April 7, 2010

Colonel Alfred A. Pantano, Jr.
District Commander
U.S. Army Corps of Engineers
701 San Marco Boulevard, Room 372
Jacksonville, Florida 32207-8175

Service Federal Activity Code: 41420-2008-FA-0019
Corps Application No: SAJ-2006-5344 (IP-JWH)
Date Received: October 2, 2007
Formal Consultation Initiation Date: September 21, 2009
Project: Segmented Breakwater
Applicant: Palm Beach County
County: Palm Beach

Dear Colonel Pantano:

This document transmits the Fish and Wildlife Service's (Service) biological opinion based on our review of a proposed segmented breakwater construction project adjacent to Singer Island, Palm Beach County, Florida. The U.S. Army Corps of Engineers (Corps) determined on September 28, 2007, the proposed project "may affect" the threatened loggerhead sea turtle (*Caretta caretta*), the endangered leatherback sea turtle (*Dermochelys coriacea*), the endangered green sea turtle (*Chelonia mydas*), the endangered hawksbill sea turtle (*Eretmochelys imbricata*), and the endangered Kemp's ridley sea turtle (*Lepidochelys kempii*), and we concur with your determination. This document is provided in accordance with section 7 of the Endangered Species Act of 1973, as amended (Act) (87 Stat. 884; 16 U.S.C. 1531 *et seq.*).

In addition, in the September 28, 2007, letter, the Corps also determined the proposed action "may affect, but is not likely to adversely affect," the endangered West Indian manatee (*Trichechus manatus*), and we concur with your determination. In order to protect this species, the Corps will ensure specific construction safety precautions are implemented as outlined in the *Standard Manatee Conditions for In-Water Work* (Florida Fish and Wildlife Conservation Commission [FWC] 2009a). In addition, critical habitat for the West Indian manatee has not been designated in or adjacent to the project area. Based upon implementation of the above stated conditions, the Service concurs with the determination in regard to the West Indian manatee.

This biological opinion is based on information provided in the Corps' letter and Public Notice dated September 28, 2007, and correspondence with the Corps, National Marine Fisheries Service (NOAA Fisheries), FWC, Florida Department of Environmental Protection (DEP), Palm Beach

County (Applicant), Continental Shelf and Associates International (CSA), and Humiston and Moore Engineers (HME). A complete administrative record of this consultation is on file at the South Florida Ecological Services Office, Vero Beach, Florida.

FISH AND WILDLIFE RESOURCES

This section is provided in accordance with the Fish and Wildlife Coordination Act of 1958, as amended (48 Stat. 401; 16 U.S.C. 661 *et seq*.) to address other fish and wildlife resources in the project area.

A complete National Environmental Policy Act (NEPA) analysis which in part would provide an alternatives analysis as it relates to avoiding or minimizing potential impacts to fish and other wildlife resources, has not been provided by the Applicant or the Corps. Although some information was provided in the Applicant's 2002 feasibility study, the study did not adequately address all alternatives, the scope of the study was limited to specific erosion hot spots and not the proposed 1.5 mile project area, and the study recommended a different alternative than the current alternative.

In a letter dated October 29, 2009, the Corps informed the Applicant that the alternatives analysis provided in the feasibility study was insufficient and requested a detailed alternatives analysis to include the technical feasibility, cost, expected performance level, and environmental impacts associated with potential shoreline stabilization methods including, but not limited to, the "no action" alternative, beach nourishment, a sand transfer plant at Jupiter Inlet, bulkheads, groins, submerged breakwaters, and emergent breakwaters. In addition, that the analysis should include combinations of these alternatives.

In a letter dated January 15, 2010, the Applicant provided an alternatives analysis as requested by the Corps; however, the analysis is incomplete. For each of the alternatives addressed, the Applicant did not provide cost, technical feasibility information, and a discussion of how each design may potentially impact other wildlife resources. By definition, other wildlife resources includes birds, fishes, mammals, and other classes of wild animals and all types of aquatic and land vegetation upon which wildlife is dependent. In addition, the Applicant did not address the sand transfer plant alternative, or combination of alternatives. Furthermore, the Applicant concluded that submerged breakwaters would have negative shoreline effects based on the results of the Prefabricated Erosion Prevention (PEP) reef constructed by the Town of Palm Beach in 1992 and 1993. However, these reef modules were very small (approximately 6 feet x 2 feet) compared to the massive (362 feet x 103 feet at the base) breakwater segments currently proposed. During our consultation with the Corps, we requested modeling and performance level data of submerged breakwaters at varying elevations, widths, and permeability. The engineers have acknowledged the difficulty and inaccuracy in modeling submerged breakwaters which was reiterated in the Applicant's January 15, 2010 letter. That said, we can not conclude that a submerged breakwater design will not provide an acceptable level of shoreline performance while avoiding or minimizing potential impacts to wildlife resources.

In conclusion, a complete NEPA analysis needs to be performed to better address these and other issues.

Hardbottom Reef Habitat

The original project as outlined in the Corps' letter and Public Notice dated September 28, 2007, was to construct a segmented breakwater consisting of 13 rubble-mound segments and a terminal breakwater structure. Due to substantial impacts to nearshore hardbottom habitat in the southern region of the project area, the Applicant modified the project design by eliminating the terminal breakwater structure and the two southernmost breakwater segments as outlined in the Corps' letter dated August 29, 2008. Mitigation and monitoring as it relates to nearshore hardbottom impacts based on the current project designed is discussed below.

Natural exposed nearshore hardbottom reef habitat is present within the action area. The area of exposed nearshore hardbottom varies considerably each year both in acreage and location based on shoreline dynamics. The area of hardbottom exposed at any given time depends on the local sand budget, prevailing weather patterns, and littoral drift. From 1991 to 2006, HME mapped the exposed nearshore hardbottom from aerial surveys. During this 15-year period, HME determined that the amount of exposed nearshore hardbottom varied from a low of 4 acres in 2003, and a high of 28.5 acres in 2005. Further analysis indicated that some areas were more consistently exposed than others. Approximately 13.4 acres of nearshore hardbottom was consistently exposed between 2005 and 2006, and only 3.9 acres between 2004 and 2006 (CSA 2008). Approximately 0.14 acres of nearshore hardbottom was habitually exposed over the 15-year period (CSA 2008). Since 2005, the combination of persistent erosion and severe storm activity has resulted in a greater area of exposed nearshore hardbottom prior to 2005.

In 2007, CSA conducted a series of nearshore surveys to verify the extent and natural community of the nearshore hardbottom habitat. These data were used to ground truth the aerial survey data, assess potential direct and indirect impacts to nearshore hardbottom habitat due to project construction, and to obtain data for the preparation of the Uniform Mitigation Assessment Method. Based on these data and analyses, it has been determined that the proposed project will impact 2.79 acres of nearshore hardbottom habitat (1.49 acres permanently covered by the segmented breakwater structures and associated salients, and 1.3 acres habitually covered by adjusting sand).

As mitigation for 2.79 acres of nearshore hardbottom habitat impacts, the Applicant shall construct 3.44 acres of artificial reef within 6 months of commencing breakwater construction, or preferably preconstruction. The artificial reef shall be located in water depths of -6 to -10 feet National Geodetic Vertical Datum (NGVD), on substrate that has a sand depth over underlying rock of 1 to 3 feet, with a final vertical relief (after subsidence) of 1 to 3 feet. The artificial reef shall not be constructed in an area where the sand depth is less than 1 foot. The artificial reef will be constructed of limestone boulders between 1 and 3 feet in diameter that will be required to be touching for inclusion as a contiguous mitigation area. Any open sand areas between all contiguous boulders will be included toward mitigation. The artificial reef will be located offshore of Singer Island between DEP reference monument R-69.50 and R-71.25 (Figure 1).

Monitoring

Biological and physical monitoring of the artificial reef will be required as a condition of the DEP permit to ensure the quantity and functionality of the mitigation reef is maintained. Biological monitoring similar to that required for the Juno Beach nourishment project (DEP permit no. 0276415-003-JN) will be required.

Artificial reef construction surveys will be submitted within 45 days of completion to document the spatial dimensions in coverage (areal exposure and rugosity). The spatial dimensions of the artificial reef shall be measured and reported during each annual monitoring event for a minimum of 3 years postconstruction. Annual monitoring shall occur during the period between May and September, ideally not more than 30 days before or after the 1-year anniversary or the previous sampling. If surveys are delayed for any reason, a thorough discussion of the reasons and consequences to the findings shall be provided in the report.

The annual artificial reef monitoring reports shall include a summary of the successes and failures of the reef during the previous interim monitoring period, and the third or final report will summarize the results of artificial reef monitoring and make recommendations for additional mitigation and how future artificial reef design and construction could be improved.

If it is determined that additional impacts to nearshore hardbottom habitat has occurred during the initial 3-year monitoring period due to the construction of the segmented breakwater, additional mitigation acreage will be required for DEP permit compliance. Any additional mitigation must be constructed within 6 months upon completion of the third annual monitoring report outlining an artificial reef acreage deficit. The artificial reef monitoring period will be extended for an additional 3 years when additional mitigation is required.

NOAA Fisheries will assess and consult with the Corps concerning potential impacts to nearshore hardbottom reef habitat within the project area, and the shoreline updrift and downdrift area.

CONSULTATION HISTORY

On October 2, 2007, the Service received the Corps' letter and a copy of the Public Notice, both dated September 28, 2007.

On October 24, 2007, the Service emailed CSA a request for additional information regarding the Singer Island Erosion Control Monitoring Plan.

On November 3, 2007, the Service emailed the Corps a request for additional information.

On March 14, 2008, the Service received a response to the first request for additional information from HME.

On April 16, 2008, the Service emailed the Corps a second request for additional information.

On May 2, 2008, the Service received a partial response to the second request for additional information from HME.

On August 22, 2008, the Service received an additional response to the second request for additional information from HME.

On August 29, 2008, the Service received an electronic copy of a letter dated August 29, 2008, from the Corps to NOAA Fisheries outlining changes in the project to decrease the size of the proposed segmented breakwater by eliminating the two southernmost breakwater segments and the terminal structure.

On September 16, 2008, the Service emailed the Corps a third request for additional information.

On January 23, 2009, the Service received a response to the third request for additional information from HME.

On February 12, 2008, the Service emailed the Corps a fourth request for additional information.

On February 19, 2009, the Service emailed the Corps inquiring whether or not an environmental or biological assessment would be provided since an alternative analysis, and a description of the avoidance, minimization, and conservation measures based on the proposed project was not been adequately addressed.

On March 7, 2009, the Service received a partial response to the fourth request for additional information from the Applicant.

On April 27, 2009, the Service emailed the Corps a fifth request for additional information.

On May 11, 2009, the Service received an electronic copy of the updated Public Notice dated May 11, 2009. The updated Public Notice included the mitigation plan to offset unavoidable functional loss to nearshore habitat.

On June 25, 2009, the Service received a response to the fifth request for additional information from the Applicant.

On July 28, 2009, the Service emailed the Corps a sixth request for additional information.

On August 14, 2009, the Service received a response to the sixth request for additional information from the Applicant.

On August 25, 2009, the Service emailed the Corps a seventh request for additional information.

On August 28, 2009, the Service received a response to the seventh request for additional information from the Applicant.

On September 1, 2009, the Service emailed the Corps an eighth request for additional information.

On September 17, 2009, the Service received a response to the eighth request for additional information from HME.

On September 21, 2009, the Service reviewed the last of the requested information received from HME and initiated formal consultation with the Corps.

On January 20, 2010, during a teleconference between the Corps, Service, and NOAA Fisheries, it was discussed whether or not the Corps could complete their Environmental Assessment (EA) without completed biological opinions from NOAA Fisheries and the Service.

On January 26, 2010, NOAA Fisheries and the Service discussed their respective concerns as they relate to potential impacts to swimming female, hatchling, and nesting sea turtles, and current effects analysis.

On January 27, 2010, the Service sent an email to the Corps requesting a 60-day extension to complete formal consultation.

On February 16, 2010, NOAA Fisheries, Service, Corps, and the Applicant, met to discuss sea turtle issues, breakwater modeling, breakwater design reconfigurations, and the status of each agency in regard to their involvement in the consultation process.

On March 19, 2010, the Service received a copy of the Corps’ Coastal and Hydraulics Laboratory Technical Review of the Singer Island Erosion Control Project Coastal Processes Analyses, Numerical Modeling, and Design Development.

On March 26, 2010, the Service participated in a meeting with the Corps, NOAA Fisheries, DEP, Applicant, HME, and County Commissioner Karen Marcus.

On March 31, 2010, the Service received a copy of a letter submitted to the Corps from the Applicant dated March 31, 2010, requesting that all agencies suspend further review of the current proposed project application.

On March 31, 2010, the Service received a copy of a letter submitted to the Applicant from the Corps dated March 31, 2010, informing the Applicant that their request to suspend the permit applicant had been granted.

On March 31, 2010, the Service received an email from the Corps requesting a copy of our draft biological opinion for the emergent Singer Island breakwater project.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

The Applicant proposes to construct an emergent rubble mound breakwater located approximately 200 feet offshore Singer Island, Palm Beach County, Florida (Figure 2). The project area consists of 11 breakwater segments extending approximately 1.1 miles between DEP reference monument R-60.5 and R-66 (Figure 2). Each breakwater segment will measure approximately 103 feet in width and 362 feet in length at the base. The crest of each breakwater segment varies between 150 to 240 feet in length and will extend +3 feet NGVD. Mean high water (MHW) is 1.98 NGVD. Each breakwater segment will be separated by approximately 180 and 300 feet, toe to toe, and crest to crest, respectively. The breakwater segments will be located in depths ranging from -10 to -16 feet NGVD. The intent of the project is provide shoreline protection and erosion control.

Each of the eleven rubble mound breakwater segments will consist of a filter fabric\geogrid layer, bedding stones, and armor stones (Figure 3). The bedding and armor stone along the landward side and at lower elevations on the seaward side of each breakwater segment will consist of native limestone. Armor stone on the crest and seaward side of each breakwater segment which will be exposed to greater wave forces will be constructed from denser granite for improved stability. Each limestone and granite armor boulder will weigh approximately 3 to 4 tons. Armor and bedding stones will be washed prior to placement, and all construction activities will be conducted from barges using long-armed excavators and rock grapplers. Barge anchoring will be seaward of any existing nearshore hardbottom habitat. All construction activities will take place during daylight hours and no construction equipment will be left in the action area over night. Most construction will take place during the summer months over a period of 2 years; however, weather permitting, construction may also take place during the winter months. Construction is scheduled to commence during the summer 2010.

The action area is defined as all areas to be affected directly or indirectly by the action and not merely the immediate area involved in the action. The Service identifies the action area to include all submerged land (extending approximately 300 feet seaward of the mean high water line) and dry beach (to the dune crest or retaining wall where no dune exists) located between DEP reference monument R-60.5 and R-66 (approximately 1.12 miles), the dry beach adjacent to and the submerged land associated with the mitigation reef (between DEP reference monument R-69.50 and R-71.25), the shoreline updrift area between DEP reference monument R-55 and R-60.5 (approximately 1.03 miles), and the shoreline downdrift area between DEP reference monument R-66 and R-72 (approximately 1.14 miles). The project is located along Singer Beach, Palm Beach County, Florida at latitude 26.8143 and longitude -80.0346.

Monitoring Plan

Although the project construction template was reduced by eliminating the terminal breakwater structure and the two southernmost breakwater segments to reduce impacts to nearshore hardbottom habitat, project performance and impacts will be monitored through physical and biological monitoring events which shall be a condition of the Corps' permit. The Applicant's Singer Island Erosion Control Project Physical Monitoring Plan will include the following components.

1. Beach profile surveys (DEP reference monument, nearshore, and MHW line profiles).
2. Aerial photography to delineate the boundaries between the salient and hardbottom.
3. Mitigation and project modification assessments to assess the performance of the segmented breakwater.
4. A contingency plan that will be implemented to mitigate for impacts if one of the trigger criteria is exceeded.
5. Annual and postconstruction monitoring reports.

In addition, extensive biological monitoring as outlined in the Applicant's Singer Island Erosion Control Project Sea Turtle Monitoring Plan will be conducted. This plan consists of five components:

1. Swimming sea turtles (inwater monitoring, monofilament surveys and removal, and benthic characterization).
2. Nesting sea turtles (daily nesting surveys, nest monitoring and evaluations, and cumulative effects annual report).
3. Hatching sea turtles (hatchling predation and orientation studies, fish surveys, bird predation surveys, and lighting surveys and compliance actions).
4. Shorebird surveys.
5. Beach response monitoring (escarpment mapping, high water line and toe of dune mapping, compaction monitoring, and survey zone characterization).

STATUS OF THE SPECIES/CRITICAL HABITAT

Species/critical habitat description

Loggerhead Sea Turtle

The loggerhead sea turtle, listed as a threatened species on July 28, 1978 (43 Federal Register [FR] 32800), inhabits the continental shelves and estuarine environments along the margins of the Atlantic, Pacific, and Indian Oceans. Loggerhead sea turtles nest within the continental United States (U.S.) from Louisiana to Virginia. Major nesting concentrations in the U.S. are found on the coastal islands of North Carolina, South Carolina, and Georgia, and on the Atlantic and Gulf coasts of Florida (Hopkins and Richardson 1984).

No critical habitat has been designated for the loggerhead sea turtle.

Green Sea Turtle

The green sea turtle was federally listed on July 28, 1978 (43 FR 32800). Breeding populations of the green turtle in Florida and along the Pacific Coast of Mexico are listed as endangered; all other populations are listed as threatened. The green turtle has a worldwide distribution in tropical and subtropical waters. Major green turtle nesting colonies in the Atlantic occur on Ascension Island, Aves Island, Costa Rica, and Suriname. Within the U.S., green 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 (NOAA Fisheries and Service 1991a). Nesting has also been documented along the Gulf coast of Florida on Santa Rosa Island (Okaloosa and Escambia Counties) and from Pinellas County through Collier County. Green turtles have been known to nest in Georgia, but only on rare occasions, and sporadically in North Carolina and South Carolina. Unconfirmed nesting of green turtles in Alabama has also been reported.

Critical habitat for the green sea turtle has been designated for the waters surrounding Culebra Island, Puerto Rico, and its outlying keys (63 FR 46693)

Leatherback Sea Turtle

The leatherback sea turtle, listed as an endangered species on June 2, 1970 (35 FR 8491), nests on shores of the Atlantic, Pacific and Indian Oceans. Nonbreeding animals have been 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). Nesting grounds are distributed worldwide, with the Pacific Coast of Mexico supporting the world’s largest known concentration of nesting leatherbacks in the Pacific. The largest nesting colony in the wider Caribbean region is found in French Guiana, but nesting occurs frequently, although in lesser numbers, from Costa Rica to Columbia and in Guyana, Suriname, and Trinidad (National Research Council 1990; NOAA Fisheries and Service 1992).

The leatherback regularly nests in the U.S. in Puerto Rico, the U.S. Virgin Islands, and along the Atlantic coast of Florida as far north as Georgia (NOAA Fisheries and Service 1992). Leatherback turtles have been known to nest in Georgia, South Carolina, and North Carolina, but only on rare occasions. Leatherback nesting has also been reported on the northwest coast of Florida (LeBuff 1990); a false crawl (nonnesting emergence) has been observed on Sanibel Island (LeBuff 1990).

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 (44 FR 17710).

Hawksbill Sea Turtle

The hawksbill sea turtle was listed as an endangered species on June 2, 1970 (35 FR 8491). The hawksbill is found in tropical and subtropical seas of the Atlantic, Pacific, and Indian Oceans.

The species is widely distributed in the Caribbean Sea and western Atlantic Ocean. Within the continental U.S., hawksbill sea turtle nesting is rare and is restricted to the southeastern coast of Florida (Volusia through Miami-Dade Counties) and the Florida Keys (Monroe County) (Meylan 1992; Meylan et al. 1995). However, hawksbill tracks are difficult to differentiate from those of loggerheads and may not be recognized by surveyors. Therefore, surveys in Florida likely underestimate actual hawksbill nesting numbers (Meylan et al. 1995). In the U.S. Caribbean, hawksbill nesting occurs on beaches throughout Puerto Rico and the U.S. Virgin Islands (NOAA Fisheries and Service 1993).

Critical habitat for the hawksbill sea turtle has been designated for selected beaches or waters of Mona, Monito, Culebrita, and Culebra Islands, Puerto Rico (63 FR 46693).

Kemp's Ridley Sea Turtle

The Kemp's Ridley sea turtle was listed as endangered on December 2, 1970 (35 FR 18320). The range of the Kemp's ridley includes the Gulf of Mexico coasts of Mexico and the U.S., and the Atlantic coast of North America as far north as Nova Scotia and Newfoundland. Most Kemp's ridleys nest on the coastal beaches of the Mexican states of Tamaulipas and Veracruz, although a very small number of Kemp's ridleys nest consistently along the Texas coast (Turtle Expert Working Group 1998). In addition, rare nesting events have been reported in Florida, Alabama, South Carolina, and North Carolina. Outside of nesting, adult Kemp's ridleys are believed to spend most of their time in the Gulf of Mexico, while juveniles and subadults also regularly occur along the eastern seaboard of the U.S. (Service and NOAA Fisheries 1992).

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

Life history

Loggerhead Sea Turtle

Loggerheads are known to nest from one to seven times within a nesting season (Talbert et al. 1980; Lenarz et al. 1981; Richardson and Richardson 1982); the mean is approximately 4.1 (Murphy and Hopkins 1984). The interval between nesting events within a season varies around a mean of about 14 days (Dodd 1988). Mean clutch size varies from about 100 to 126 eggs along the southeastern U.S. coast (NOAA Fisheries and Service 1991b). Incubation ranges from about 45 to 95 days. Nesting migration intervals of 2 to 3 years are most common in loggerheads, but the number can vary from 1 to 7 years (Dodd 1988). Age at sexual maturity is believed to be about 20 to 30 years (Turtle Expert Working Group 1998).

Green Sea Turtle

Green turtles deposit from one to nine clutches within a nesting season, but the overall average is 3.3. The mean interval between nesting events within a season is 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). Incubation ranges from about 45 to 75 days. Only occasionally do females produce clutches in successive years. Usually 2 or more years intervene between breeding seasons (NOAA Fisheries and Service 1991a). Age at sexual maturity is believed to be 20 to 50 years (Hirth 1997).

Leatherback Sea Turtle

Leatherbacks nest five to seven times within a nesting season, with an observed maximum of 11 (NOAA Fisheries and Service 1992). The interval between nesting events within a season is about 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). Incubation ranges from about 55 to 75 days. Nesting migration intervals of 2 to 3 years were observed in leatherbacks nesting on Sandy Point National Wildlife Refuge, St. Croix, U.S. Virgin Islands (McDonald and Dutton 1996). Leatherbacks are believed to reach sexual maturity in 6 to 10 years (Zug and Parham 1996).

Hawksbill Sea Turtle

Hawksbills nest on average four and one half times per season at intervals of approximately 14 days (Corliss et al. 1989). In Florida and the U.S. Caribbean, clutch size is approximately 140 eggs, although several records exist of over 200 eggs per nest (NOAA Fisheries and Service 1993). Incubation lasts for about 60 days. On the basis of limited information, nesting migration intervals of 2 to 3 years appear to predominate. Hawksbills are recruited into the reef environment at about 14 inches in length and are believed to begin breeding about 30 years later. The time required to reach 14 inches in length however, is unknown, and growth rates vary geographically. As a result, actual age at sexual maturity is not known.

Kemp's Ridley Sea Turtle

Nesting occurs from April into July during which time the turtles appear off the Tamaulipas and Veracruz coasts of Mexico. Precipitated by strong winds, the females swarm to mass nesting emergences, known as *arribadas* or *arribazones*, to nest during daylight hours. Clutch size averages 100 eggs (Service and NOAA Fisheries 1992). The incubation period ranges from 45 to 70 days. Hatchlings, after leaving the nesting beach, are believed to become entrained in eddies within the Gulf of Mexico, where they are dispersed within the Gulf and Atlantic by oceanic surface currents until they reach about 8 inches in length, at which size they enter coastal shallow water habitats (Ogren 1989). Some females breed annually and nest an average of one to four times in a season at intervals of 10 to 28 days. Age at sexual maturity is believed to be between 7 to 15 years (Turtle Expert Working Group 1998).

Population dynamics

Loggerhead Sea Turtle

The loggerhead occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans. However, the majority of loggerhead nesting is at the western regions of the

Atlantic and Indian Oceans. The most recent reviews show that only two loggerhead nesting beaches (South Florida [U.S.] and Masirah [Oman]) have greater than 10,000 females nesting per year (Baldwin et al. 2003; Ehrhart et al. 2003; Kamezaki et al. 2003; Limpus and Limpus 2003; Margaritoulis et al. 2003). Beaches with 1,000 to 9,999 females nesting each year are Georgia through North Carolina (U.S.), Quintana Roo and Yucatán (Mexico), Cape Verde Islands (Cape Verde, eastern Atlantic off Africa), and Western Australia (Australia). Smaller nesting aggregations with 100 to 999 nesting females annually occur in the Northern Gulf of Mexico (U.S.), Dry Tortugas (U.S.), Cay Sal Bank (Bahamas), Sergipe and Northern Bahia (Brazil), Southern Bahia to Rio de 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 47,000 and 90,000 nests per year over the last decade (FWC, unpublished data; Georgia and South Carolina Department of Natural Resources, unpublished data; North Carolina Wildlife Resources Commission, unpublished data). 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 nonnesting 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). 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. The loggerhead nesting aggregations in Oman and the U.S. account for the majority of nesting worldwide.

Green Sea Turtle

About 150 to 2,750 females are estimated to nest on beaches in the continental U.S. annually. 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 (NOAA Fisheries and Service 1998a). 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 group 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 possible 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 was 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 (Turtle Expert Working Group 2007). In Florida, an annual increase in number of leatherback nests at the core set of index beaches ranged from 27 to 498 between 1989 and 2008. Under the Core Index Nesting Beach Survey (INBS) program, 198.8 miles of nesting beach have been divided into zones, know as core index zones, averaging 0.5 mile in length. Annually, between 1989 and 2008, these core index zones were monitored daily during the 109-day sea turtle index nesting season (May 15 to August 31). On all index beaches, researchers recorded nests and nesting attempts by species, nest location, and date.

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 between a low of 5,029 nests in 1967 to a high of 63,294 nests in 2005, which represents a 92 percent increase since 1967 (Turtle Expert Working Group 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 on the main island of Puerto Rico and on the island of Culebra. Between 1978 and 2005, nesting increased in Puerto Rico with a minimum of 9 nests recorded in 1978 and a minimum of 469 to 882 nests recorded each year between 2000 and 2005. Recorded leatherback nesting on the Sandy Point National Wildlife Refuge on the island of St. Croix, U.S. Virgin Islands between 1990 and 2005, ranged from a low of 143 in 1990 to a high of 1,008 in 2001. In the British Virgin Islands, annual nest numbers have increased in Tortola from 0 to 6 nests per year in the late 1980s to 35 to 65 nests per year in the 2000s.

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. 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 and the Democratic Republic of the Congo, and Angola. In addition, a large nesting population is found on the island of Bioko (Equatorial Guinea).

Hawksbill Sea Turtle

About 15,000 females are estimated to nest each year throughout the world with the Caribbean accounting for 20 to 30 percent of the world’s hawksbill population. Only five regional populations remain with more than 1,000 females nesting annually (Seychelles, Mexico, Indonesia, and two in Australia) (Meylan and Donnelly 1999). Mexico is now the most important region for hawksbills in the Caribbean with about 3,000 nests per year (Meylan 1999). Other significant but smaller populations in the Caribbean still occur in Martinique, Jamaica, Guatemala, Nicaragua, Grenada, Dominican Republic, Turks and Caicos Islands, Cuba, Puerto Rico, and U.S. Virgin Islands. In the U.S. Caribbean, about 150 to 500 nests per year are laid on Mona Island, Puerto Rico and 70 to 130 nests per year are laid on Buck Island Reef National Monument, U.S. Virgin Islands. In the U.S. Pacific, hawksbills nest only on main island beaches in Hawaii, primarily along the east coast of the island of Hawaii. Hawksbill nesting has also been documented in American Samoa and Guam (NOAA Fisheries and Service 1998b).

Kemp’s Ridley Sea Turtle

Most Kemp’s ridleys nest on the coastal beaches of the Mexican states of Tamaulipas and Veracruz, although a small number of Kemp’s ridleys nest consistently along the Texas coast (Turtle Expert Working Group 1998). 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 Kemp’s 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 2007, 11,268 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 15,032 (Service 2007). During the 2007 nesting season, an arribada with an estimated 5,000 turtles was recorded at Rancho Nuevo from May 20 to May 23. In addition, 128 nests were recorded during 2007 in the U.S., primarily in Texas.

Status and distribution

Loggerhead Sea Turtle

Genetic research involving analysis of mitochondrial DNA has identified five different loggerhead subpopulations per nesting aggregations in the western North Atlantic: (1) the Northern Subpopulation occurring from North Carolina to around Cape Canaveral, Florida (about 29° N.); (2) South Florida Subpopulation occurring from about 29° N. on Florida’s east coast to Sarasota on Florida’s west coast; (3) Dry Tortugas, Florida, Subpopulation, (4) Northwest Florida Subpopulation occurring at Eglin Air Force Base and the beaches near Panama City; and (5) Yucatán Subpopulation occurring on the eastern Yucatán Peninsula, Mexico (Bowen et al. 1993; Bowen 1994, 1995; Encalada et al. 1998; Pearce 2001). These data indicate gene flow between the five regions is very low. If nesting females are extirpated from one of these regions, regional dispersal will not be sufficient to replenish the depleted nesting subpopulation. The Northern Subpopulation has declined substantially since the early 1970s. Recent estimates of loggerhead nesting trends from daily beach surveys showed a significant decline of 1.3 percent annually for the period 1989 to 2008 (NOAA Fisheries and Service 2008). Nest totals from aerial surveys conducted by the South Carolina Department of Natural Resources showed a 3.3 percent annual decline in nesting since 1980 (NOAA Fisheries and Service 2008). Overall, there is strong statistical evidence to suggest the Northern Subpopulation has sustained a long-term decline.

Furthermore, data from all beaches where nesting activity has been recorded indicate the South Florida Subpopulation has shown significant increases over the last 25 years. However, an analysis of nesting data from the Florida INBS Program from 1989 to 2002, a period encompassing index surveys that are more consistent and more accurate than surveys in previous years, has shown no detectable trend and, more recently (1998 through 2008), has shown evidence of a declining trend (Figure 4). Given inherent annual fluctuations in nesting and the short time period over which the decline has been noted, caution is warranted in interpreting the decrease in terms of nesting trends.

A near complete census of the Florida Panhandle Subpopulation undertaken from 1989 to 2007, revealed a mean of 64,513 nests per year, which represents approximately 15,735 females nesting per year. This near complete census provides the best statewide estimate of total abundance, but because of viable survey effort, these numbers cannot be used to assess trends. Loggerhead nesting trends are best assessed using standardized nest counts made at INBS sites surveyed with constant effort over time. An analysis of these data has shown a decline in nesting from 1989 to 2008 (Witherington et al. 2009).

A near complete census of the Dry Tortugas Subpopulation undertaken from 1995 to 2004 (excluding 2002), reveals a mean of 246 nests per year, which equates to about 60 females nesting per year. The nesting trend data for the Dry Tortugas Subpopulation are from beaches that were not part of the INBS program, but are part of the Statewide Nesting Beach Survey program. There are 9 continuous years (1995 to 2004) of data for this Subpopulation, but the time series is too short to detect a trend.

Nesting surveys in the Yucatán Subpopulations have been too irregular to date to allow for a meaningful trend analysis (Turtle Expert Working Group 1998, 2000).

Threats include incidental take from channel dredging and commercial trawling, longline, and gill net fisheries; loss or degradation of nesting habitat from coastal development and beach armoring; disorientation of hatchlings by beachfront lighting; excessive nest predation by native and nonnative predators; degradation of foraging habitat; marine pollution and debris; watercraft strikes; and disease. There is particular concern about the extensive incidental take of juvenile loggerheads in the eastern Atlantic by longline fishing vessels from several countries.

Green Sea Turtle

Total population estimates for the green turtle are unavailable, and trends based on nesting data are difficult to assess because of large annual fluctuations in numbers of nesting females. For instance, in Florida, where the majority of green turtle nesting in the southeastern U.S. occurs, estimates range from 150 to 2,750 females nesting annually. Populations in Suriname and Tortuguero, Costa Rica, may be stable, but there is insufficient data for other areas to confirm a trend.

A major factor contributing to the green turtle's decline worldwide is commercial harvest for eggs and food. Fibropapillomatosis, a disease of sea turtles characterized by the development of multiple tumors on the skin and internal organs, is also a mortality factor and has seriously impacted green turtle populations in Florida, Hawaii, and other parts of the world. The tumors interfere with swimming, eating, breathing, vision, and reproduction, and turtles with heavy tumor burdens may die. Other threats include loss or degradation of nesting habitat from coastal development and beach armoring; disorientation of hatchlings by beachfront lighting; excessive nest predation by native and nonnative predators; degradation of foraging habitat; marine pollution and debris; watercraft strikes; and incidental take from channel dredging and commercial fishing operations.

Leatherback Sea Turtle

Declines in leatherback nesting have occurred over the last 2 decades along the Pacific coasts of Mexico and Costa Rica. The Mexican leatherback nesting population, once considered to be the world’s largest leatherback nesting population (historically estimated to be 65 percent of the worldwide population), is now less than 1 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. Presently, the largest population is in the western Atlantic. Using an age-based demographic model, Spotila et al. (1996) determined leatherback populations in the Indian Ocean and western Pacific Ocean cannot withstand even moderate levels of adult mortality and even the Atlantic populations are being exploited at a rate that cannot be sustained. They concluded leatherbacks are on the road to extinction and further population declines can be expected unless we take action to reduce adult mortality and increase survival of eggs and hatchlings.

The crash of the Pacific leatherback population is believed primarily to be the result of exploitation by humans for the eggs and meat, as well as incidental take in numerous commercial fisheries of the Pacific. Other factors threatening leatherbacks globally include loss or degradation of nesting habitat from coastal development; disorientation of hatchlings by beachfront lighting; excessive nest predation by native and nonnative predators; degradation of foraging habitat; marine pollution and debris; and watercraft strikes.

Hawksbill Sea Turtle

The hawksbill sea turtle has experienced global population declines of 80 percent or more during the past century and continued declines are projected (Meylan and Donnelly 1999). Most populations are declining, depleted, or remnants of larger aggregations. Hawksbills were previously abundant, as evidenced by high-density nesting at a few remaining sites and by trade statistics. The decline of this species is primarily due to human exploitation for tortoiseshell. While the legal hawksbill shell trade ended when Japan agreed to stop importing shell in 1993, a significant illegal trade continues. It is believed individual hawksbill populations around the world will continue to disappear under the current regime of exploitation for eggs, meat, and tortoiseshell, loss of nesting and foraging habitat, incidental capture in fishing gear, ingestion of and entanglement in marine debris, oil pollution, and boat collisions. Hawksbills are closely associated with coral reefs, one of the most endangered marine ecosystems.

Kemp's Ridley Sea Turtle

The decline of this species was primarily due to human activities, including the direct harvest of adults and eggs and incidental capture in commercial fishing operations. Today, under strict protection, the population appears to be in the early stages of recovery. The recent nesting increase can be attributed to full protection of nesting females and their nests in Mexico resulting from a binational effort between Mexico and the U.S. to prevent the extinction of the Kemp's ridley, and the requirement to use turtle excluder devices in shrimp trawls in both nations.

The Mexican government also prohibits harvesting, and is working to increase the population through more intensive law enforcement, by fencing nest areas to reduce natural predation, and by relocating all nests into corrals to prevent poaching and predation. While relocation of nests into corrals is currently a necessary management measure, this relocation and concentration of eggs into a “safe” area is of concern since it makes the eggs more susceptible to reduced viability due to movement-induced mortality, disease vectors, catastrophic events like hurricanes, and marine predators once the predators learn where to concentrate their efforts.

Analysis of the species/critical habitat likely to be affected

<u>Sea Turtles</u>

Annual sea turtle nesting surveys conducted along Singer Island indicate that the loggerhead, green, and leatherback sea turtles are the only species that regularly nest within the action area. Although hawksbill sea turtle nesting has been documented five times in Palm Beach County since 1985 (Meylan et al. 1995), with the most recent report in 2004, no nesting has been reported from the proposed action area. Although no nesting has been reported in Palm Beach County for Kemp’s ridley sea turtles, four false crawls at Phipps Ocean Park were reported in 1989 (Meylan et al. 1995).

The proposed action has the potential to adversely affect sea turtle nesting and hatchling success within the action area. 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 any sea turtle in the continental U.S.; therefore, the proposed action would not result in an adverse modification to critical habitat.

ENVIRONMENTAL BASELINE

Climate Change

According to the Intergovernmental Panel on Climate Change Report (IPCC 2007), warming of the earth’s climate is unequivocal, as is now evident from observations of increases in average global air and ocean temperatures, widespread melting of snow and ice, and rising sea level. The IPCC Report (2007) describes changes in natural ecosystems with potential widespread effects on many organisms, including marine mammals, reptiles, and migratory birds. The potential for rapid climate change poses a significant challenge for fish and wildlife conservation. Species abundance and distribution are dynamic, relative to a variety of factors, including climate. As climate changes, the abundance and distribution of fish and wildlife will also change. Highly specialized or endemic species are likely to be most susceptible to the stresses of changing climate. Based on these findings and other similar studies, the Department of the Interior requires agencies under its direction to consider potential climate change effects as part of their long-range planning activities (Service 2008).

Climate change at the global level drives alterations in weather at the regional level, although weather is also strongly affected by season and local effects (*e.g*., elevation, topography, latitude, proximity to the ocean). Average temperature is predicted to rise from 36^{o}F to 41^{o}F for North America by the end of this century (IPCC 2007). Other processes to be affected by this projected warming include rainfall (amount, seasonal timing, and distribution), storms (frequency and intensity), and sea level rise. However, the exact magnitude, direction, and distribution of these changes at the regional level are not well understood or easy to predict. Seasonal change and local geography make prediction of the effects of climate change at any location variable. Climatic changes in south Florida could amplify current land management challenges involving habitat fragmentation, urbanization, invasive species, disease, parasites, and water management (Pearlstine 2008).

Air Temperature

Current models predict changes in mean global temperature in the range of 4^{o}F to 8^{o}F by 2100. How this manifests at the regional and local scale is uncertain. A change of just a couple degrees can have profound effects, particularly at temperature extremes. For example, in Florida, winter frost, a 2-degree transition from 33^{o}F to 31^{o}F, greatly affects vegetation. While predicted changes in average annual temperature appear small, local and seasonal temperature variation may be greater. It is also important to consider that an increase in the temperature of the global atmosphere may manifest as an increase or a decrease in local means and extremes. We do not currently know either the direction or anticipated size of temperature change in Florida, but the following possibilities at the local level should be considered:

1. Changes (likely small) in mean annual temperature.
2. Greater extremes of temperature in summer (average highs) and winter (average lows).
3. More prolonged and seasonally extended frosts.
4. Shifts in the distribution of temperature regimes (*e.g.*, isotherms and growing zones).
5. Changes in the seasonal onset of temperature changes (*e.g.*, earlier spring).
6. Changes in the duration of temperature regimes (*e.g.*, longer and warmer summers).
7. Changes in both air and water (lake, river, ocean) temperature.

Most organisms have preferred ranges of temperature and lethal temperature limits they cannot survive. Many organisms require temperature signals or suitable temperature regimes to successfully complete life cycle activities such as nesting and winter dormancy. Some organisms are sensitive to temperature for incubation, sex determination (*e.g.*, sea turtles, alligators), or seed germination. The oxygen content of water (affecting fish) and the water content of vegetation (affecting fire combustion) are temperature-dependent. Some noxious or undesirable organisms may proliferate under different temperature regimes (*e.g.*, blue green algae in lakes and exotic species). Changes in temperature will likely affect fish and wildlife resources in many ways depending on the direction, amount, timing, and duration of the changes.

Rainfall

Ecosystems in Florida are sensitive to variation in rainfall. Well-drained soils, rapid runoff, and high plant transpiration quickly redistribute water available to organisms. Despite a high average rainfall, much of Florida experiences seasonal drought that profoundly affects fish and wildlife resources. Florida’s rain depends on both global and regional climate factors (*e.g.*, jet stream, El

Niño, frontal progression, storms and hurricanes) and local weather (*e.g.*, thunderstorms, sea breezes, lake effects and local circulation) that are likely affected by climate change. The following possibilities at the local level should be considered:

1. Changes in average annual rainfall (*e.g.*, higher or lower).
2. Changed seasonal distribution of rainfall (*e.g.*, when rain falls).
3. Changed regional distribution of rainfall (*e.g.*, where rain falls).
4. Changed intensity (*e.g.*, more severe storm rain, or dispersed "misty" rain).

Rainfall changes are affected by temperature. The affects of changes in rainfall will likely be mediated through responses by vegetation and the changed availability of surface water (*e.g.*, lakes, ponds, rivers, swamps, and wet prairies) on which many organisms depend. In the longer term, changes in deposition or recharge to surficial and deep aquifers may affect spring flow. Florida has an unusually large area of wetland habitats supporting wildlife. If climate change reduces rainfall, then desertification of much of Florida is possible and it may come to resemble "desert islands" such as much of the Bahamas that occur at the same latitude. Rainfall changes may have the most profound effects on Florida's fish and wildlife resources.

Storms

Another predicted effect of climate change is to increase the frequency and intensity of severe storms, particularly tropical cyclones (hurricanes). Higher sea temperatures and high atmosphere conditions generate energy and conditions suitable for storms. There is some controversy about whether this effect is already discernible against the background of natural variation and cycles of hurricane occurrence.

Hurricanes are generally considered detrimental to human interests and may directly cause wildlife mortality. However, their effect in natural systems is generally transient; plants and animals tend to rapidly recover. Hurricanes do have significant secondary effects, reshaping coastal habitat structure (barrier islands, beaches, salt/freshwater intrusion to marshes, and estuaries), replenishing water bodies and aquifers and renewing plant succession, which are not completely negative for wildlife. Hurricane effects will interact with rainfall and sea level changes, possibly exacerbating coastal flooding. Hurricanes also redistribute organisms, particularly plants, by spreading seeds and other propagules. The following possibilities at the local level should be considered:

1. Changes in storm intensity and frequency.
2. Changes in the possibility of more concentrated storm tracks leading to more frequent storm landfall.
3. Interaction of surge and sea level for more severe coastal and adjacent inland effects.
4. Distribution of invasive species.

Sea Level Rise

All current predictions suggest sea level will rise due to melting of continental and glacial ice and thermal expansion of the oceans. Florida, with its extensive coastline and low topography is highly vulnerable to sea level rise. The magnitude of the predicted rise is currently unknown and estimates vary from a few inches to yards. Modeled predictions using median consensus sea level rise estimates indicate that significant portions of Florida's coastline will be inundated and a major redistribution of coastal habitats is likely. However, to put this in context, Florida's coast currently experiences sea level fluctuations of 2 to 6 feet twice daily as tides and is exposed to storm surges of 10 to 16 feet in occasional hurricanes. Sea level changes will be superimposed on these normal, larger fluctuations. While these changes will likely be disastrous to human structures and activities, the effect on wildlife and its habitat may be less damaging. In essence, coastal habitats will migrate inland and Florida's flat coastal topography, a result of previous sea level changes, will mitigate the effect. Current coastal forests, dunes, and beaches will migrate inland and be displaced by marsh, while current marsh will become sea grass, barrier islands will become sandbars and new barrier islands arise. The primary effect for wildlife will be redistribution, and possibly increase in some habitats at the expense of others.

More profound changes in the coastal and marine environment may be driven by the temperature and rainfall effects that may promote the distribution of mangroves and coral reefs into the expanded coastal zone. The main hazard to wildlife from sea level rise will arise from efforts to protect human structures from these changes by dikes, seawalls, dredging, beach nourishment and similar engineering responses. Changes in temperature regimes in the ocean may cause shifts in distribution of marine species, and profound but entirely unpredictable effects may be generated if climate changes causes large scale change in ocean circulation such as the Florida Current. The following possibilities at the local level should be considered:

1. Transient but damaging effects on vulnerable coastal species (*e.g.*, beach nesting shorebirds, and sea turtles).
2. Redistribution of coastal habitats with disruptions of productivity.
3. Sedimentation effects during the transition.
4. Interactive synergy with other climate effects (*e.g.*, temperature, and storm frequency) to generate unanticipated second order effects.
5. Disruption of coastal migration patterns, particularly "passive" migrations of larvae driven by local water movement effects.
6. Secondary effects of protection of human structures.
7. Migration zones and corridors available to allow changes in distribution.

To summarize, effects of climate change on wildlife in Florida are likely to be widespread and profound, and occur over a variety of dimensions and variables. As these effects cannot be prevented or delayed under current circumstances, a practical response will be to identify key areas and key species and habitats that are vulnerable to irreversible change and develop policy and planning to mitigate effects on these vulnerable entities.

Global warming will be a particular challenge for endangered, threatened, and other "at risk" species. It is difficult to estimate, with any degree of precision, which species will be affected by climate change or exactly how they will be affected. However, as it relates to nesting sea turtles, if predictions about global warming are realized, increased storms and rising sea levels could damage or destroy nests and nesting habitat, and temperature changes could skew sex ratios. Consequently, the Service will use Strategic Habitat Conservation planning, an adaptive science-driven process that begins with explicit trust resource population objectives, as the framework for adjusting our management strategies in response to climate change (Service 2006).

Status of the species/critical habitat within the action area

Sea Turtles

In 2008, Palm Beach County beaches supported approximately 23.5 percent of the overall sea turtle nesting along the east coast of Florida (FWC 2009b). In total, 15,218 loggerhead, green, and leatherback sea turtle nests were recorded in 2008, along the 43.1 miles of Palm Beach County beaches included in the FWC's Florida Statewide Nesting Beach Survey (Table 1). The distribution of nests among species in 2008 included 12,703 loggerhead sea turtles, 2,272 green sea turtles, and 243 leatherback sea turtles (Table 1). From 2004 to 2008, there was an average of 11,202 loggerhead, 2,046 green, and 282 leatherback sea turtle nests laid within Palm Beach County annually (Table 1).

Loggerhead Sea Turtle

Of the counties along the east coast of Florida, Palm Beach County supported the second highest nesting of loggerhead sea turtles with 12,703 nests or 295 nests per mile in 2008 (FWC 2009b; Table 1). In 2008, loggerhead sea turtles laid 822 nests or 685 nests per mile in the project area (Table 2). In 2008, loggerhead sea turtles made 16,345 false crawls in Palm Beach County (Table 1). In the project area, loggerhead sea turtles made 970 false crawls in 2008 (Table 2). Over a period of 12 years (1996 to 2007), the number of loggerhead sea turtle nests deposited along 2.5 miles of shoreline on Singer Island has exhibited a significant decline (Figure 5).

Green Sea Turtle

Of the counties along the east coast of Florida, Palm Beach County supported the second highest nesting of green sea turtles with 2,272 nests or 53 nests per mile in 2008 (FWC 2009b; Table 1). In 2008, green sea turtles laid 161 nests or 134 nests per mile in the project area (Table 2). In 2008, green sea turtles made 2,802 false crawls in Palm Beach County (Table 1). In the project area, green sea turtles made 315 false crawls in 2008 (Table 2).

Leatherback Sea Turtle

Of the counties along the east coast of Florida, Palm Beach County supported the second highest nesting of leatherback sea turtles with 243 nests or seven nests per mile in 2008 (FWC 2009b; Table 1). In 2008, leatherback sea turtles laid two nests or 1.7 nests per mile in the project area (Table 2). In 2008, leatherback sea turtles made 36 false crawls in Palm Beach County (Table 1). In the project area, leatherback sea turtles made one false crawl in 2008 (Table 2).

Hawksbill Sea Turtle

Nesting by this species has been documented five times in Palm Beach County since 1985 (Meylan et al. 1995), with the most recent report in 2004. No nesting has been reported from the proposed action area.

Kemp’s Ridley Sea Turtle

Although no nesting has been reported in Palm Beach County for Kemp’s ridley sea turtles, four false crawls at Phipps Ocean Park were reported in 1989 (Meylan et al. 1995). The majority of nesting surveys conducted in Florida occur during the morning hours and are based on interpretation of the tracks left by the turtles as they ascend and descend the beach; the turtles themselves are rarely observed. Because Kemp’s ridley sea turtle tracks are difficult to discern from loggerhead tracks, it is likely that nesting by Kemp’s ridley sea turtles is underreported (Meylan et al. 1995).

Factors affecting the species habitat within the action area

A 1.7 mile length of shoreline (DEP reference monument R-60.5 to R-69) along Singer Island which in part encompasses the project area, is classified as critically eroded beach. Between 1990 and 2005, it is estimated that the project area has lost approximately 500,000 cubic yards of fill in the nearshore area. A large nearshore rock outcrop located at DEP reference monument R-67, influences both littoral sand transport and the width of the shoreline at Ocean Reef Park (DEP reference monument R-67 to R-68). North of the rock outcrop which encompasses the proposed project area, erosion of the dune has threatened upland infrastructure. Due to dune erosion, the Applicant has performed dune restoration events in 2001, and annually between 2004 and 2006. Emergency dune restoration events between 850 feet north of DEP reference monument R-61 and 850 feet south of R-65 were completed in June 2007 and January 2008, due to impacts of Subtropical Storm Andrea and Tropical Storm Noel, respectively.

Beach Maintenance And Pollution

Regular beach maintenance in the form of tractor tilling may disrupt or impact deposited nests and nesting sea turtles. Plastics, styrofoam, and fishing line are pollutants that may negatively impact nesting success and nearshore foraging.

Lighting

A primary anthropogenic threat to sea turtles along nesting shorelines includes sea turtle hatchling disorientation as a result of artificial lighting along the beach. Typically, sea turtle hatchlings will emerge from the nest and orient themselves towards the brighter, open horizon of the ocean (Salmon et al. 1992). If artificial lights are visible from the beach, sea turtle hatchlings tend to travel toward the artificial lights instead of the ocean. Disorientation events often result in hatchling mortality as a result of dehydration, predation, and in some cases, motor vehicle strikes.

Palm Beach County has a Unified Land Development Code that includes measures to reduce impacts of coastal lighting on nesting sea turtles and hatchlings. The proposed action area is subject to this code.

Predation

Depredation of sea turtle eggs and hatchlings by natural and introduced species occurs on almost all nesting beaches. Depredation 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*), cats (*Felis catus)*, dogs (*Canis lupus familiaris*), and fire ants (*Solenopsis* spp.) (Dodd 1988; Stancyk 1995; Indian River County 2008). Raccoons are particularly destructive on the Atlantic coast and may take 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).

EFFECTS OF THE ACTION

The analysis of the direct and indirect effects of the proposed action on sea turtles and the interrelated and interdependent activities of those effects was based on beneficial and detrimental factors.

Factors to be considered

The proposed action has the potential to adversely affect nesting sea turtles and their nests, and hatchlings within the proposed action area during breakwater construction activities and for the life of the breakwater. It is important to note that the segmented breakwater is a permanent structure and therefore, any impacts to sea turtles and habitat will be in perpetuity. The effects of the proposed action on sea turtles will be considered further in the remaining sections of this biological opinion.

All impacts that relate to free-swimming sea turtles (*e.g.,* loss of nearshore hardbottom habitat, inwater construction, hatchling predation, egress and ingress of adult females, increase in hatchling and adult female energy expenditure in attempts to overcome the breakwater) are under the purview of NOAA Fisheries and will be analyzed under a separate biological opinion to be provided by NOAA Fisheries.

Analyses for effects of the action

Beneficial effects

Breakwaters constructed in appropriate high erosion areas, or to offset the effects of shoreline armoring, may benefit sea turtles in areas by reestablishing nesting habitat where none currently exists, stabilize the beach in rapidly eroding areas to reduce potential for escarpment formation, reduce destruction of nests from erosion, and reduce the need for future sand placement events by extending the interval between sand placement events. However, caution should be exercised to avoid automatically assuming the reestablishment of nesting habitat will wholly benefit sea turtle populations without determining the extent of the breakwater affect on nesting and hatchling sea turtle behavior.

Direct effects

The proposed segmented breakwater will be constructed and permanently located in the marine environment. Consequently, the proposed project will affect nesting female sea turtles and hatchlings in the marine environment, which is under the jurisdiction of NOAA Fisheries. Although there are no direct impacts to nesting female sea turtles on dry beach, their nests and eggs, and hatchlings as they emerge from the nest and crawl to the sea based on the proposed project, indirect effects discussed below are of concern to the Service.

Indirect effects

Many of the direct effects of breakwater construction may persist over time and become indirect impacts. These indirect effects include:

1. A decrease in sea turtle nesting and hatch success along the beach adjacent to the segmented breakwater due to beach dynamics (*e.g.*, tombolo formation, etc.).
2. Change in sea turtle nesting habitat and shoreline profile.
3. Potential increased beachfront development.
4. Escarpment formation.
5. Increased erosion downdrift of the breakwater.
6. Deflection of sea turtle nesting updrift of the breakwater.
7. Impacts of debris on the beach from breakwater deterioration.
8. Disorientation of hatchling sea turtles on beaches adjacent to the breakwater as they emerge from the nest and crawl to the water as a result of breakwater presence.

<u>Decrease in Sea Turtle Nesting and Hatch Success</u>

The presence of the segmented breakwater, especially owing to their fully emergent design, could potentially impact nesting female sea turtles resulting in reduced nesting success which will in turn effect hatchling success. Although it is not possible to determine the exact severity that the breakwater will have on nesting, we expect that there will be some reduction in nesting along the shoreline parallel to the breakwater similar to that observed for loggerhead sea turtles nesting associated with large-scale, emergent breakwater projects in Japan (Imamura 2009; Witherington 2009).

Similar results were observed in conjunction with the construction of a submerged PEP reef in Indian River County. In 1999, 3 years postconstruction, it was concluded that the shoreline adjacent to the PEP reef had significantly fewer sea turtle crawls and lower nesting success compared to the north and south control sites (D.B. Ecological Services, Inc. 1999).

Given the potential increase in hatchling mortality expected from the proposed breakwater due to disorientation and predation which is under the purview of NOAA Fisheries, and will be analyzed in their biological opinion, the likelihood of a sea turtle hatchling emerging from the project shoreline reaching sexual maturity and returning to the project shoreline to nest is expected to be substantially lower than it is currently. If the Service takes the most conservative approach as mandated by the Act and assume a loss of all reproductive value along the project shoreline, the following represents the maximum impact for loggerhead, green, and leatherback sea turtles.

Over a 5-year period (2004 to 2008) an average of 937 loggerhead, 247 green, and 16 leatherback sea turtle nests were deposited along Singer Island (2.1 miles) (Meylan 2009). During this same time period, the number of loggerhead, green, and leatherback hatchlings produced based on the weighted mean emergence success was 57,789, 16,638, and 509, respectively (Meylan 2009). The Singer Island breakwater project area is approximately 1.1 miles or 52 percent of the shoreline surveyed during the 5-year period. Consequently, it is reasonable to assume that the breakwater will impact 52 percent of the average number of nests and hatchlings which translates as follows:

1. Four hundred and eighty-eight loggerhead sea turtles nests and 30,051 hatchlings impacted annually.
2. One hundred and twenty-nine green sea turtle nests and 8,652 hatchlings impacted annually.
3. Nine leatherback sea turtle nests and 260 hatchlings impacted annually.

Since only one of every 1,000 to 10,000 hatchlings is expected to reach sexual maturity (Stewart and Wyneken 2004; Klemm 2010), the project area would be expected to produce the following number of adults annually:

1. Three to 30 loggerhead sea turtles.
2. One to nine green sea turtles.
3. One leatherback sea turtle.

In addition, the 5-year average number of loggerhead sea turtle deposited within the project area is 779 (Table 2). These 779 nests represent 1.70 percent of the total number of loggerhead sea turtle nests (44,792) deposited within the Peninsular Florida Recovery Unit (PFRU) based on 20 years of core index beach data. If we examine the total length of shoreline adjacent to all breakwater gaps (3,338 feet) and breakwater crests (2,470 feet), the 5-year average number of loggerhead sea turtle nests is 444 and 335 nests, respectively, that represents 0.99 and 0.75 percent of the total number of nests deposited within the PFRU based on 20 years of core index beach data.

According to the recovery plan for the northwest Atlantic population of the loggerhead sea turtle (NOAA Fisheries and Service 2008), the recovery criteria for the PFRU is a 1 percent annual increase over a generation time of 50 years resulting in a total annual number of nests of 106,100 or greater. In addition, the increase in the number of nests must be a result of corresponding increases in the number of nesting females (estimated from nests, clutch frequency, and remigration interval). Consequently, a 0.75 to 1.70 percent decrease in loggerhead sea turtle nesting could have potentially serious consequences in regard to the recovery of this species within the PFRU.

<u>Change in Sea Turtle Nesting Habitat and Shoreline Profile</u>

The placement of emergent breakwater segments immediately offshore could potentially create a less favorable and turtle friendly beach profile. For example, monitoring associated with concrete block, emergent, shore parallel breakwaters constructed along Omotehama Beach, Japan, concluded significant net erosion along the breakwater shoreline compared to adjacent shoreline without breakwaters (Witherington 2009). In addition, monitoring of a submerged PEP reef constructed along the Town of Palm Beach in 1992 and 1993, concluded a negative net volumetric change along the shoreline adjacent to the reef (Martin and Smith 1997). Furthermore, of four designated hot spots in need of immediate nourishment to protect infrastructure along the Dade County Beach Erosion Project, the 32nd and 63rd fill templates have the highest priority. Originally nourished in 1974, the 32nd Street site has undergone nine additional nourishment projects between 1985 and 2006. Even after the construction of three emergent breakwaters in 2002, this shoreline was renourished in July 2006 with a current nourishment event scheduled for July 2010. The Corps recently obtained a DEP permit to conduct similar beach nourishment activities, once every 2 years over the life of the 10-year DEP permit.

Over time, it is expected that the shoreline landward of the breakwater segments will become low-energy, with the formation of gradually sloping salients and possibly tombolos (the accumulation of sand landward of the breakwater which is physically connected to the breakwater). This reduction in beach slope will be very different from the steeper beach profile most favored by Florida’s nesting sea turtles (Witherington et al. 2009). Modeling predictions conducted by Humiston and Moore, conclude that the shoreline adjacent to the segmented breakwater will continue to be a dynamic feature that will fluctuate in response to seasonal variations and weather events. Based on 2006 model predictions the average shoreline response gain and loss within the project area is 7.2 and 0.2 acres, respectively. The gain is associated with salient formation behind breakwater segments and the loss with steeper shoreline profiles. Similar modeling predictions using a base date greater than 2006 have not been conducted to date.

<u>Increased Beachfront Development</u>

Pilkey and Dixon (1996) state that beach replenishment frequently leads to more development in greater density within shorefront communities that are then left with a future of further replenishment or more drastic stabilization measures. Dean (1999) also notes the very existence of a sand placement project can encourage more development in coastal areas. Following completion of a sand placement project in Miami during 1982, investment in new and updated facilities substantially increased tourism in the area (National Research Council 1995). Increased building density immediately adjacent to the beach often resulted as older buildings were replaced by much larger ones that accommodated more beach users. Overall, shoreline management creates an upward spiral of initial protective measures resulting in more expensive development which leads to the need for more and larger protective measures. Increased shoreline development may adversely affect sea turtle nesting success. Greater development may support larger populations of mammalian predators, such as foxes and raccoons, than undeveloped areas (National Research Council 1990), and can also result in greater adverse effects due to artificial lighting, as discussed above. The proposed segmented breakwater project could potentially produce similar beachfront development results.

Escarpment Formation

On nourished beaches, steep escarpments may develop along their waterline interface as they adjust from an unnatural construction profile to a more natural beach profile (Coastal Engineering Research Center 1984; Nelson et al. 1987). These escarpments can hamper or prevent access to nesting sites (Nelson and Blihovde 1998). Researchers have shown that female 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 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. Although it has been demonstrated that the proposed breakwater design reduces potential escarpment formation and reduces the height of any escarpments that may form, escarpments may develop on the shoreline between the breakwater segments as the shoreline equilibrates to its final profile.

Downdrift Erosion Related To Erosion Control Structures

Erosion control structures (*e.g.,* terminal groins, T-groins, and breakwaters), in conjunction with beach nourishment, can help stabilize U.S. Gulf and Atlantic coast barrier island beaches (Leonard et al. 1990). However, groins and breakwaters often result in accelerated beach erosion downdrift of the structures (Komar 1983; National Research Council 1987) and corresponding degradation of suitable sea turtle nesting habitat (NOAA Fisheries and Service 1991a, 1991b, 1992). Initially, the greatest changes are observed close to the structures, but effects may eventually extend significant distances along the coast (Komar 1983). Beach nourishment only partly alleviates impacts of groin construction on downdrift beaches (Komar 1983).

Breakwaters are designed to attenuate wave energy which reduces the primary cause of erosion. Additionally, breakwaters modify wave patterns through diffraction. The combination of these factors on wave energy modifies the local littoral transport rates and may result in the accumulation of sand and minimization of erosion along the shoreline behind the breakwater. When properly designed, the shoreline forms a salient (the accumulation of sand landward of the breakwater, but physically detached from the breakwater) which eventually achieves a state of equilibrium. Once this equilibrium is achieved, sand transport past the breakwater resumes, thereby minimizing potential adverse downdrift effects. The segmentation of the proposed breakwater is in part designed to minimize this effect.

If breakwaters are not designed properly they may adversely affect the adjacent shoreline. This creates a situation where the breakwater acts as a headland (a prominent land feature) rather than an offshore feature. In these instances the breakwater functions as a barrier to the longshore transport of sand in a manner similar to a conventional terminal groin, resulting in offshore sand movement and downdrift erosion. Consequently, erosion may increase downdrift of the breakwater and therefore compromising suitable sea turtle nesting habitat.

Although the sea turtle nesting density downdrift (DEP reference monument R-66.75 to R-72; approximately 0.92 mile) of the project area is considerably less compared to both the project and updrift areas, it is substantial with a 7-year (2003 to 2009) average of 155 loggerhead, 16 green, and 12 leatherback sea turtle nests. The loggerhead, green, and leatherback sea turtle nesting density during this same period was 168, 17, and 13 nests per mile.

In addition, another segmented breakwater has been proposed south of the Singer Island breakwater which could further compound potential impacts to nesting sea turtles downdrift. The Jupiter Beach Erosion Control Project encompasses approximately 0.5 mile of shoreline located south of Jupiter Inlet extending to the Jupiter Beach Resort. This segmented breakwater design has not been finalized; however, it will consist of a series of nearshore breakwater segments.

<u>Deflection of Nesting Updrift</u>

The presence of the proposed breakwater may deflect sea turtle nesting activity north of the project area, producing a higher than normal density of sea turtle nests in this area. In projects involving large scale, emergent breakwaters in Japan, Imamura (2009) recorded a reduction in sea turtle nesting along the shoreline parallel to the breakwater, while some nesting was deflected updrift of the breakwater. In addition, similar results were observed concerning PEP reefs constructed in Indian River and Palm Beach counties in 1996 and 1993, respectively. Although it is reasonable to assume that some nesting activity may deflect to the shoreline updrift of the proposed segmented breakwater, it presents a potential problem of concentrating nesting activities in this area. Concentrating nesting activities can lead to density-dependent effects (*e.g.,* reduced or depleted oxygen levels in the sand due to an over abundance of incubating eggs, digging up of previously deposited nests) on hatching success and hatchling survivorship (Ackerman 1980). In addition, hatchlings released from concentrated areas may also be subject to greater predation rates from both land and marine predators, because the predators learn where to concentrate their efforts (Glenn 1998; Wyneken et al. 1998).

According to FWC statewide nesting beach surveys, the shoreline updrift of the proposed breakwater (John D. MacArthur Beach State Park; DEP reference monument R-54.5 to R-60.5) is currently experiencing nest densities high enough to produce density-dependent mortality effects. The loggerhead nesting density between 2003 and 2009, along the 1.13 miles of shoreline adjacent to John D. MacArthur Beach State Park was 610 nests per mile which is only slightly lower than the nesting density of 685 nests per mile for the shoreline adjacent to the project area. Although impossible to predict the amount of nesting activity that may deflect to the updrift shoreline, it is reasonable to assume that any additional nesting activity deflected updrift will potentially compound any density-dependent effects.

In addition, another segmented breakwater has been proposed north of the Singer Island breakwater which could further compound potential impacts to nesting sea turtles updrift. The South Palm Beach/Lantana Beach Erosion Control Project encompasses approximately 0.8 mile of shoreline extending from the north boundary of the Town of South Palm Beach to the Ritz Carlton Hotel located in Manalapan. This project is currently being modified to include approximately 1.2 miles of shoreline along Reach 8 given that the nourishment project along this shoreline was recently denied. This segmented breakwater design has not been finalized; however, it will consist of a series of nearshore breakwater segments.

Erosion Control Structure Breakdown

If the breakwater segments fail and break apart, debris may spread upon the beach, which may further impede nesting females from accessing suitable nesting sites (resulting in a higher incidence of false crawls) and trap hatchlings and nesting turtles (NOAA Fisheries and Service 1991a, 1991b).

Disorientation of Hatchlings

Typically, sea turtles emerge from the nest at night when lower sand temperatures elicit an increase in hatchling activity (Witherington et al. 1990). After emergence, approximately 20-120 hatchlings crawl *en masse* immediately to the surf using predominately visual cues to orient themselves (Witherington and Salmon 1992; Lohmann et al. 1997). Upon reaching the water loggerhead and green turtle hatchlings orient themselves into the waves and begin a period of hyperactive swimming activity, or swim frenzy, which lasts for approximately 24 hours (Salmon and Wyneken 1987; Wyneken et al. 1990; Witherington 1991). The swim frenzy effectively moves the hatchling quickly away from shallow, predator rich, nearshore waters to the relative safety of deeper water (Gyuris 1994; Wyneken et al. 2000).

The first hour of a hatchling’s life is precarious and predation is high, but threats decrease as hatchlings distance themselves from the natal beach (Stancyk 1995; Pilcher et al. 2000). Delays in hatchling migration (both on the beach and in the water) can cause added expenditures of energy and an increase of time spent in predator rich nearshore water.

Rarely will hatchlings encounter natural nearshore features that are similar to the emergent segmented breakwater proposed for this project. However, observations of hatchling behavior during an encounter with a sand bar at low tide, a natural shore-parallel barrier, showed that hatchlings maintained their shore-perpendicular path seaward, by crawling over the sand bar versus deviating from this path to swim parallel around the sand bar through the trough, an easier alternative. The segmented breakwater may adversely effect sea turtle hatchlings by serving as a physical or visual barrier, delaying offshore migration, causing disorientation, depleting or increasing expenditure of the "swim frenzy" energy critical to reach the relative safety of offshore areas, and possibly entrapping hatchlings within the crevices of the structures or within eddies or other associated currents.

Species' response to a proposed action

The Service believes there is a potential for long-term adverse effects on sea turtles, both nesting females and hatchlings, as a result of the construction of the permanent segmented breakwater. However, the Service acknowledges the potential benefits of the breakwater since it may minimize the effects of erosion on sea turtle nesting habitat and extend the interval of any future sand placement events. Nonetheless, an increase in sandy beach may not necessarily equate to an increase in suitable sea turtle nesting habitat.

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 Act.

Potential future actions involve the construction of seawalls adjacent to the breakwater template by private entities. Currently, 12 of 17 condominium properties either have existing seawalls, permits to construct seawalls, or a pending application. Many of the private entities that have secured State permits are waiting in anticipation that the segmented breakwater will be constructed in a timely manner. The purpose of the seawalls is to provide protection to shoreline properties and infrastructure if the segmented breakwater is not constructed or doesn't function as designed.

CONCLUSION

Because of the significant impacts to sea turtles documented in the analysis and other concerns raised by NOAA Fisheries and the Corps, the Applicant has withdrawn their proposal.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act 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 Act provided that such taking is in compliance with the terms and conditions of this incidental take statement.

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

AMOUNT OR EXTENT OF TAKE

Sea Turtles

The Service anticipates approximately 1.1 miles of nesting beach habitat could be taken as a result of the proposed action; however, incidental take of sea turtles will be difficult to detect for the following reasons:

1. An unknown number of females may avoid the project beach and be forced to nest in a less than optimal area.
2. Escarpments may form and obstruct an unknown number of females from accessing a suitable nesting site.
3. The number of nests lost due to erosion of the shoreline adjacent to the segmented breakwater is unknown.
4. Breakwater segments may obstruct or entrap an unknown number of adult and hatchling sea turtles during ingress or egress at nesting sites.
5. An unknown number of hatchlings may be predated as a result of obstruction or increased predators associated with the breakwater segments.

However, the level of take of these species can be anticipated by breakwater construction adjacent to suitable turtle nesting beach habitat because of the following:

1. Turtles nest within the project area.
2. Project construction may occur during a portion of the nesting season.
3. Breakwater construction will modify the beach profile and topography and may increase

the presence of escarpments.

Take is expected to be in the form of:

1. Harassment in the form of disturbing or interfering with sea turtles attempting to nest within the project area or on adjacent beaches as a result of construction activities, or segmented breakwater presence.
2. Behavior modification of nesting sea turtles 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.
3. Destruction of nests from escarpment leveling within a nesting season when such leveling has been approved by the Service.
4. Behavior modification of nesting sea turtles or hatchlings due to the presence of a breakwater segments which may act as barriers to movement, or cause disorientation.
5. Physical entrapment and predation of hatchling sea turtles due to the presence of breakwater segments.

EFFECT OF THE TAKE

Sea Turtles

Because of the significant impacts to sea turtles documented in the analysis and other concerns raised by NOAA Fisheries and the Corps, the Applicant has withdrawn their proposal.

REASONABLE AND PRUDENT MEASURES/ALTERNATIVES

The Service believes the following reasonable and prudent measures/alternatives are necessary and appropriate to minimize take of loggerhead, green, leatherback, hawksbill, and Kemp’s ridley sea turtles in the proposed action area.

Sea Turtles

1. Redesign the project by submerging the breakwater segments.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the Corps must comply with the following terms and conditions, which implement the reasonable and prudent measures/alternatives described above, and outline required reporting and monitoring requirements. These terms and conditions are nondiscretionary.

Protection of sea turtles

1. Conduct the necessary modeling and engineering to modify breakwater design (*e.g.*,submerged) to minimize sea turtle hatchling mortality.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act 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. Establish a moratorium on all seawall construction adjacent to the breakwater.
2. Consider the upland retreat of present and future construction based on climate change and sea level rise impacts on Florida's shoreline.
3. Construction activities should be planned to take place outside the sea turtle nesting and hatching season.
4. Educational signs should be placed at appropriate beach access points to explain the life history of sea turtles species that nest in the area, and potential breakwater impacts to both nesting and swimming sea turtles.
5. Extend the physical and biological monitoring activities beyond the 5 years required to assess the long term effects of the breakwater.

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

REINITIATION NOTICE

This concludes formal consultation on the action outlined in the request. 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.
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.

Should you have additional questions or require clarification, please contact Jeff Howe at 772-562-3909, extension 283.

Sincerely yours,

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LITERATURE CITED

Ackerman, R.A. 1980. Physiological and ecological aspects of gas exchange by sea turtle eggs. American Zoologist 20:575-583.

Baldwin, R., G.R. Hughes, and R.I.T. Prince. 2003. Loggerhead turtles in the Indian Ocean. Pages 218-232 *in* A.B. Bolten and B.E. Witherington, editors. Loggerhead Sea Turtles. Smithsonian Books; Washington, D.C.

Bowen, B.W. 1994. Personal communication. Letter to U.S. Fish and Wildlife Service dated November 17, 1994. University of Florida; Gainesville, Florida.

Bowen, B.W. 1995. Personal communication. Letter to U.S. Fish and Wildlife Service dated October 26, 1995. University of Florida; Gainesville, Florida.

Bowen, B., J.C. Avise, J.I. Richardson, A.B. Meylan, D. Margaritoulis, and S.R. Hopkins-Murphy. 1993. Population structure of loggerhead turtles (*Caretta caretta*) in the northwestern Atlantic Ocean and Mediterranean Sea. Conservation Biology 7(4):834-844.

Coastal Engineering Research Center. 1984. Shore protection manual, volumes I and II. U.S. Army Corps of Engineers Waterways Experiment Station; Vicksburg, Mississippi.

Continental Shelf and Associates International (CSA). 2008. Singer Island Erosion Control Project Nearshore Hard Bottom Characterization. Report prepared for the Palm Beach County Environmental Resources Management; West Palm Beach, Florida.

Corliss, L.A., J.I. Richardson, C. Ryder, and R. Bell. 1989. The hawksbills of Jumby Bay, Antigua, West Indies. Pages 33-35 *in* S.A. Eckert, K.L. Eckert, and T.H. Richardson, compilers. Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFC-232.

D. B. Ecological Services, Inc. 1999. 1999 Sea turtle report: Indian River County, Vero Beach PEP reef. D.B. Ecological Services, Inc., Boca Raton, Florida.

Davis, G.E. and M.C. Whiting. 1977. Loggerhead sea turtle nesting in Everglades National Park, Florida, U.S.A. Herpetologica 33:18-28.

Dean, C. 1999. Against the tide: the battle for America's beaches. Columbia University Press; New York, New York.

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).

Ehrhart, L.M. 1989. Status report of the loggerhead turtle. Pages 122-139 *in* L. Ogren, 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.

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* A.B. Bolten and B.E. Witherington, editors. Loggerhead Sea Turtles. Smithsonian Books; Washington, D.C.

Encalada, S.E., K.A. Bjorndal, A.B. Bolten, J.C. Zurita, B. Schroeder, E. Possardt, C.J. Sears, and B.W. Bowen. 1998. Population structure of loggerhead turtle (*Caretta caretta*) nesting colonies in the Atlantic and Mediterranean as inferred from mitochondrial DNA control region sequences. Marine Biology 130:567-575.

Florida Fish and Wildlife Conservation Commission (FWC). 2009a. Standard Manatee Conditions for In-water Work. Tallahassee, Florida [Internet]. [cited July 23, 2009]. Available from: http://myfwc.com/docs/WildlifeHabitats/Manatee_StdCondIn_waterWork.pdf.

Florida Fish and Wildlife Conservation Commission (FWC). 2009b. Florida Statewide Nesting Beach Survey Data-2008 Season [Internet]. [cited July 23, 2009]. Available from: http://www.floridamarine.org/features/ view_article.asp?id=11812.

Foley, A., B. Schroeder, and S. MacPherson. 2008. Post-nesting migrations and resident areas of Florida loggerheads. Pages 75-76 *in* H. Kalb, 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.

Glenn, L. 1998. The consequences of human manipulation of the coastal environment on hatchling loggerhead sea turtles (*Caretta caretta*, L.). Pages 58-59 *in* R. Byles and Y. Fernandez, compilers. Proceedings of the Sixteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-412.

Gyuris, E. 1994. The rate of predation by fishes on hatchlings of the green turtle (*Chelonia mydas*). Coral Reefs 13:137-144.

Hildebrand, H. 1963. Hallazgo del area de anidacion de la tortuga “lora” *Lepidochelys kempii* (Garman), en la costa occidental del Golfo de Mexico (Rept., Chel.). Ciencia Mexicana 22(4):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.

Hopkins, S.R. and J.I. Richardson, editors. 1984. Recovery plan for marine turtles. National Marine Fisheries Service; St. Petersburg, Florida.

Imamura, K. 2009. Environmental factors on the sandy beaches of Omotehama, Toyohashi, influencing the reproductive activity of loggerhead sea turtles (*Caretta caretta*). Master of Engineering Thesis. Toyohashi University, Japan.

Indian River County. 2008. A plan for the protection of sea turtles on the eroding beaches of Indian River County, Florida. Annual report – 2007 to the U.S. Fish and Wildlife Service in support of Indian River County's incidental take permit (TE057875-0) causally related to emergency shoreline protection activities.

Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC). 2007. Climate Change 2007: Synthesis Report. Summary for Policy Makers. Valencia, Spain.

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* A.B. Bolten and B.E. Witherington, editors. Loggerhead Sea Turtles. Smithsonian Books; Washington, D.C.

Klemm, D. 2010. Personal communication. Sea turtle coordinator. E-mail to the U.S. Fish and Wildlife Service dated January 20, 2010. National Marine Fisheries Service; St. Petersburg, Florida.

Komar, P.D. 1983. Rhythmic shoreline features and their origins. Pages 92-112 *in* R. Gardner and H. Scoging, editors. Mega-Geomorphology. Clarendon Press; Oxford, England.

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.

Lenarz, M.S., N.B. Frazer, M.S. Ralston, and R.B. Mast. 1981. Seven nests recorded for loggerhead turtle (*Caretta caretta*) in one season. Herpetological Review 12(1):9.

Leonard, L.A., T.D. Clayton, and O.H. Pilkey. 1990. An analysis of replenished beach design parameters on U.S. East Coast barrier islands. Journal of Coastal Research 6(1):15-36.

Limpus, C., J.D. Miller, and C.J. Parmenter. 1993. The northern Great Barrier Reef green turtle *Chelonia mydas* breeding population. Pages 47-50 *in* A.K. Smith, 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.

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

Lohmann, J.J., B.E. Witherington, C.M.F. Lohmann, and M. Salmon. 1997. Orientation, navigation, and natal beach homing in sea turtles. Pages 107-135 *in* P.I. Lutz and J. A. Musick, editors. The Biology of Sea Turtles. CRC Press; 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* A.B. Bolten and B.E. Witherington, editors. Loggerhead Sea Turtles. Smithsonian Books; Washington, D.C.

Martin, T.R. and J.B. Smith. 1997. Analysis of the performance of the prefabricated erosion prevention (P.E.P.) reef system, Town of Palm Beach, Florida. U.S. Army Corps of Engineers; Coastal Engineering Research Center; Vicksburg, Mississippi.

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.B. 1992. Hawksbill turtle *Eretmochelys imbricata*. Pages 95-99 *in* P.E. Moler, editor. Rare and endangered biota of Florida, volume III. University Press of Florida; Gainesville, Florida.

Meylan, A.B. 1999. Status of the hawksbill turtle (*Eretmochelys imbricata*) in the Caribbean region. Chelonian Conservation and Biology 3(2):177-184.

Meylan, A.B. 2009. Personal communication. Biologist. E-mail to the U.S. Fish and Wildlife Service dated May 20, 2009. Florida Fish and Wildlife Conservation Commission; St. Petersburg, Florida.

Meylan, A.B. and M. Donnelly. 1999. Status justification for listing the hawksbill turtle (*Eretmochelys imbricata*) as critically endangered on the 1996 IUCN *Red List of Threatened Animals*. Chelonian Conservation and Biology 3(2):200-224.

Meylan, A., B. Schroeder, and A. Mosier. 1995. Sea turtle nesting activity in the State of Florida 1979-1992. Florida Marine Research Publications Number 52; St. Petersburg, Florida.

Murphy, T.M. and S.R. Hopkins. 1984. Aerial and ground surveys of marine turtle nesting beaches in the southeast region. Report prepared to the National Marine Fisheries Service [Internet]. [cited July 16, 2009]. Available from: http://www.dnr.sc.gov/seaturtle/Literature/Murphy%201984survey%20marine%20turtle%20nest%20bch.pdf.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NOAA Fisheries and Service). 1991a. 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 (NOAA Fisheries and Service). 1991b. Recovery plan for U.S. population of loggerhead turtle (*Caretta caretta*). National Marine Fisheries Service; Washington, D.C.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NOAA Fisheries and Service). 1992. Recovery plan for leatherback turtles (*Dermochelys coriacea*) in the U.S. Caribbean, Atlantic, and Gulf of Mexico. National Marine Fisheries Service; Washington, D.C.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NOAA Fisheries and Service). 1993. Recovery plan for hawksbill turtle (*Eretmochelys imbricata*) in the U.S. Caribbean, Atlantic, and Gulf of Mexico. National Marine Fisheries Service; St. Petersburg, Florida.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NOAA Fisheries and Service). 1998a. 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 U.S. Fish and Wildlife Service (NOAA Fisheries and Service). 1998b. Recovery plan for U.S. Pacific populations of the hawksbill turtle (*Eretmochelys imbricata*). National Marine Fisheries Service; Silver Spring, Maryland.

National Marine Fisheries Service and U.S. Fish and Wildlife Service (NOAA Fisheries and Service). 2008. Recovery plan for northwest Atlantic population of the loggerhead sea turtle (*Caretta caretta*), Second Edition. National Marine Fisheries Service; Silver Spring, Maryland.

National Research Council. 1987. Responding to changes in sea level: engineering implications. National Academy Press; Washington, D.C.

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

National Research Council. 1995. Beach nourishment and protection. National Academy Press; Washington, D.C.

Nelson, D.A. and B. Blihovde. 1998. Nesting sea turtle response to beach scarps. Page 113 *in* R. Byles, 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., 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.

Ogren, L.H. 1989. Distribution of juvenile and subadult Kemp's ridley turtles: preliminary results from the 1984-1987 surveys. Pages 116-123 *in* C.W. Caillouet, Jr., and A.M. Landry, Jr., editors. 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.

Pearce, A.F. 2001. Contrasting population structure of the loggerhead turtle (*Caretta caretta*) using mitochondrial and nuclear DNA markers. M.S. thesis. University of Florida; Gainesville, Florida.

Pearlstine, L.G. 2008. Ecological consequences of climate change for the Florida Everglades: An initial summary. Technical memorandum. South Florida Natural Resources Center; Everglades National Park, Homestead, Florida.

Pilcher, J.J., S. Enderby, T. Stringell, and L. Bateman. 2000. Nearshore turtle hatchling distribution and predation in Sabah, Malaysia. Pages 7-31 *in* H.J. Kalb and T. Wibbels, compilers. Proceedings of the Nineteenth Annual Symposium on Sea Turtle Biology and Conservation. U.S. Department of Commerce NOAA Technical Memorandum NMFS-SEFSC-443.

Pilkey, O.H. and K.L. Dixon. 1996. The Corps and the shore. Island Press; Washington, D.C.

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* P.E. Moler, editor. Rare and Endangered Biota of Florida, Volume III. University Press of Florida; Gainesville, Florida.

Richardson, J.I. and T.H. Richardson. 1982. An experimental population model for the loggerhead sea turtle (*Caretta caretta)*. Pages 165-176 *in* K.A. Bjorndal, editor. Biology and Conservation of Sea Turtles. Smithsonian Institution Press; Washington, D.C.

Ross, J.P. 1979. Sea turtles in the Sultanate of Oman. World Wildlife Fund Project 1320, Washington, D.C.

Ross, J.P. 1982. Historical decline of loggerhead, ridley, and leatherback sea turtles. Pages 189-195 *in* K.A. Bjorndal, 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* K.A. Bjorndal, editor. Biology and Conservation of Sea Turtles, Revised Edition. Smithsonian Institution Press; Washington, D.C.

Salmon, M. and J. Wyneken. 1987. Orientation and swimming behavior of hatchling loggerhead turtles *Caretta caretta* L during their offshore migration. Journal of Experimental Marine Biology and Ecology 109:137-153.

Salmon, M., J. Wyneken, E.U. Fritz, and M. Lucas. 1992. Ocean finding by hatchling sea turtles interplay of silhouette, slope, brightness as guideposts in orientation. Page 101 *in* M. Salmon and J. Wyneken, compilers. Proceedings of the Eleventh Annual Workshop in Sea Turtle Biology and Conservation. NOAA Technical Memorandum. NMFS-SEFSC-302.

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., A.M. Foley, and D.A. Bagley. 2003. Nesting patterns, reproductive migrations, and adult foraging areas of loggerhead turtles. Pages 114-124 *in* A.B. Bolten and B.E. Witherington, editors. Loggerhead Sea Turtles. Smithsonian Books; Washington, D.C.

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. 1995. Non-human predators of sea turtles and their control. Pages 139-152 *in* K.A. Bjorndal, editor. Biology and Conservation of Sea Turtles. Smithsonian Institution Press; Washington, D.C.

Stancyk, S.E., O.R. Talbert, and J.M. Dean. 1980. Nesting activity of the loggerhead turtle *Caretta caretta* in South Carolina, II: protection of nests from raccoon predation by transplantation. Biological Conservation 18:289-298.

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.

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.

Turtle Expert Working Group. 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. 2000. Assessment update 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. 2007. An assessment of the leatherback turtle population in the Atlantic Ocean. NOAA Technical Memorandum NMFS-SEFSC-555.

U.S. Fish and Wildlife Service (Service). 2006. Strategic Habitat Conservation [Internet]. Final Report of the National Ecological Assessment Team to the U.S. Fish and Wildlife Service and U.S. Geologic Survey. Arlington, Virginia [cited February 6, 2009]. Available from: http://www.fws.gov/science/doc/SHC_FinalRpt.pdf.

U.S. Fish and Wildife Service (Service). 2007. 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. U.S. Fish and Wildlife Service; Arlington, Virginia.

U.S. Fish and Wildlife Service (Service). 2008. Rising to the urgent challenges of a changing climate. Draft Strategic Plan [Internet]. Arlington, Virginia [cited February 6, 2009]. Available from: http://www.fws.gov/home/climatechange/pdf/climate_change_draft_strategic_plan.pdf

U.S. Fish and Wildlife Service and National Marine Fisheries Service (Service and NOAA Fisheries). 1992. Recovery plan for the Kemp's ridley sea turtle (*Lepidochelys kempii*). National Marine Fisheries Service; St. Petersburg, Florida.

Witherington, B.E. 1991. Orientation of hatchling loggerhead turtles at sea off artificially lighted and dark beaches. Journal of Experimental Marine Biology and Ecology 149:1-11.

Witherington, B.E., K.A. Bjorndal, and C.M. McCabe. 1990. Temporal pattern of nocturnal emergence of loggerhead turtle hatchlings from natural nests. Copeia 1990(4):1165-1168.

Witherington, B.E. and L.M. Ehrhart. 1989. Status and reproductive characteristics of green turtles (*Chelonia mydas*) nesting in Florida. Pages 351-352 *in* L. Ogren, 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 M. Salmon. 1992. Predation on loggerhead turtle hatchlings after entering the sea. Journal of Herpetology 26(2):226-228.

Witherington, B.E. 2009. Personal communication. Biologist. E-mail to the U.S. Fish and Wildlife Service dated February 18, 2009. Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute; Melbourne, Florida.

Witherington, B.E., 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.

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

Wyneken, J., L. Fisher, M. Salmon, and S. Weege. 2000. Managing relocated sea turtle nests in open-beach hatcheries. Lessons in hatchery design and implementation in Hillsboro Beach, Broward County, Florida. Pages 193-194 *in* H.J. Kalb and T. Wibbels, compilers. Proceedings of the Nineteenth Annual Symposium on Sea Turtle Biology and Conservation. U.S. Dept. Commerce. NOAA Technical Memorandum NMFS-SEFSC-443.

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

Zug, G.R. and J.F. Parham. 1996. Age and growth in leatherback turtles, *Dermochelys coriacea* (Testidines: Dermochelyidae): a skeletochronological analysis. Chelonian Conservation and Biology 2(2):244-249.

Table 1. Summary of sea turtle nesting data for Palm Beach County, Florida from 2004 to 2008 (FWC 2009b).

Year	Loggerhead Nests	Loggerhead False Crawls	Green Nests	Green False Crawls	Leatherback Nests	Leatherback False Crawls
2004	10759	15822	968	1283	166	25
2005	10791	14345	2252	3142	284	52
2006	11196	13329	1351	1351	225	58
2007	10559	15495	3389	5186	490	68
2008	12703	16345	2272	2802	243	36
Average	**11202**	**15067**	**2046**	**2753**	**282**	**48**

Table 2. Summary of sea turtle nesting data along approximately 1.2 miles of shoreline between DEP reference monument R-60.50 and R-66.75, Singer Island, Palm Beach County, Florida, from 2004 to 2008. Data provided by Palm Beach County Department of Environmental Resources Management.

Year	Loggerhead Nests	Loggerhead False Crawls	Green Nests	Green False Crawls	Leatherback Nests	Leatherback False Crawls
2004	685	550	68	34	3	1
2005	965	1066	371	371	17	4
2006	730	1006	191	202	2	2
2007	694	1439	341	543	6	3
2008	822	970	161	315	2	1
Average	**779**	**1006**	**226**	**293**	**6**	**2**

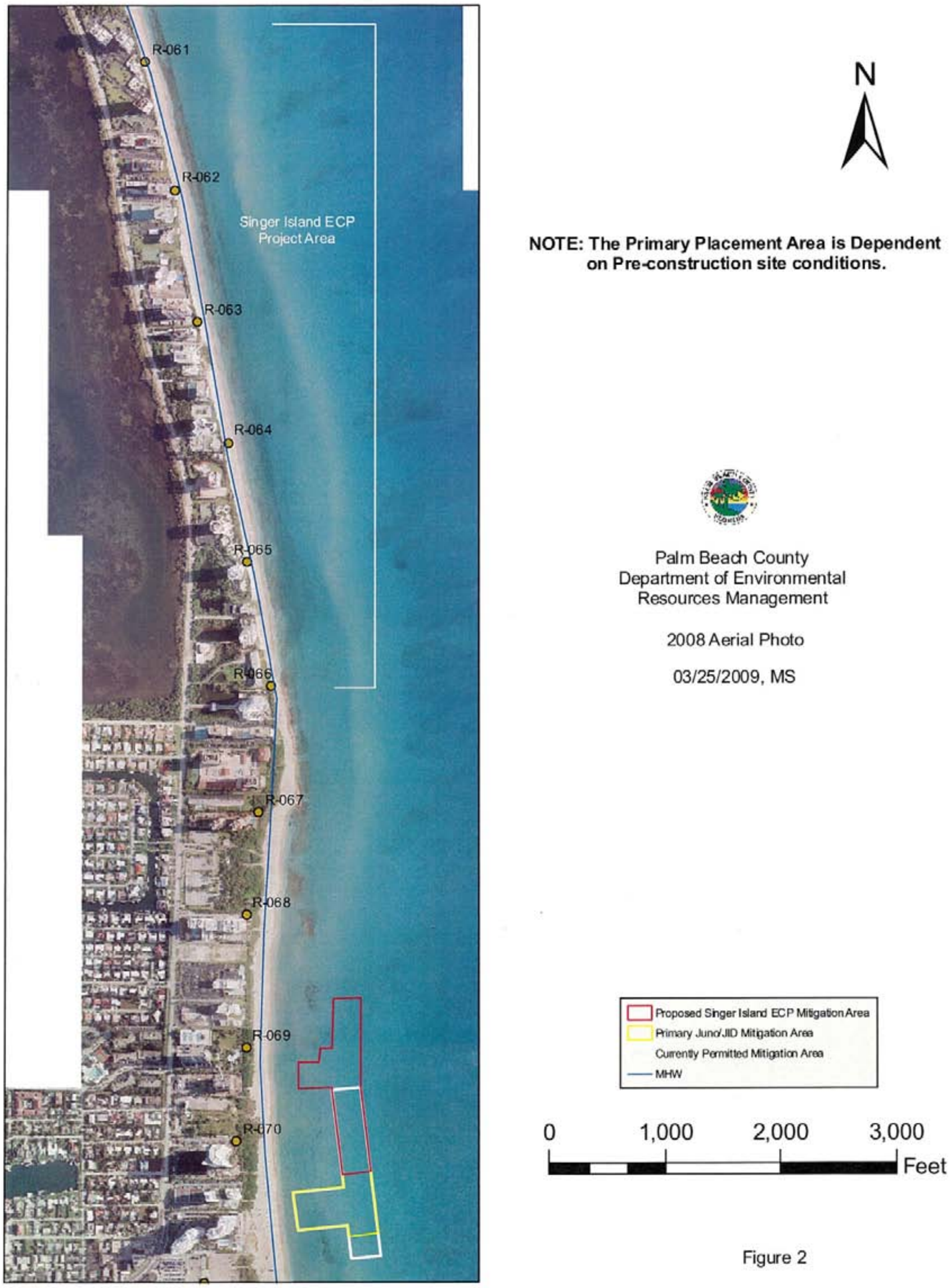

Figure 1. Location of the mitigation area to offset nearshore hardbottom impacts associated with the proposed breakwater along Singer Island, Palm Beach County, Florida.

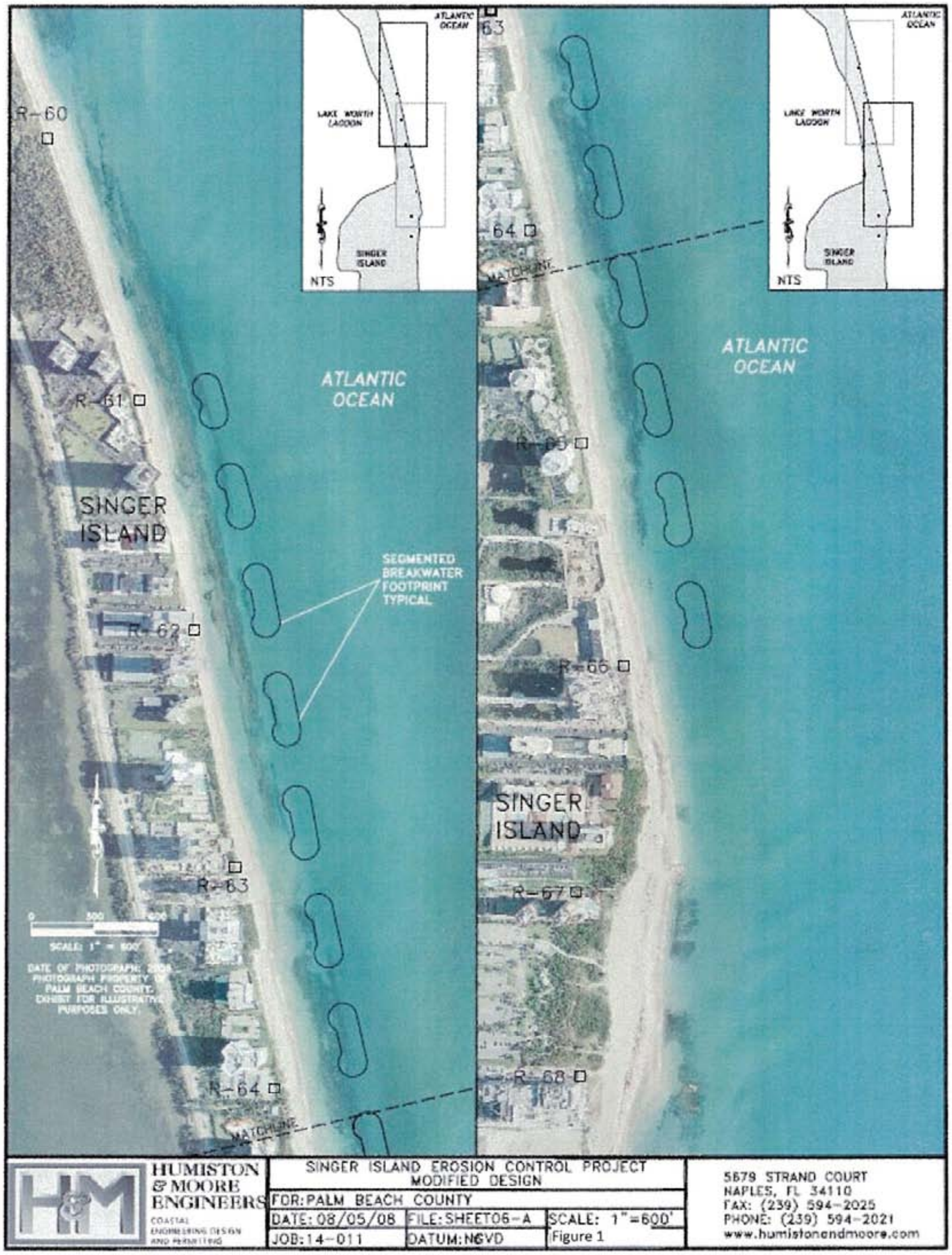

Figure 2. Location of the project area consisting of 11 breakwater segments along Singer Island, Palm Beach County, Florida.

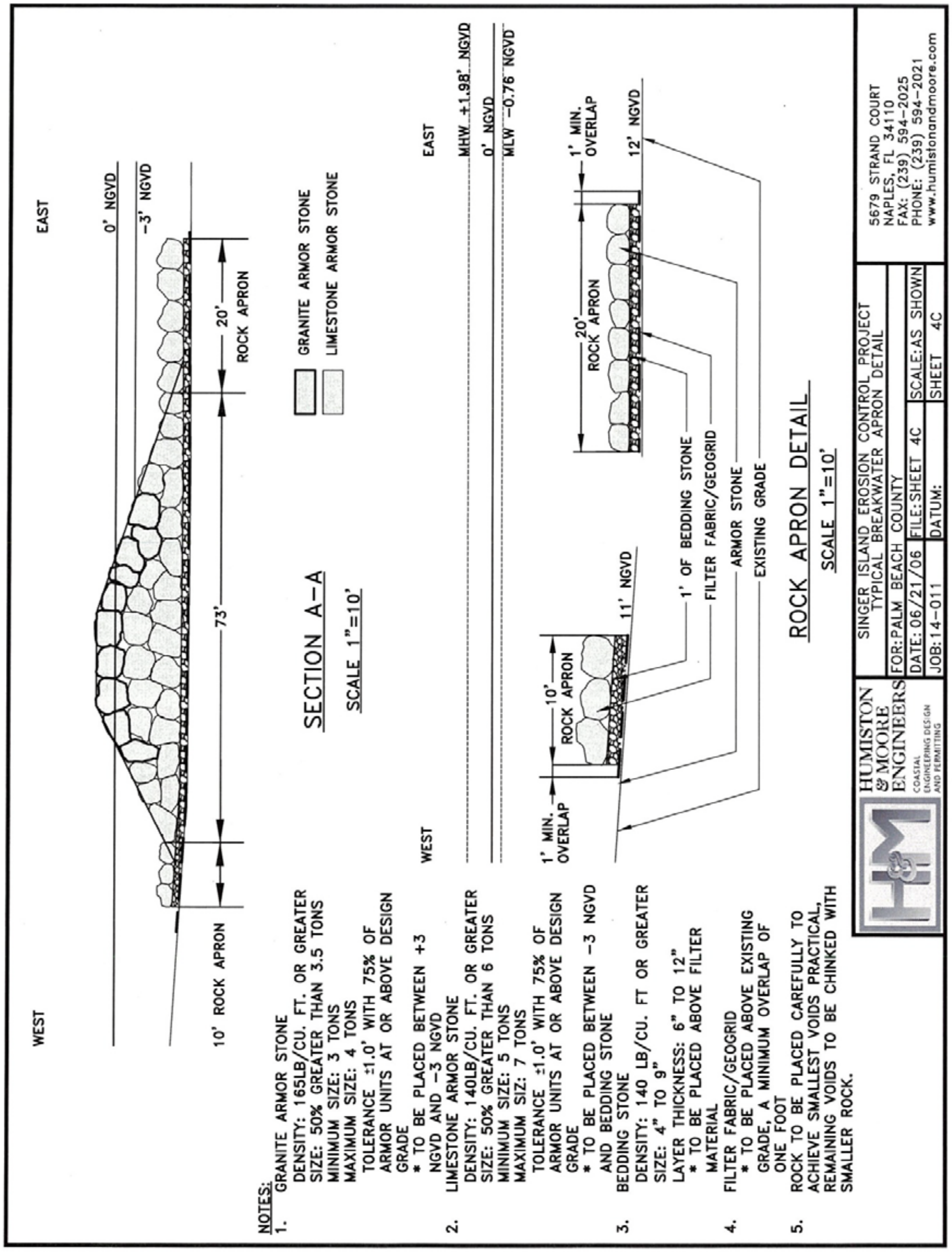

Figure 3. Breakwater segment design profile.

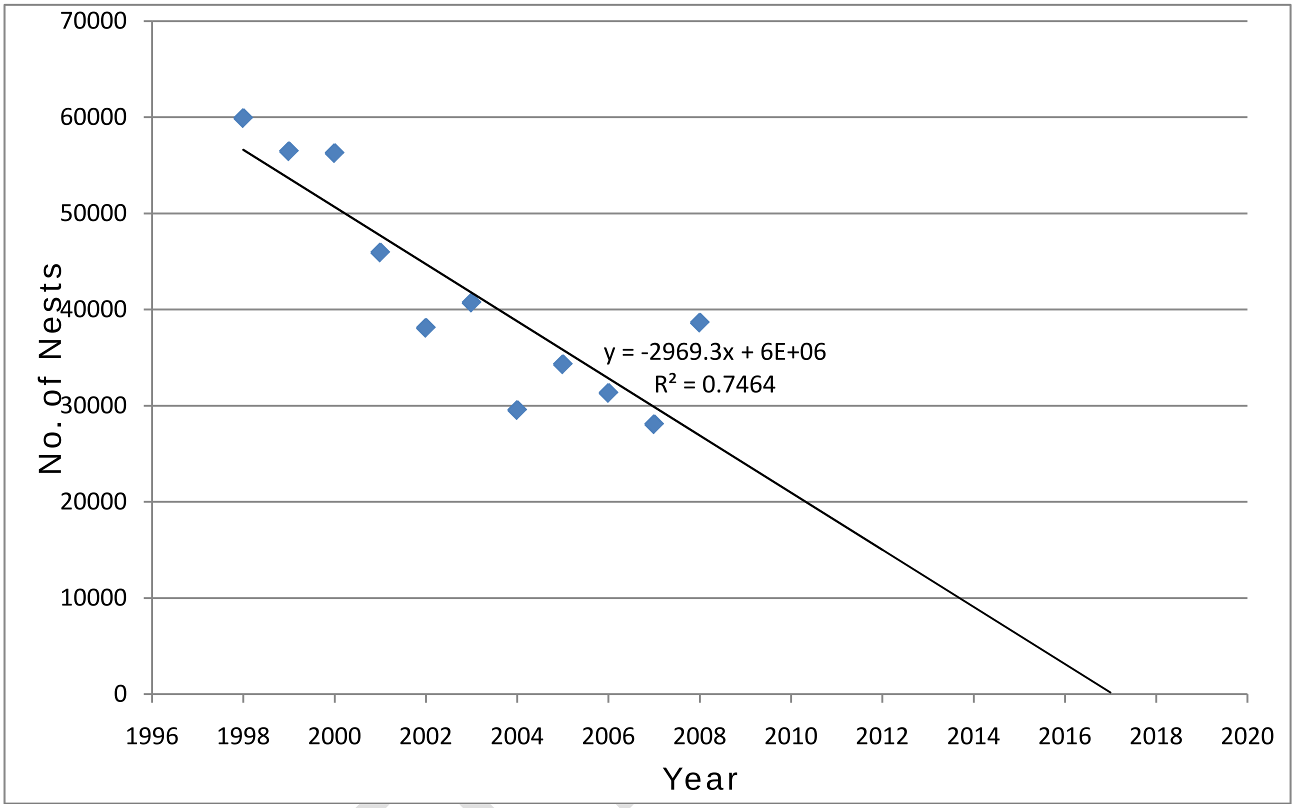

Figure 4. Loggerhead sea turtle nesting data from selected peninsular Florida beaches (n=26) from 1998 to 2008.

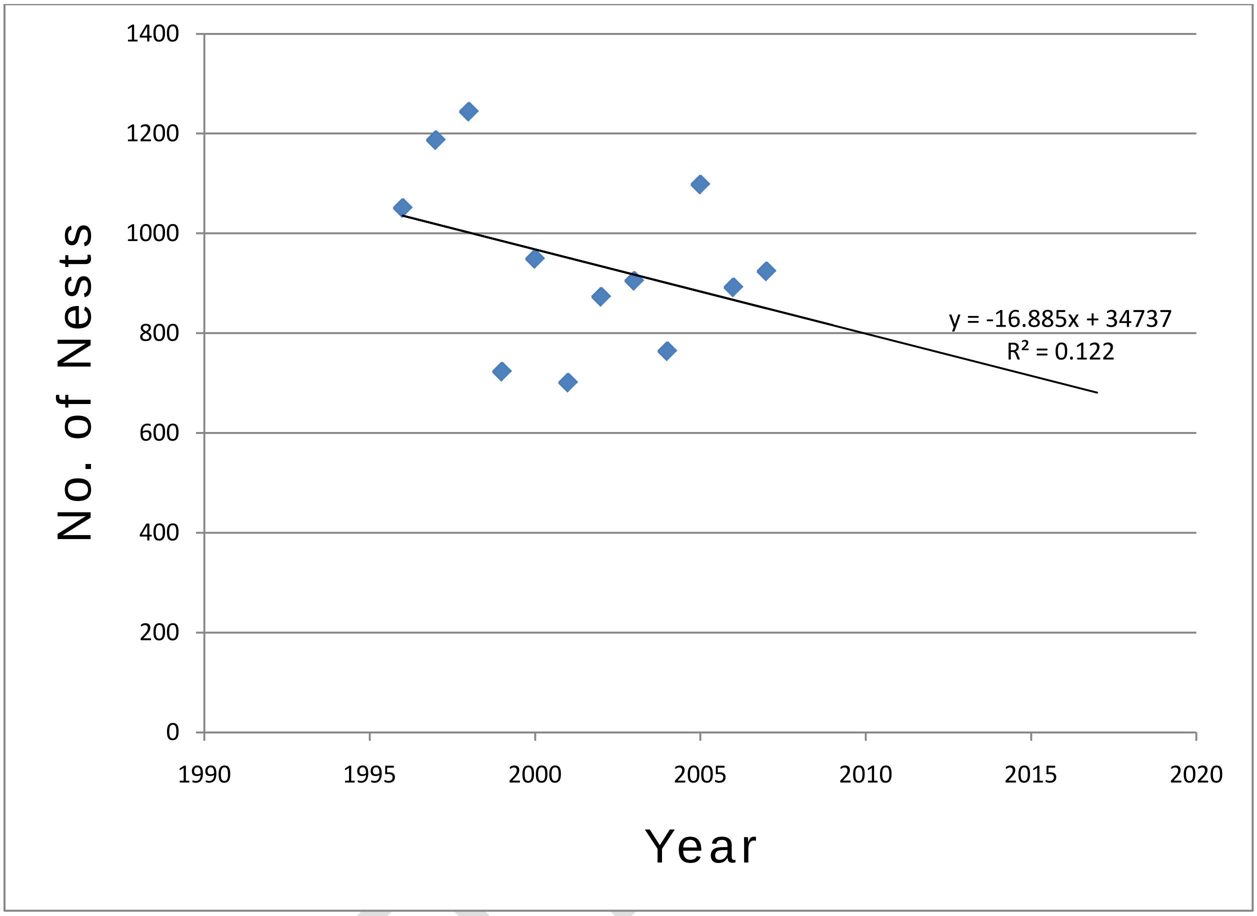

Figure 5. Loggerhead sea turtle nesting abundance from 1996 to 2007, along 2.5 miles of shoreline on Singer Island, Palm Beach County, Florida.