechus manatus*), piping plover (*Charadrius melodus*), and seabeach amaranth (*Amaranthus pumilus*). Based on available information, the Service concurs with these conclusions. The rufa red knot (*Calidris canutus rufa*) has been proposed to be listed as federally threatened. The USACE has determined that the project may affect, but is not likely to adversely affect the rufa red knot. Based on available information, the Service concurs with this conclusion. The hawksbill sea turtle (*Eretmochelys imbricata*) does not nest in North Carolina, but occurs in waters off the North Carolina coast. The hawksbill sea turtle, along with the shortnose sturgeon (*Acipenser brevirostrum*) and Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), fall within the regulatory purview of the NMFS. The species discussed in this paragraph will not be considered further in this BO.

## III. ENVIRONMENTAL BASELINE

Under section 7(a)(2) of the ESA, when considering the "effects of the action" on federally listed species, the Service is required to take into consideration the environmental baseline. The environmental baseline includes past and ongoing natural factors and the past and present impacts of all federal, state, or private actions and other activities in the action area (50 CFR 402.02), including federal actions in the area that have already undergone section 7 consultation, and the impacts of state or private actions which are contemporaneous with the consultation in process.

## A. Status of the Species Within the Action Area

### Loggerhead sea turtle

In North Carolina, the loggerhead sea turtle nesting and hatching season is May 1 through November 15. Incubation ranges from about 45 to 95 days. From 2004 to 2013, there were a total of 23 loggerhead sea turtle nests within the action area, averaging 2.3 nests per year (Godfrey 2014).

### Green sea turtle

In North Carolina, the green sea turtle nesting and hatching season is May 15 through November 15. Incubation ranges from about 45 to 75 days. From 2004 to 2013, there were a total of three green sea turtle nests within the action area, averaging 0.3 nests per year (Godfrey 2014).

### Leatherback sea turtle

In North Carolina, the leatherback sea turtle nesting and hatching season is April 15 through September 30. Incubation ranges from about 55 to 75 days. From 2004 to 2013, there were no leatherback sea turtle nests within the action area. However, it is possible that nesting could occur during the implementation of the project (Godfrey 2014).

### Kemp's ridley sea turtle

The Kemp's ridley sea turtle is a very rare nester in North Carolina. From 2004 to 2013, there were no Kemp's ridley sea turtle nests within the action area, and during the same time frame there were only six nests within the entire state. However, it is possible that nesting could occur during the implementation of the project (Godfrey 2014).

## B. Factors Affecting the Species Environment Within the Action Area

A number of ongoing anthropogenic and natural factors may affect the species addressed in this BO. Many of these effects have not been evaluated with respect to biological impacts on the species. In addition, some are interrelated and the effects of one cannot be separated from others. Known or suspected factors affecting the species addressed in this BO are discussed below.

### Pea Island National Wildlife Refuge

Most of the action area is within the PINWR. The staff at PINWR monitor for sea turtles in the refuge from the end of May through the end of the nesting season. Any sea turtle nests that are located in what is deemed an untenable location (e.g. subject to inundation at high tide or in a location subject to extreme beach erosion) are relocated to a safer location. Sea turtle nests receive a higher level of protection within the refuge, and at the time of hatching, PINWR staff and volunteers implement measures to assist hatchings in reaching the ocean.

Public ownership confers some conservation benefit to listed species. Public ownership removes some threats that might otherwise be present if the properties were owned by private landowners and subsequently developed. Public ownership also minimizes the likelihood that light pollution from homes and other development will become a significant problem since no commercial and residential development will occur on public lands. Therefore, along the shoreline of public lands, disorientation or misorientation of adult or hatchling sea turtles due to artificial lighting of homes or businesses will have been avoided or greatly reduced with public ownership.

### NC 12 and Sand Berm Maintenance

The NCDOT regularly reconstructs the sand berms along portions of NC 12 within the action area after storms, especially after nor'easters. This generally occurs several times per year. These projects vary in scale and scope, but typically entail placing sand that has washed or blown from the seaward dune onto the road back into the footprint of the seaward dune and is intended to maintain access along NC 12. Sand berm reconstruction may occur adjacent to areas used by sea turtles for nesting. Anticipated impacts of sand berm construction on sea turtles include:

- harassment in the form of disturbing or interfering with female sea turtles attempting to nest adjacent to the construction area as a result of construction activities;
- disorientation/misorientation of hatchling sea turtles on beaches adjacent to the construction area as they emerge from nests and crawl to the water because of project lighting; and
- compaction of the sand on the nesting beach.

### Coastal Development

The southernmost 0.7 mile portion of the project occurs within the Mirlo Beach community and the village of Rodanthe. This portion of the action area contains private residences. This beachfront development has rendered this portion of the action area as marginal habitat for sea turtles. The presence of residents and their pets provides a constant source of disturbance during the sea turtle nesting season.

### Artificial Lights

The artificial light emanating from the community of Mirlo Beach and the village of Rodanthe impacts the sea turtle nesting habitat in the southern portion of the action area. 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. During the 2010 sea turtle nesting season in Florida, over 47,000 turtle hatchlings were documented as being disoriented (FWC/FWRI 2011).

### Recreational Beach Use

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 (i.e. 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. Beach walkers have been documented harassing nesting sea turtles within Cape Hatteras National Seashore (e.g. crowding around nesting turtle and taking flash photographs) and digging within turtle nests (NPS 2007).

### 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).

**Hurricanes/Nor'easters**

Hurricanes and nor'easters 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).

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. On developed beaches, typically little space remains for sandy beaches to become reestablished after periodic storms. In August 2011, Hurricane Irene severely damaged NC 12 within the action area and reduced much of the beach to a narrow ribbon between the road and the ocean. In October 2012, Hurricane Sandy again impacted the action area with similar results.

**Climate Change/Sea Level Rise**

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. These impacts may take place gradually or episodically in major leaps.

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.* 2009).

In areas where shoreline protection structures have been constructed to limit shoreline movement, rising sea levels may 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 1990). 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, 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.

## IV. EFFECTS OF THE ACTION

Under section 7(a)(2) of the ESA, "effects of the action" refers to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action. The federal agency is responsible for analyzing these effects. The effects of the proposed action are added to the environmental baseline to determine the future baseline, which serves as the basis for the determination in this BO. Should the effects of the federal action result in a situation that would jeopardize the continued existence of the species, we may propose reasonable and prudent alternatives that the federal agency can take to avoid a violation of section 7(a)(2). The discussion that follows is our evaluation of the anticipated direct and indirect effects of the proposed project. Indirect effects are those caused by the proposed action that occur later in time but are still reasonably certain to occur (50 CFR 402.02).

### A. Factors to be Considered

Proximity of action: Sand placement activities will occur within and adjacent to nesting habitat for sea turtles and dune habitats that ensure the stability and integrity of the nesting beach. Specifically, the project will potentially impact loggerhead, green, leatherback, and Kemp's ridley nesting females, their nests, and hatchling sea turtles.

Distribution: The expected disturbance from the proposed action will occur on all of the ocean facing beach throughout the action area.

Timing: The timing of the sand placement activities could directly and indirectly impact nesting females, their nests, and hatchling sea turtles when conducted between May 1 and November 15. The greatest effects may occur at night from construction lighting

Nature of the effect: The effects of the sand placement activities may change the nesting behavior of adult female sea turtles, diminish nesting success, and cause reduced hatching and emerging success. Sand placement can also change the incubation conditions within the nest. Any decrease in productivity and/or survival rates would contribute to the vulnerability of the sea turtles nesting in the southeastern United States.

Duration: The sand placement activity is estimated to take 60-90 days to complete, assuming 24 hour per day operation throughout a seven day work week. Thus, the direct effects would be expected to be short-term in duration. Indirect effects from the activity may continue to impact nesting and hatchling sea turtles and sea turtle nests in subsequent nesting seasons due to alteration of the beach habitat.

Disturbance frequency: The beach nourishment project will be a one-time event which may occur within some portion of the May 1 – November 15 sea turtle nesting season.

Disturbance intensity and severity: The amount of effect of this project on the sea turtle species and their ability to recover, when compared to the overall populations of the species, is very small. The action area only provides marginal nesting habitat and is located near the northern edge of each species nesting range.

**B. Analyses for effects of the action**

**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. 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.

**Direct effects**

1. Placement of sand on the beach

Projects conducted during the nesting and hatching season can result in the loss of sea turtles through disruption of adult nesting activity and by burial or crushing of nests or hatchlings. While a nest monitoring and egg relocation program will 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. In addition, nests may be destroyed by operations at night prior to beach patrols being performed. Even under the best of conditions, about 7 percent of the nests can be misidentified as false crawls by experienced sea turtle nest surveyors (Schroeder 1994).

In the past, all detected sea turtle nests within the action area have been relocated either by PINWR staff and their volunteers or by Cape Hatteras National Seashore staff and their volunteers. Relocations have occurred due to the presence of marginal habitat and the low probability of nest success. These relocations have been and are expected to continue independent of the NC 12 Emergency Beach Nourishment Project. Therefore, it is unlikely that any project-related adverse effects will occur due to relocation of sea turtle nests. The action area will be monitored daily for sea turtle nesting activity by PINWR staff and their volunteers, Cape Hatteras National Seashore staff and their volunteers, NCDOT, and consultants employed by NCDOT. However, any nests missed by these monitors would likely result in lethal effects to the eggs and/or hatchlings by burial or crushing from deposited sand or heavy equipment.

2. Vehicles and equipment

The use of vehicles and heavy equipment on beaches during a construction project may have adverse effects on sea turtles. Equipment left on the nesting beach overnight can create barriers to nesting females emerging from the surf and crawling up the beach, causing a higher incidence of false crawls and unnecessary energy expenditure. The operation of vehicles or equipment on the beach at night affects sea turtle nesting by: interrupting or colliding with a nesting female on the beach, headlights disorienting or misorienting emergent hatchlings, vehicles running over hatchlings attempting to reach the ocean, and vehicle ruts on the beach interfering with hatchlings crawling to the ocean. Apparently, hatchlings traversing ruts become diverted not because they cannot physically climb out of a 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 ruts may increase the susceptibility of hatchlings to dehydration and depredation during migration to the ocean (Hosier *et al.* 1981). Driving directly over incubating egg clutches or on the beach can cause sand compaction, which may result in adverse effects in 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).

3. Artificial lighting

Visual cues are the primary sea-finding mechanism for hatchling sea turtles (Mrosovsky and Carr 1967, Mrosovsky and Shettleworth 1968, Dickerson and Nelson 1989, Witherington and Bjorndal 1991). When artificial lighting is present on or near the beach, it can misdirect hatchlings once they emerge from their nests and prevent them from reaching the ocean (Philibosian 1976, Mann 1977, FWC 2007). In addition, a significant reduction in sea turtle nesting activity has been documented on beaches illuminated with artificial lights (Witherington 1992). Therefore, construction lights along a project beach and on the dredging vessel may deter females from coming ashore to nest, misdirect females trying to return to the surf after a nesting event, and misdirect emergent hatchlings from adjacent non-project beaches. It is expected that portions of the action area will be illuminated at night by portable construction lighting throughout the entire 60-90 day estimated construction time.

The newly created wider and flatter beach berm exposes sea turtles and their nests to lights that were less visible, or not visible, from nesting areas before the sand placement activity, leading to higher mortality of hatchlings. Review of over ten years of empirical information from beach nourishment projects indicates that the number of sea turtles impacted by lights increases on the post-construction berm. A review of selected nourished beaches in Florida (South Brevard, North Brevard, Captiva Island, Ocean Ridge, Boca Raton, Town of Palm Beach, Longboat Key, and Bonita Beach) indicated disorientation reporting increased by approximately 300 percent the first nesting season after project construction and up to 542 percent the second year compared to pre-nourishment reports (Trindell 2005).

**<u>Interrelated and interdependent actions</u>**

None known.

## Indirect effects

1. Changes in the physical environment
Beach nourishment 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 can result in adverse effects 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. With the exception of green sea turtles (Wetterer et al. 2007), most 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).

Beach compaction and unnatural beach profiles resulting from beach nourishment activities can adversely affect 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 ten years or more. Also, a change in sediment color on a beach can change the natural incubation temperatures of nests in an area, which, in turn, could alter natural sex ratios (Hays et al. 2001). These effects can be minimized by using suitable sand and by judicious tilling of compacted sand after project completion.

2. Escarpment formation
On nourished beaches, steep escarpments may develop along their water line interface as they adjust from an unnatural construction profile to a more natural beach profile (Coastal Engineering Research Center 1984, Nelson *et al.* 1987). Escarpments can hamper or prevent access to nesting sites (Nelson and Blihovde 1998). Researchers have shown that female sea turtles coming ashore to nest can be discouraged by the formation of an escarpment, leading to situations where they choose marginal or unsuitable nesting areas to deposit eggs (e.g., in front of the escarpments, which often results in failure of nests due to prolonged tidal inundation). This impact can be minimized by leveling any escarpments prior to the nesting season.

## C. Species' response to the proposed action

The following summary illustrates sea turtle responses to and recovery from a nourishment project comprehensively studied by Ernest and Martin (1999). A significantly larger proportion of turtles emerging on nourished beaches abandoned their nesting attempts than turtles emerging on natural or pre-nourished beaches. This reduction in nesting success is most pronounced during the first year following project construction and is most likely the result of changes in physical beach characteristics associated with the nourishment project (e.g., beach profile, sediment grain size, beach compaction, frequency and extent of escarpments). During the first post-construction year, the time required for turtles to excavate an egg chamber on untilled, hard-packed sands increases significantly relative to natural conditions. However, in some cases, tilling can be effective in reducing sediment compaction to levels that did not significantly prolong digging times. As natural processes reduced compaction levels on nourished beaches during the second post-construction year, digging times returned to natural levels (Ernest and Martin 1999).

During the first post-construction year, most nests on nourished beaches are deposited significantly seaward of the toe of the dune and significantly landward of the tide line than nests on natural beaches. More nests are washed out on the wide, flat beaches of the nourished treatments than on the narrower steeply sloped natural beaches. This phenomenon may persist through the second post-construction year monitoring and result from the placement of nests near the seaward edge of the beach berm where dramatic profile changes, caused by erosion and scarping, occur as the beach equilibrates to a more natural contour.

The principal effect of beach nourishment on sea turtle reproduction is a reduction in nesting success during the first year following project construction. Although most studies have attributed this phenomenon to an increase in beach compaction and escarpment formation, Ernest and Martin (1999) indicated that changes in beach profile may be more important. Regardless, as a nourished beach is reworked by natural processes in subsequent years and adjusts from an unnatural construction profile to a natural beach profile, beach compaction and the frequency of escarpment formation decline, and nesting and nesting success return to levels found on natural beaches.

## V. 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 biological opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA.

Any maintenance activities on NC 12 that are conducted entirely within the NCDOT right-of-way do not have any federal nexus. These activities are most likely to occur after storm events in which sand is blown or washed over the road. Removal of the sand and reconstruction of the existing artificial berm would not likely be conducted within sea turtle habitat; however, the activities would be immediately adjacent to potential nesting habitat. Nesting sea turtles could be disturbed by the presence of heavy equipment. Lights from construction equipment may misorient or disorient sea turtle hatchlings. These effects would be expected to be short in duration for each maintenance event, but have historically occurred several times a year.

## VI. **CONCLUSION**

After reviewing the current status of the loggerhead sea turtle, green sea turtle, leatherback sea turtle, and Kemp's ridley sea turtle; the environmental baseline for the action area; the effects of the proposed project and the cumulative effects, it is the Service's biological opinion that the NC 12 Emergency Beach Nourishment Project, as proposed, is not likely to jeopardize the continued existence of the these species and is not likely to destroy or adversely modify designated critical habitat. Critical habitat has been proposed for nesting loggerhead sea turtles, but the proposed action does not occur within or near this proposed critical habitat. No critical habitat has been designated for the green sea turtle, leatherback sea turtle, or Kemp's ridley sea turtle in the continental United States. Therefore, no designated or proposed critical habitat will be affected.

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. The action area for the NC 12 Emergency Beach Nourishment Project occurs within the Northern Recovery Unit (NRU). The NRU had over 8,734 nests in 2013 (excludes small contribution from Virginia).

Green, leatherback, and Kemp's ridley sea turtle nesting generally overlaps with or occurs within the beaches where loggerhead sea turtles nest on both the Atlantic and Gulf of Mexico beaches. The proposed project will affect only 2.27 miles of the approximately 1,400 miles of available sea turtle nesting habitat in the southeastern U.S. Much of this 2.27 mile length of beach is of only marginal quality for nesting.

Research has shown that the principal effect of sand placement on sea turtle reproduction is a reduction in nesting success, and this reduction is most often limited to the first year or two following project construction. Research has also shown that the impacts of a nourishment project on sea turtle nesting habitat are typically short-term because a nourished beach will be reworked by natural processes in subsequent years, and beach compaction and the frequency of escarpment formation will decline. Although a variety of factors, including some that cannot be controlled, can influence how a nourishment project will perform from an engineering perspective, measures will be implemented to minimize impacts to sea turtles.

Over the past ten years (2004 to 2013), the action area averaged only 2.3 loggerhead sea turtle nests and 0.3 green sea turtle nests per year. No leatherback or Kemp's ridley sea turtles were observed to nest within the action area. From 2004 to 2013, the extent of sea turtle nesting within the action area annually represented only 0.0 to 0.9% of total sea turtle nests in North Carolina (Godfrey 2014) and less than 0.1% of the average number of loggerhead nests within the NRU. Overall, sea turtle nesting within the action area represents a miniscule contribution to all the sea turtle nesting in the southeastern U.S.

## 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 USACE so that they become binding conditions of any grant or permit issued to the NCDOT, as appropriate, for the exemption in section 7(o)(2) to apply. The USACE has a continuing duty to regulate the activity covered by this incidental take statement. If the USACE (1) fails to assume and implement the terms and conditions or (2) fails to require the NCDOT 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 USACE or NCDOT must report the progress of the action and its impacts on the species to the Service [50 CFR §402.14(i)(3)].

### AMOUNT OR EXTENT OF TAKE

The Service anticipates 2.27 miles of sea turtle nesting beach habitat could be taken as a result of this proposed action. The take is expected to be in the form of: (1) destruction of all nests that may be constructed and eggs that may be deposited and missed by a nest survey and egg relocation program within the boundaries of the proposed project; (2) harassment in the form of disturbing or interfering with female turtles attempting to nest within the construction area or on adjacent beaches as a result of construction activities; (3) misdirection of nesting and hatchling turtles on beaches adjacent to the sand placement or construction area as a result of construction lighting; (4) misdirection of nesting sea turtles or hatchling turtles on beaches adjacent to the construction area as they emerge from the nest and crawl to the water as a result of lights from beachfront development that reach the elevated berm post-construction; (5) behavior modification of nesting females due to escarpment formation within the project area during a nesting season, resulting in false crawls or situations where they choose marginal or unsuitable nesting areas to deposit eggs; and (6) destruction of nests from escarpment leveling within a nesting season when such leveling has been approved by the Service.

Incidental take is anticipated for only the 2.27 miles of beach that have been identified for sand placement. 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 egg relocation program; (2) the total number of hatchlings per undiscovered nest is unknown; (3) an unknown number of females may avoid the project beach and be forced to nest in a less than optimal area; (4) lights may misdirect an unknown number of hatchlings and cause death; and (5) escarpments may form and prevent an unknown number of females from accessing a suitable nesting site. However, the level of take of these species can be anticipated by the disturbance and nourishment of suitable turtle nesting beach habitat because: (1) turtles nest within the project site; (2) beach nourishment will likely occur during a portion of the nesting season; (3) the nourishment project will modify the incubation substrate, beach slope, and sand compaction; and (4) artificial lighting will deter and/or misdirect nesting and hatchling turtles.

## EFFECT OF THE TAKE

In the accompanying biological opinion, 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.

## REASONABLE AND PRUDENT MEASURES

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of loggerhead, green, leatherback, and Kemp's ridley sea turtles.

1. Beach quality sand suitable for sea turtle nesting, successful incubation, and hatchling emergence must be used on the project site.

2. All derelict material or other debris must be removed from the beach prior to any sand placement.

3. Daily early morning surveys for sea turtle nests will be required if any portion of the beach nourishment project occurs during the period from May 1 through November 15.

4. During the period from May 1 through November 15, if sand is placed on the beach at night, a nighttime monitor will be utilized to detect any turtle nesting activity that may occur within that night's work area.

5. During the sea turtle nesting season, construction equipment and materials must be stored in a manner that will minimize impacts to sea turtles to the maximum extent practicable.

6. During the sea turtle nesting season, lighting associated with the project must be minimized to reduce the possibility of disrupting and misdirecting nesting and/or hatchling sea turtles.

7. Educate construction contractors and pertinent NCDOT and USACE staff as to the adverse effects of artificial lighting on sea turtles.

8. Sand compaction must be monitored and tilling must be conducted if needed to reduce the likelihood of impacting sea turtle nesting and hatching activities.

9. Escarpment formation must be monitored and leveling must be conducted if needed to reduce the likelihood of impacting nesting and hatchling sea turtles.

10. The Service and the North Carolina Wildlife Resources Commission sea turtle coordinator must be notified if a sea turtle adult, hatchling, or egg is harmed or destroyed as a direct or indirect result of the project.

**TERMS AND CONDITIONS**

In order to be exempt from the prohibitions of Section 9 of the ESA, the USACE must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

1. Beach compatible fill must be placed on the beach and associated dune system. Beach compatible fill must be sand that is similar to the native beach in the vicinity of the site that has not been affected by prior sand placement activity. The material placed on the beach will be in compliance with sand suitability standards as specified in the terms and conditions of PINWR Special Use Permit # 2013-005.

2. All derelict concrete, metal, coastal armoring material or other debris must be removed from the beach prior to any sand placement to the maximum extent possible. If debris removal activities take place during the sea turtle nesting season, the work must be conducted during daylight hours only and must not commence until completion of the sea turtle nesting survey each day.

3. Daily early morning surveys for sea turtle nests are required if any portion of the beach nourishment project occurs during the period from May 1 through November 15. (The PINWR and the Cape Hatteras National Seashore generally survey most of the action area independent of the proposed action. This term and condition is to ensure that any gaps in the area or time in which surveys are conducted are covered.)

   Any detected sea turtle nesting activity must be reported to the PINWR (if activity occurs on the Refuge) or to the Cape Hatteras National Seashore (if the activity occurs outside PINWR). It is assumed that detected nests will be relocated (independent of this project) by PINWR or the Cape Hatteras National Seashore as has been done in the past). All detected nesting activity must also be reported to the Service's Raleigh Field Office. No nest site containing eggs or hatchlings may be disturbed until after the eggs have been relocated.

4. During the period from May 1 through November 15, if sand if placed on the beach at night, a nighttime monitor must observe the beach area that will likely be affected that night prior to the morning's normal nesting activity survey. If a female sea turtle is observed attempting to nest, all work on the beach will cease and all lights will be extinguished (except for those absolutely necessary for safety) until after the female finishes laying eggs. If a female turtle successfully lays eggs in a nest, no work may occur within 50 feet of the nest site until after the eggs have been relocated. If hatchlings are observed emerging from a previously undetected nest, all work on the beach will cease and all lights will be extinguished (except for those absolutely necessary for safety) until after the hatchlings have entered the ocean.

5. From May 1 through November 15, staging areas for construction equipment and materials 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.

6. From May 1 through November 15, use the minimum number and the lowest wattage lights that are necessary for construction. Portable construction lighting must be directional LED lights with a predominant wavelength of about 650nm. Amber colored construction lights are preferred. Portable construction lights must be mounted as low to the ground as possible, and directional shields must be utilized. Direct lighting of the beach and nearshore waters must be limited to the immediate construction area only. Turn off all lights not immediately needed. Bulldozers and other heavy equipment will either utilize LED lights with a predominant wavelength of about 650nm or will operate underneath the acceptable portable construction lights with their standard lights turned off.

7. Provide an opportunity for the Service or a Service designee to educate construction contractor managers, supervisors, foremen and other key personnel and resident NCDOT personnel with oversight duties (division engineer, resident engineer, division environmental officer, etc.) as to adverse effects of artificial lighting on nesting sea turtles and hatchlings, and to the importance of minimizing those effects.

8. During and after construction, the beach will be monitored for sand compaction. This monitoring data will be reported to the PINWR Refuge Manager (if on the refuge), the Service's Raleigh Field Office, and to the North Carolina Wildlife Resources sea turtle coordinator (Matthew Godfrey at 252-728-1528). If there is compaction sufficient to limit the ability of sea turtles to successfully construct a nest cavity, tilling of the disposal

material may be required. On Refuge land and when compaction exceeds refuge standards, as determined by the Refuge Manager, tilling will be required.

9. 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 1for three subsequent years if sand in the project area still remains on the dry beach. Through coordination with and approval by the PINWR Refuge Manager (if on the refuge), 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 May 1. Any escarpment removal must be reported by location to the PINWR Refuge Manager (if on the refuge) and to the Service's Raleigh Field Office.

10. 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 USACE or the NCDOT must notify the PINWR (if located within the Refuge) or the Cape Hatteras National Sea Shore (if located outside PINWR) and the North Carolina Wildlife Resources Commission sea turtle coordinator (Matthew Godfrey at 252-728-1528).

The Service believes that incidental take will be limited to the 2.27 miles of beach that have been identified for sand placement. The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. The amount or extent of incidental take for sea turtles will be considered exceeded if the project results in more than a one-time placement of sand on the 2.27 miles of beach that have been identified for sand placement. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The USACE must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

## 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. Construction activities for this project and similar future projects within sea turtle nesting areas should be planned to take place outside the main part of the sea turtle nesting season (i.e. egg-laying portion of season) from May 1 through September 15.

2. NCDOT could install light shields along other coastal highways or state-maintained roadways that are currently visible at sea turtle nesting sites. This would reduce the possible misorientation impacts of NCDOT lighting on sea turtles.

3. NCDOT and/or USACE could provide money to pay for the signs that are used by volunteers to mark sea turtle nests during egg incubation on various beaches. These signs are integral to the NC nest monitoring program, which provides key data used to assess recovery goals.

4. NCDOT and/or USACE could contribute funding to the Network for Endangered Sea Turtles (N.E.S.T.), a nonprofit organization dedicated to the preservation and protection of sea turtle habitat in the Outer Banks.

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 February 28, 2014 request for formal consultation. 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; (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.

## LITERATURE CITED

Anonymous. 1992. First Kemp's ridley nesting in South Carolina. Marine Turtle Newsletter 59:23.

Baker, S. and B. Higgins. 2003. Summary of CWT project and recoveries, tag detection, and protocol for packaging and shipping Kemp's ridley flippers. Unpublished presentation at the Sea Turtle Stranding and Salvage Network annual meeting. February 2003.

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.

Billes, A., J.-B. Moundemba, and S. Gontier. 2000. Campagne Nyamu 1999-2000. Rapport de fin de saison. PROTOMAC-ECOFAC. 111 pages.

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 Master of Science thesis. Florida Atlantic University, Boca Raton, Florida.

Bleakney, J.S. 1955. Four records of the Atlantic ridley turtle, *Lepidochelys kempi*, from Nova Scotia. Copeia 2:137.

Bolten, A.B. and H.R. Martins. 1990. Kemp's ridley captured in the Azores. Marine Turtle Newsletter 48:23.

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.

Brongersma, L.D. 1972. European Atlantic Turtles. Zoologische Verhandelingen 121:318.

Brongersma, L. and A. Carr. 1983. *Lepidochelys kempii* (Garman) from Malta. Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen (Series C) 86(4):445-454.

Burchfield, P.M. and J.L Peña. 2011. Final report on the Mexico/United Stated of America population for the Kemp's Ridley sea turtle, *Lepidochelys kempii*, on the coasts of Tamaupilas, Mexico. 2011. Annual report to Fish and Wildlife Service. 43 pages.

Caldwell, D.K. 1962. Comments on the nesting behavior of Atlantic loggerhead sea turtles, based primarily on tagging returns. Quarterly Journal of the Florida Academy of Sciences 25(4):287-302.

Carr, A. 1961. The ridley mystery today. Animal Kingdom 64(1):7-12.

Carr, A. 1963. Panspecific reproductive convergence in *Lepidochelys kempii*. Ergebnisse der Biologie 26:298-303.

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.

Collard, S.B. and L.H. Ogren. 1990. Dispersal scenarios for pelagic post-hatchling sea turtles. Bulletin of Marine Science 47(1):233-243.

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 pages.

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.

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 i*n* 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.

Deraniyagala, P.E.P. 1938. The Mexican loggerhead turtle in Europe. Nature 142:540.

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.

Diez, C. E. 2011. Personal communication to the U.S. Fish and Wildlife Service. Puerto Rico Department of Natural and Environmental Resources.

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 report

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.

Dodd, M.G. and A.H. Mackinnon. 2001. Loggerhead turtle (*Caretta caretta*) nesting in Georgia, 2001. Georgia Department of Natural Resources. Report to the U.S. Fish and Wildlife Service, Jacksonville, Florida..

Dodd, M.G. and A.H. Mackinnon. 2002. Loggerhead turtle (*Caretta caretta*) nesting in Georgia, 2002. Georgia Department of Natural Resources. Report submitted to the U.S. Fish and Wildlife Service, Jacksonville, Florida.

Dodd, M.G. and A.H. Mackinnon. 2003. Loggerhead turtle (*Caretta caretta*) nesting in Georgia, 2003. Georgia Department of Natural Resources. Report submitted to the U.S. Fish and Wildlife Service, Jacksonville, Florida.

Dodd, M.G. and A.H. Mackinnon. 2004. Loggerhead turtle (*Caretta caretta*) nesting in Georgia, 2004. Georgia Department of Natural Resources. Report submitted to the U.S. Fish and Wildlife Service, Jacksonville, Florida.

Dodge, K.D., R. Prescott, D. Lewis, D. Murley, and C. Merigo. 2003. A review of cold stun strandings on Cape Cod, Massachusetts from 1979-2003. Unpublished Poster NOAA, Mass Audubon, New England Aquarium. http://galveston.ssp.nmfs.gov/research/protectedspecies/

Dutton, D.L., P.H. Dutton, M. Chaloupka, and R.H. Boulon. 2005. Increase of a Caribbean leatherback turtle *Dermochelys coriacea* nesting population linked to long-term nest protection. Biological Conservation 126:186-194.

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.

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.

Fletemeyer, J. 1980. Sea turtle monitoring project. Unpublished report prepared for the Broward County Environmental Quality Control Board, Florida.

Florida Fish and Wildlife Conservation Commission (FWC). 2007. Light sources contributing to reported disorientation events in Florida, 2007. http://www.myfwc.com/docs/WildlifeHabitats/Seaturtle_DisorientationEvents2007.pdf

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). 2009a. Statewide Nesting Beach Survey database http://research.myfwc.com/features/view_article.asp?id=10690

Florida Fish and Wildlife Conservation Commission (FWC). 2009b. Index Nesting Beach Survey Totals. http://research.myfwc.com/features/view_article.asp?id=10690

Florida Fish and Wildlife Conservation Commission (FWC). 2009c. Florida's endangered species, threatened species, and species of special concern. http://research.myfwc.com/features/view_article.asp?id=5182

Florida Fish and Wildlife Conservation Commission/Florida Fish and Wildlife Research Institute (FWC/FWRI). 2010a. 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). 2010b. Index nesting beach survey totals (1989 - 2010). http://myfwc.com/research/wildlife/sea-turtles/nesting/beach-survey-totals-1989-2010/

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.

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.

Fontaine, C.T., S.A. Manzella, T.D. Williams, R.M. Harris, and W.J. Browning. 1989. Distribution, growth and survival of head started, tagged and released Kemp's ridley sea turtle *(Lepidochelys kempii)* from year-classes 1978-1983. Pages 124-144 *in* Caillouet, C.W., Jr., and A.M. Landry Jr. (editors). Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management. TAMU-SG:89-105.

Foote, J.J. and T.L. Mueller. 2002. Two Kemp's ridley (*Lepidochelys kempii*) nests on the Gulf coast of Sarasota County, Florida, USA. Page 217 *in* Mosier, A., A. Foley, and B. Brost (compilers). Proceedings of the Twentieth Annual Symposium Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-477.

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.

Frair, W., R.G. Ackerman, and N. Mrosovsky. 1972. Body temperature of *Dermochelys coriacea:* warm water turtle from cold water. Science 177:791-793.

Francisco-Pearce, A.M. 2001. Contrasting population structure of *Caretta caretta* using mitochondrial and nuclear DNA primers. Unpublished Master of Science thesis. University of Florida, Gainesville, Florida.

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.

Fretey, J., A. Billes, and M. Tiwari. 2007. Leatherback *Dermochelys coriacea*, nesting along the Atlantic coast of Africa. Chelonian Conservation and Biology 6(1): 126-129.

Garner, J.A. and S.A. Garner. 2010. Saturation tagging and nest management of leatherback sea turtles on (*Dermochelys coriacea*) on Sandy Point, St. Croix, U.S. Virgin Island, 2010. Annual report to U.S. Fish and Wildlife Service. 49 pages.

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.

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, M. 2014. Unpublished data provided in a February 5, 2014 email from NCWRC sea turtle coordinator Matthew Godfrey to Service biologist Gary Jordan.

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.

Greer, A.E., J.D. Lazell, Jr., and R.M. Wright. 1973. Anatomical evidence for counter-current heat exchanger in the leatherback turtle (*Dermochelys coriacea*). Nature 244:181.

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.

Hailman, J.P. and A.M. Elowson. 1992. Ethogram of the nesting female loggerhead (*Caretta caretta*). Herpetologica 48:1-30.

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. 2009. Climate change and marine turtles. Endangered Species Research 7:137-154.

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.

Hays, G.C., J.S. Ashworth, M.J. Barnsley, A.C. Broderick, D.R. Emery, B.J. Godley, A. Henwood, and E.L. Jones. 2001. The importance of sand albedo for the thermal conditions on sea turtle beaches. Oikos 93:87-94.

Hegna, R.H., M.J. Warren, C.J. Carter, and J.C. Stiner. 2006. *Lepidochelys kempii* (Kemp's Ridley sea turtle). Herpetological Review 37(4):492.

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, Washinghton D.C.

Heppell, S.S., D.T. Crouse, L.B. Crowder, S.P. Epperly, W. Gabriel, T. Henwood, R. Marquez, and N.B. Thompson. 2005. A population model to estimate recovery time, population size, and management impacts on Kemp's ridley sea turtles. Chelonian Conservation and Biology 4(4):767-773.

Hildebrand, H.H. 1963. Hallazgo del área de anidación de la tortuga marina "lora" *Lepidochelys kempi* (Garman), en la coasta occidental del Golfo de México. Sobretiro de Ciencia, México 22:105-112.

Hirth, H.F. 1997. Synopsis of the biological data on the green turtle *Chelonia mydas* (Linnaeus 1758). U.S. Fish and Wildlife Service, Biological Report 97(1).

Hopkins, S.R. and T.M. Murphy. 1980. Reproductive ecology of *Caretta caretta* in South Carolina. South Carolina Wildlife Marine Resources Department Completion Report.

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.

Hughes, A.L. and E.A. Caine. 1994. The effects of beach features on hatchling loggerhead sea turtles. Pages 237 *in* Bjorndal, K.A., A.B. Bolten, D.A. Johnson, and P.J. Eliazar (compilers). Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-351.

Insacco, G. and F. Spadola. 2010. First record of Kemp's ridley sea turtle, *Lepidocheyls kempii* (Garman 1880) (Cheloniidae), from the Italian waters (Mediterranean Sea). Acta Herpetologica 5(1):113-117.

Intergovernmental Panel on Climate Change (IPCC). 2007a. Climate Change 2007: The Physical Science Basis - Summary for Policymakers. Contribution of Working Group I Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

Intergovernmental Panel on Climate Change (IPCC). 2007b. Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Intergovernmental Panel on Climate Change. Fourth Assessment Report.

Jimenez, M.C., A. Filonov, I. Tereshchenko, and R.M. Marquez. 2005. Time-series analyses of the relationship between nesting frequency of the Kemp's ridley sea turtle and meteorological conditions. Chelonian Conservation and Biology 4(4):774-780.

Johnson, S.A., A.L. Bass, B. Libert, M. Marmust, and D. Fulk. 1999. Kemp's ridley (*Lepidochelys kempi*) nesting in Florida. Florida Scientist 62(3/4):194-204.

Jones, T.T., M.D. Hastings, B.L. Bostrom, D. Pauly, and D.R. Jones. 2011. Growth of captive leatherback turtles, *Dermochelys coriacea*, with inferences on growth in the wild: Implications for population decline and recovery. Journal of Experimental Marine Biology and Ecology 399:84-92.

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.

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.

LeBuff, C.R., Jr. 1990. The loggerhead turtle in the eastern Gulf of Mexico. Caretta Research, Inc.; Sanibel Island, Florida.

Limpus, C.J. 1971. Sea turtle ocean finding behaviour. Search 2(10):385-387.

Limpus C.J. and D.J. Limpus. 2003a. Loggerhead turtles in the equatorial and southern Pacific Ocean. Pages 199-209 *in* Bolten, A.B. and B.E. Witherington (editors). Loggerhead Sea Turtles. Smithsonian Books, Washington, DC.

Limpus C.J. and D.J. Limpus. 2003b. Biology of the loggerhead turtle in western South Pacific Ocean foraging areas. Pages 93-113 *in* Bolten, A.B. and B.E. Witherington (editors). Loggerhead Sea Turtles. Smithsonian Books, Washington, DC.

Limpus, C., J.D. Miller, and C.J. Parmenter. 1993. The northern Great Barrier Reef green turtle *Chelonia mydas* breeding population. Pages 47-50 *in* Smith, A.K. (compiler), K.H. Zevering and C.E. Zevering (editors). Raine Island and Environs Great Barrier Reef: Quest to Preserve a Fragile Outpost of Nature. Raine Island Corporation and Great Barrier Reef Marine Park Authority, Townsville, Queensland, Australia.

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.

Mann, T.M. 1977. Impact of developed coastline on nesting and hatchling sea turtles in southeastern Florida. Unpublished Master of Science 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.

Marquez-Millan, R. 1994. Synopsis of biological data on the Kemp's ridley sea turtle, *Lepidochelys kempi* (Garman, 1880). NOAA Technical Memorandum NMFS-SEFC-343.

Márquez, M.R., A. Villanueva O., and M. Sánchez P. 1982. The population of the Kemp's ridley sea turtle in the Gulf of Mexico – *Lepidochelys kempii*. Pages 159-164 *in* Bjorndal, K.A. (editor). Biology and Conservation of Sea Turtles. Washington, D.C. Smithsonian Institute Press.

McDonald, D.L. and P.H. Dutton. 1996. Use of PIT tags and photoidentification to revise remigration estimates of leatherback turtles (*Dermochelys coriacea*) nesting in St. Croix, U.S. Virgin Islands, 1979-1995. Chelonian Conservation and Biology 2(2):148-152.

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, J.D. 1997. Reproduction in sea turtles. Pages 51-81 *in* P.L. Lutz and J.A. Musick (Eds.). The Biology of Sea Turtles. CRC Press, Boca Raton, Florida.

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.

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. Behavior 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. Behavior 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 mammals. 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). 2009a. 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 (NMFS). 2009b. Green Sea Turtles (*Chelonia mydas*). National Marine Fisheries Service, Office of Protected Resources. Silver Springs, Maryland. http://www.nmfs.noaa.gov/pr/species/turtles/green.htm

National Marine Fisheries Service (NMFS). 2009c. Leatherback Sea Turtles (*Dermochelys coriacea*). National Marine Fisheries Service, Office of Protected Resources. Silver Springs, Maryland. http://www.nmfs.noaa.gov/pr/species/turtles/leatherback.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 the U.S. Fish and Wildlife Service (NMFS and USFWS). 1998. Recovery plan for U.S. Pacific populations of the green turtle (*Chelonia mydas*). National Marine Fisheries Service, Silver Spring, Maryland.

National Marine Fisheries Service and the U.S. Fish and Wildlife Service (NMFS and USFWS). 2007a. Green sea turtle (*Chelonia mydas*) 5-year review: summary and evaluation. 102 pages.

National Marine Fisheries Service and the U.S. Fish and Wildlife Service (NMFS and USFWS). 2007b. Leatherback sea turtle (*Dermochelys coriacea*) 5-year review: summary and evaluation. 79 pages.

National Marine Fisheries Service and the 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, Maryland.

National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service, and SEMARNAT. 2011. Bi-national recovery plan for the Kemp's ridley sea turtle (*Lepidochelys kempii*), second revision. National Marine Fisheries Service, Silver Spring, Maryland.

National Park Service (NPS). 2007. Cape Hatteras National Seashore 2007 sea turtle annual report. Manteo, NC.

National Research Council. 1990. Decline of the sea turtles: causes and prevention. National Academy Press; Washington, D.C.

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

Ogren, L.H. 1989. Distribution of juvenile and subadult Kemp's ridley turtles: preliminary results from the 1984-1987 surveys. Pages 116-123 *in* Caillouet, C.W., Jr., and A.M. Landry, Jr. (eds.). Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management. Texas A&M University Sea Grant College Program TAMU-SG-89-105.

Philibosian, R. 1976. Disorientation of hawksbill turtle hatchlings (*Eretmochelys imbricata*) by stadium lights. Copeia 1976:824.

Possardt, E. 2005. Personal communication to Sandy MacPherson, U.S. Fish and Wildlife Service, Jacksonville, Florida. U.S. Fish and Wildlife Service, Atlanta, GA.

Pritchard, P.C.H. 1982. Nesting of the leatherback turtle, *Dermochelys coriacea* in Pacific Mexico, with a new estimate of the world population status. Copeia 1982(4):741-747.

Pritchard, P.C.H. 1992. Leatherback turtle *Dermochelys coriacea*. Pages 214-218 *in* Moler, P.E. (editor). Rare and Endangered Biota of Florida, Volume III. University Press of Florida; Gainesville, Florida.

Pritchard, P.C.H. and R. Márquez M. 1973. Kemp's ridley or Atlantic ridley, *Lepidochelys kempii*. IUCN Monograph No. 2. (Marine Turtle Series).

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.

Putman, N.F., T.J. Shay, and K.J. Lohmann. 2010. Is the geographic distribution of nesting in the Kemp's ridley turtle shaped by the migratory needs of offspring? Integrative and Comparative Biology, a symposium presented at the annual meeting of the Society for Integrative and Comparative Biology, Seattle, WA. 10 pages.

Rabon, D.R., Jr., S.A. Johnson, R. Boettcher, M. Dodd, M. Lyons, S. Murphy, S. Ramsey, S. Roff, and K. Stewart. 2003. Confirmed leatherback turtle (*Dermochelys coriacea*) nests from North Carolina, with a summary of leatherback nesting activities north of Florida. Marine Turtle Newslettter 101:4-8.

Raymond, P.W. 1984. The effects of beach restoration on marine turtles nesting in south Brevard County, Florida. Unpublished Master of Science 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.

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. 53 pages.

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.

Ross, J.P. and M.A. Barwani. 1995. Review of sea turtles in the Arabian area. Pages 373-383 *in* Bjorndal, K.A. (editor). Biology and Conservation of Sea Turtles, Revised Edition. Smithsonian Institution Press, Washington, D.C. 615 pages.

Rostal, D.C. 2007. Reproductive physiology of the ridley sea turtle. Pages 151-165 *in* Plotkin P.T. (editor). Biology and Conservation of Ridley Sea Turtles. Johns Hopkins University Press, Baltimore, Maryland.

Routa, R.A. 1968. Sea turtle nest survey of Hutchinson Island, Florida. Quarterly Journal of the Florida Academy of Sciences 30(4):287-294.

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., 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.

Shaver, D.J. 2002. Research in support of the restoration of sea turtles and their habitat in national seashores and areas along the Texas coast, including the Laguna Madre. Final NRPP Report. U.S. Geological Survey, Department of the Interior.

Shaver, D.J. 2005. Analysis of the Kemp's ridley imprinting and headstart project at Padre Island National Seashore, Texas, 1978-88, with subsequent nesting and stranding records on the Texas coast. Chelonian Conservation and Biology 4(4):846-859.

Shaver, D.J. 2006a. Kemp's ridley sea turtle project at Padre Island National Seashore and Texas sea turtle nesting and stranding 2004 report. National Park Service, Department of the Interior.

Shaver, D.J. 2006b. Kemp's ridley sea turtle project at Padre Island National Seashore and Texas sea turtle nesting and stranding 2005 report. National Park Service, Department of the Interior.

Shaver, D.J. 2007. Texas sea turtle nesting and stranding 2006 report. National Park Service, Department of the Interior.

Shaver, D.J. 2008. Texas sea turtle nesting and stranding 2007 report. National Park Service, Department of the Interior.

Shaver, D.J. and C.W. Caillouet, Jr. 1998. More Kemp's ridley turtles return to south Texas to nest. Marine Turtle Newsletter 82:1-5.

Snover, M. 2005. Personal communication to the Loggerhead Sea Turtle Recovery Team. National Marine Fisheries Service.

Snover, M.L., A.A. Hohn, L.B. Crowder, and S.S. Heppell. 2007. Age and growth in Kemp's ridley sea turtles: evidence from mark-recapture and skeletochronology. Pages 89-106 *in* Plotkin P.T. (editor). Biology and Conservation of Ridley Sea Turtles. John Hopkins University Press, Baltimore, Maryland.

Sobel, D. 2002. A photographic documentation of aborted nesting at tempts 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., A.E. Dunham, A.J. Leslie, A.C. Steyermark, P.T. Plotkin, and F.V. Paladino. 1996. Worldwide population decline of *Dermochelys coriacea*: are leatherback turtles going extinct? Chelonian Conservation and Biology 2(2):290-222.

Spotila, J.R. R.D. Reina, A.C. Steyermark, P.T. Plotkin, and F.V. Paladino. 2000. Pacific leatherback turtles face extinction. Nature 405:529-530.

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.

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.

Sternberg, J. 1981. The worldwide distribution of sea turtle nesting beaches. Center for Environmental Education, Washington, D.C.

Stewart, K.R. 2007. Establishment and growth of a sea turtle rookery: the population biology of the leatherback in Florida. Unpublished Ph.D. dissertation. Duke University, Durham, North Carolina. 129 pages.

Stewart, K. and C. Johnson. 2006. *Dermochelys coriacea*-Leatherback sea turtle. In Meylan, P.A. (editor). Biology and Conservation of Florida Turtles. Chelonian Research Monographs 3:144-157.

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.

Stewart, K., M. Sims, A. Meylan, B. Witherington, B. Brost, and L.B. Crowder. 2011. Leatherback nests increasing significantly in Florida, USA; trends assessed over 30 years using multilevel modeling. Ecological Applications 21(1):263-273.

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.

Tomas, J. and J.A. Raga. 2007. Occurrence of Kemp's ridley sea turtle (*Lepidochelys kempii*) in the Mediterranean. Journal of the Marine Biological Association of the United Kingdom 2. Biodiversity Records 5640. 3 pages.

Trindell, R. 2005. Sea turtles and beach nourishment. Florida Fish and Wildlife Conservation Commission, Imperiled Species Management Section. Invited Instructor, CLE Conference.

Turtle Expert Working Group (TEWG). 1998. An assessment of the Kemp's ridley (*Lepidochelys kempii*) and loggerhead (*Caretta caretta*) sea turtle populations in the western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-409.

Turtle Expert Working Group (TEWG). 2000. Assessment for the Kemp's ridley and loggerhead sea turtle populations in the western North Atlantic. NOAA Technical Memorandum. NMFS-SEFSC-444.

Turtle Expert Working Group (TEWG). 2007. An assessment of the leatherback turtle population in the Atlantic Ocean. NOAA Technical Memorandum NMFS-SEFSC-555.

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.

U.S. Fish and Wildlife Service (USFWS). 2010. Final report on the Mexico/United States of America population restoration project for the Kemp's ridley sea turtle, *Lepidochelys kempii,* on the coasts of Tamaulipas and Veracruz, Mexico.

Watson, J.W., D. G. Foster, S. Epperly, and A. Shah. 2004. Experiments in the western Atlantic Northeast Distant Waters to evaluate sea turtle mitigation measures in the pelagic longline fishery. Report on experiments conducted in 2001-2003. February 4, 2004.

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.

Werler, J.E. 1951. Miscellaneous notes on the eggs and young of Texan and Mexican reptiles. Zoologica 36(3):37-38.

Wetterer, J.K., L.D. Wood, C. Johnson, H. Krahe, and S. Fitchett. 2007. Predaceous ants, beach replenishment, and nest placement by sea turtles. Environmental Entomology 36(5):1084-1091.

Wibbels, T., D.W. Owens, and D.R. Rostal. 1991. Soft plastra of adult male sea turtles: an apparent secondary sexual characteristic. Herpetological Review 22:47-49.

Williams, K.L., M.G. Frick, and J.B. Pfaller. 2006. First report of green, *Chelonia mydas*, and Kemp's ridley, *Lepidochelys kempii*, turtle nesting on Wassaw Island, Georgia, USA. Marine Turtle Newsletter 113:8.

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 Master of Science thesis. University of Central Florida, Orlando, Florida.

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. 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 L.M. Ehrhart. 1989. Status and reproductive characteristics of green turtles (*Chelonia mydas*) nesting in Florida. Pages 351-352 *in* Ogren, L., F. Berry, K. Bjorndal, H. Kumpf, R. Mast, G. Medina, H. Reichart, and R. Witham (editors). Proceedings of the Second Western Atlantic Turtle Symposium. NOAA Technical Memorandum NMFS-SEFC-226.

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.

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., 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.

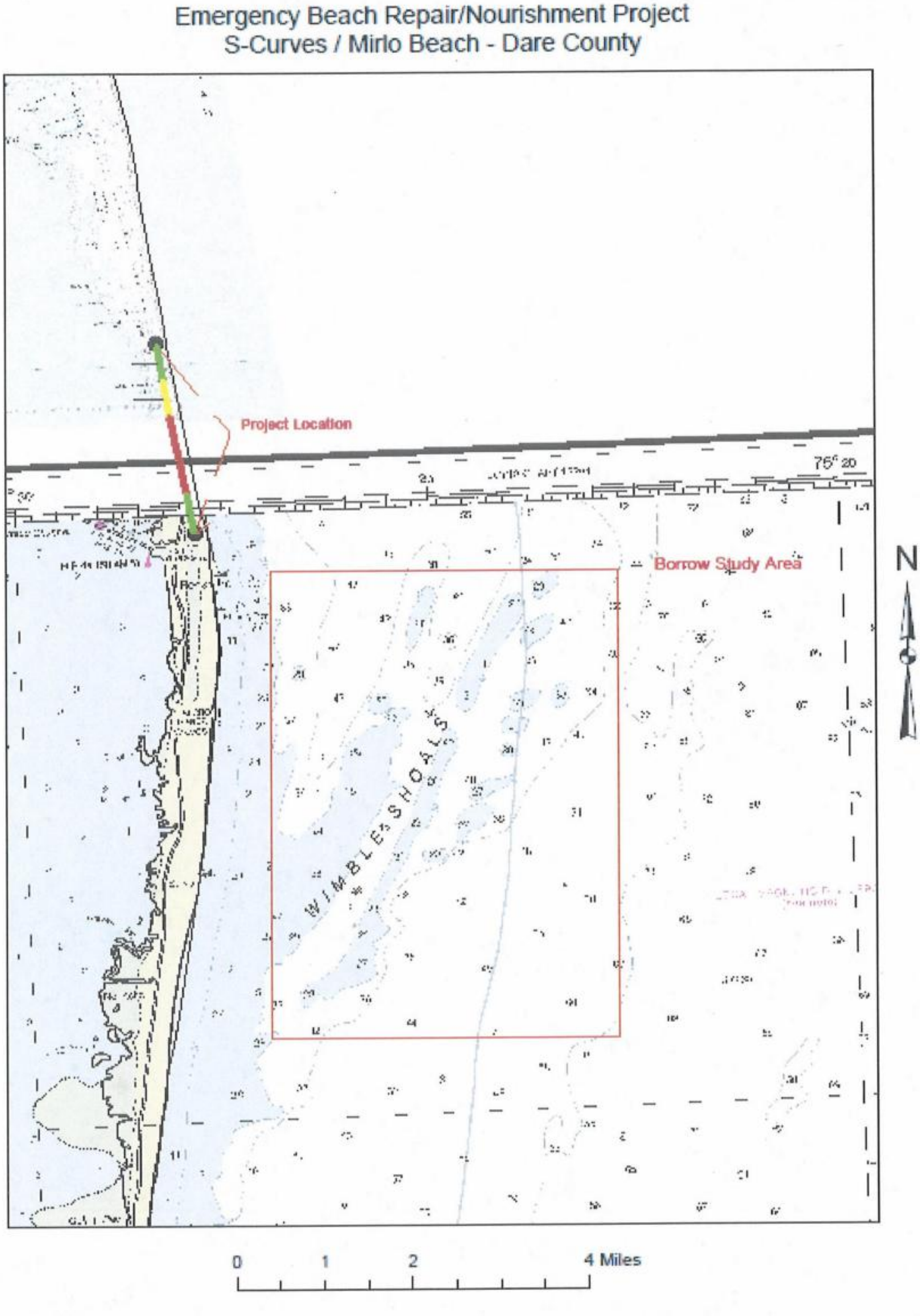
Wyneken, J., L.B. Crowder, and S. Epperly. 2005. Final report: evaluating multiple stressors in loggerhead sea turtles: developing a two-sex spatially explicit model. Final Report to the U.S. Environmental Protection Agency National Center for Environmental Research, Washington, DC. EPA Grant Number: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

# Figure 1

Emergency Beach Repair/Nourishment Project
S-Curves / Mirlo Beach - Dare County

# Figure 2



Emergency Beach Repair/Nourishment Project
S-Curves / Mirlo Beach - Dare County
Project Location
Borrow Study Area
WIMBLE SHOALS
75° 20
N
0
1
2
4 Miles