P1.27 ASSESSING THE EFFECT OF WEATHER ON SEA TURTLE NESTS, DAYTONA BEACH, FLORIDA

Richard K. Snow* and Mary M. Snow

Embry-Riddle Aeronautical University, Daytona Beach, Florida

1. INTRODUCTION

Daytona Beach is known as the "World's Most Famous Beach" and is located in Volusia County on a barrier island along the Atlantic Seaboard of eastern Florida. As with many coastal communities, Daytona Beach is highly vulnerable to tropical storms, hurricanes, and the storm surges that accompany these events. From 1 May through 31 October, Daytona Beach is home to a number of endangered and threatened nesting sea turtles including leatherbacks (*Dermochelys coriacea*), greens (*Chelonia mydas*), and loggerheads (*Caretta caretta*). Volusia County has established natural beach management areas and conservation zones that are off limits to public vehicles to protect the sand dunes where the turtles nest. During sea turtle nesting season, the beaches are not open to public driving until every drivable mile has been inspected by specially trained and permitted sea turtle monitoring teams. Within 48 hours of the eggs being deposited, all turtle nests are mapped with GPS. These data points are entered into a sea turtle database and used to develop a GIS of all nest locations. Loggerheads are the dominant species in Volusia County with 245 nests in 1988 (the first year of monitoring) and a high of 626 nests in 1999. However, during 2004 the number of loggerhead nests dropped to 230, possibly as a result of hurricane related storm surge. This research analyzes the temporal and spatial distribution of nests and examines the relationship between sea turtle nests and storm surge events.

2. BACKGROUND

Sea turtles are ancient reptiles that live in tropical and subtropical seas across the planet. The earliest known sea turtle fossils are about 150 million years old. They have a keen sense of smell and excellent underwater vision. Their large flippers and aerodynamic shape allow them to adapt to a variety of conditions in the sea. While males rarely return to land after crawling into the sea as hatchlings, females must come ashore to lay their eggs in the sand, and much research has focused on nesting females and hatchlings. In Florida, nesting tends to occur from May through October with most females returning to the beach where they were born to lay their eggs. Hatchlings that survive and reach the open sea grow slowly taking 15 to 30 years before reaching reproductive maturity, and they can live for 100 years or more.

Although sea turtles were once plentiful, over the past century their populations have dropped dramatically due to habitat destruction, pollution, and commercial fishing. Several species have been placed on the International Endangered Species List. Among these are the green sea turtles, the leatherbacks, and the loggerheads, all of which nest on the shores of Daytona Beach.

3. SPECIES DESCRIPTIONS

Green sea turtles (*Chelonia mydas*) have a greenish fat under their shells and a single pair of scales in front of their eyes instead of two pairs like all other sea turtles (figure 1). The head of the green sea turtle is small with a saw-toothed jaw that helps them shred vegetation. They have a bony shell with large scales that do not overlap. Adults are 3 to 4 feet in length and weigh from 300 to 400 pounds. The females nest between 3 to 5 times per season and at intervals of 2 or more years. Each nest can contain 100 eggs, and hatchlings appear in approximately 60 days. When they are young, green sea turtles eat aquatic insects, small crustaceans, algae, and sea grass. However, when they become adults, green sea turtles are strictly herbivorous eating only sea grass and algae. Green sea turtles range throughout the temperate and tropical waters of the world living near coastal areas and bays among beds of sea grass and are rarely found in the open ocean. The greatest threats to green sea turtles are the commercial harvest of the turtles and their eggs for food and the incidental catch from commercial shrimp trawling.

Figure 1. Green Sea Turtle

*Corresponding author address: Richard K. Snow, Embry-Riddle Aeronautical Univ., Dept. of Applied Aviation Sciences, Daytona Beach, FL, 32114; email: richard.snow@erau.edu

Leatherback sea turtles (*Dermochelys coriacea*) have a unique shell composed of a firm, thin, rubbery skin giving it a leathery-looking texture and are the only sea turtle without a hard shell (figure 2). As deep-sea divers, the flexible shell of the leatherback can withstand high pressures without cracking. The head of the leatherback has a profoundly irregular upper jaw that is fragile and scissor-like. As a result, leatherbacks dine almost exclusively on jellyfish. Despite this seemingly limited food source, leatherbacks are quite sizeable ranging from 4 to 6 feet in length and weighing from 500 to 1,500 pounds. The largest known leatherback was 10 feet long and weighed over 2,000 pounds. Leatherbacks typically nest at 2 or 3-year intervals and do change nesting beaches unlike other species of sea turtles. However, occasionally they nest annually laying an average of 80 large eggs 6 to 9 times a year. Incubation lasts for approximately 65 days. The greatest threats to leatherback sea turtles include incidental takings from commercial fisheries and marine pollution such as plastic bags, which the leatherbacks often mistake for jellyfish.

Figure 2. Leatherback Sea Turtle

Loggerhead sea turtles (*Caretta caretta)* are named for their extremely large heads with heavy, powerful jaws (figure 3). Their shells are heart-shaped with large, non-overlapping, rough scales. Loggerheads are carnivorous reptiles feeding on shellfish such as crabs, clams, and mussels, which they are able to crush with their strong jaws. Loggerheads typically are 2 to 4 feet long and weigh up to 350 pounds feeding in the shallow water along the continental shelves of the Atlantic, Pacific, and Indian Oceans as well as coastal bays and estuaries. They nest primarily at night with intervals of 2 or more years and can lay 4 to 7 nests per season with an average of 100 eggs in each nest. Nests are made between the high tide line and the dune front. The females usually return to the same beach each time they are ready to lay and often within a few hundred yards of where they last nested. Sometimes she will crawl out of the ocean, but decide not to nest producing what is referred to as a "false crawl," which can be caused by the distraction of artificial lighting or the presence of people on the beach. Incubation time is approximately 60 days with hatchlings emerging at night, which often causes disorientation of the hatchlings by beachfront lighting. The obstacles are so numerous for baby turtles that only about 1 in 1,000 survive to adulthood. Other threats to loggerheads include loss or degradation of nesting habitat from coastal development, nest predation, marine pollution and debris, watercraft strikes, and incidental takes from commercial fishing.

Figure 3. Loggerhead Sea Turtle

4. MIGRATION

Questions regarding how and where sea turtles migrate have been the focus of research for years. The ability of a female sea turtle to migrate thousands of miles from her feeding ground to nest on the beach where she was born is remarkable. Recent studies suggest that sea turtles migrate their entire lives beginning with the first furious crawl in which the hatchling must travel from the nest on the beach to the relative safety of the ocean. Once in the water, the hatchling must seek a location where it can feed and will be protected from predators. Hatchlings along the Atlantic Coast migrate to the Gulf Stream where they find a steady source of food and safety among the floating beds of sargassum weed. Several years of drifting within the safe harbor of the sargassum enables the sea turtles to become large enough to eventually return to the coastal waters where they spend their juvenile years. When they become adults, sea turtles again migrate to their primary feeding area where they stay throughout most of the remainder of their lives. After mating, the females leave their feeding grounds to navigate great distances to find the same small stretch of nesting beach where they were born, beginning the cycle once more. It is believed that sea turtles navigate by detecting both the angle and intensity of Earth's magnetic field enabling them to determine their latitude and longitude. This ability to know their exact position allows sea turtles to migrate freely, which also creates numerous challenges for researchers attempting to better understand and protect them.

5. DAYTONA BEACH

Daytona Beach in Volusia County, Florida, is located at approximately 29 degrees north latitude and 81 degrees west longitude along the east coast of Florida and is situated on a barrier island facing the Atlantic Ocean. While this location is advantageous for the

tourism industry, Daytona Beach is susceptible to tropical storms, hurricanes, and their associated storm surges. Daytona Beach is one of the few areas in the United States that allows driving on the beach with almost 16 miles of hard-packed sand open to automobile traffic. The beach also is home to a variety of animals that depend on the dunes that lie immediately west of the driving lanes such as mice, snakes, crabs, and nesting sea turtles including the leatherbacks, greens, and loggerheads.

A GIS of Daytona Beach was created with digitized 7.5-minute quadrangle maps and the corresponding DEMs available from the USGS, which offers these products to the general public with grid sizes of 30 meters and elevations rounded to the nearest foot. Among the Daytona Beach data entered into the GIS were conservation lands, parcel ownership, hydrology, marina locations, aquifer recharge areas, vegetation, streets, and zoning. These files are available at no cost through the Volusia County government website. The elevation data were added to the GIS using 3-D software, which allows the user to view a surface from multiple viewpoints, query a surface, determine what is visible from a chosen location on a surface, and perform 3-dimensional navigation. One-meter resolution Digital Orthophoto Quarter Quad (DOQQ) images developed with the relatively new ADS40 sensor were draped over the elevation surface creating a realistic perspective image that was integrated into the GIS.

The results of the spatial analysis based on a modeled storm surge of 4-5 feet that could accompany a Category 1 hurricane, suggest that much of the Daytona Beach barrier island would be inundated under such circumstances (figure 4). A Category 2 or Category 3 hurricane could send storm surge as far as 3 miles inland. As seen in figure 1, a direct or nearly direct hit from a Category 1 hurricane event would decimate virtually all of the sea turtle nests. The following section examines the recent history of sea turtle monitoring in Volusia County and discusses the possible effects of major storm events on nesting.

Figure 4. Category 1 Storm Surge, Daytona Beach

6. STORMS AND NESTS

The first major storm event to affect Volusia County since 1988 when record keeping of nest sites began (table 1) was Hurricane Floyd which passed 115 miles off the coast of east central Florida on 15 September 1999. Both Brevard and Volusia counties experienced widespread wind gusts near 70 mph. Initial damage estimates in Volusia County were near $42 million with $10 million of that attributed to beach erosion. A large section of the Main Street Pier was destroyed by heavy surf in Daytona Beach. Beachfront homes received major damage from surf and wind while many high-rise hotels received water damage from wind driven rain.

Table 1. 1988-2004 Volusia County Turtle Nest Totals

Year	Logger	Green	Leather	Total
1988	245	0	0	245
1989	286	0	0	283
1990	403	1	1	405
1991	384	3	2	389
1992	198	5	1	204
1993	338	0	0	338
1994	490	5	0	495
1995	443	0	0	443
1996	491	7	0	498
1997	337	4	5	346
1998	517	16	4	537
1999	626	0	2	628
2000	596	20	2	618
2001	438	1	9	448
2002	435	21	1	457
2003	393	1	5	399
2004	230	9	1	240

One month later on 15 October, Hurricane Irene moved northeast from the Florida Keys across south Florida and emerged over the Atlantic near Ft. Pierce. The storm was classified as a Category 1 hurricane with winds gusting to 70 knots over coastal locations in Daytona Beach. In Volusia, Brevard, and Indian River counties, hundreds of homes received minor wind destruction and about 50 residences were seriously damaged. The hardest hit areas were beachfront communities. Many houses and high-rise hotels suffered roof and wind driven rain damage. Substantial beach erosion was reported along the entire east coast. From 4 to 10 feet of beachfront was lost in most areas with damage estimated in the millions of dollars in each affected county. Floyd and Irene hit late in the nesting season, which in 1999 had the greatest number of nesting sites since record keeping began with a total of 628 nests. However, the Volusia County Turtle Patrol estimates that Floyd destroyed 17 percent of the nests.

Two years later, the next major storm event took place on 14 September 2001 as Tropical Storm Gabrielle moved onshore near Sarasota and exited the state just north of Cape Canaveral. Sustained tropical storm force winds occurred along the northern coast of Brevard County and along much of the Volusia County

coast. Storm tides reached about 2 feet above normal and produced significant beach erosion in Brevard and Volusia counties with winds gusting to around 45 knots across much of east central Florida. Just 448 nests were reported during 2001, and although Gabrielle stuck late in the year, the storm cut the nesting season short.

On 4 September 2002 with a total of 457 nests recorded, tropical storm Edouard approached central Florida from the east and moved on shore in northern Volusia County. However, although tropical storm warnings were issued for the storm, sustained tropical storm force winds were not observed. Wind gusts to 34 knots were recorded in a rain band at Patrick AFB as the storm approached. However, no significant beach erosion was reported.

According to the Volusia County Turtle Patrol, the 2004 sea turtle nesting season had a slow start. The first loggerhead nest in Volusia County did not appear until 12 May and only 12 more nests were reported by the end of the month. This pattern was repeated across the state. By mid-August, nesting was down approximately 50% from the previous season, and only a third of the nests had hatched by that time. Then Hurricane Charley struck southern Florida and produced hurricane strength wind gusts as it crossed Volusia County from the southwest. Daytona Beach reported a wind gust of 72 knots and Ormond Beach reported wind gusts of 76 knots. Volusia County experienced widespread power outages, thousands of downed trees, and major structural damage. The Ormond Beach area was hit especially hard with east winds from the Atlantic as the hurricane center moved off the coast just to the south near Daytona Beach. Because the duration of the onshore wind was brief, there was negligible storm surge. When Charley had passed, most of the nests were still on the beach and appeared viable.

However, the hurricane season was just beginning. Hurricane Frances was classified as a Category 2 storm when she reached the Florida east coast in Martin County early on 5 September 2004 (figure 5). Frances moved to the northwest and maintained hurricane strength as it crossed the eastern half of Florida. Brevard and Volusia counties recorded hours of hurricane force winds from the north side of the storm. Thousands of homes and businesses were destroyed or damaged and hundreds of thousands of residences were without power. Damage estimates in Volusia County were $240 million. The NWS surface wind equipment failed to operate when power was lost and as a result, the highest recorded surface wind gust was just 78 knots at Merritt Island Airport. Daytona Beach International Airport recorded a wind gust of 65 knots prior to the power outage. Beach erosion was moderate to severe at Cocoa Beach, ranging from 5 to 6 feet in southern Brevard County to 12 feet near Vero Beach where a large section of a beach road was washed out. Surge heights ranged from 3 to 4 feet at Cape Canaveral north through Volusia County. Radar estimates indicated 13 inches of rain fell in Volusia County. By the time the storm had passed, only 2-dozen turtle nests were left on the Volusia County beaches.

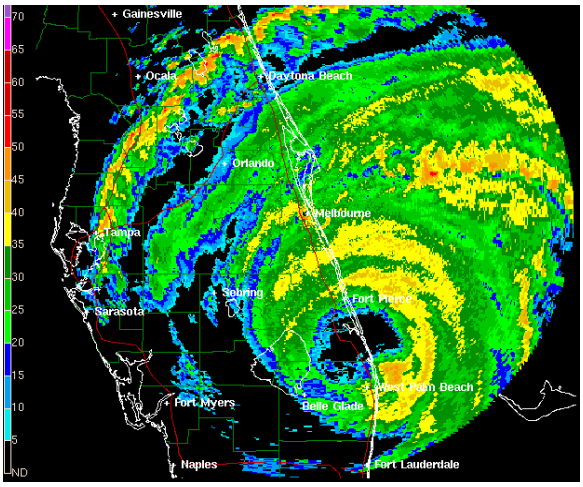

Figure 5. Hurricane Frances (NWS)

Soon following Frances, Category 3 Hurricane Jeanne reached the Florida east coast making landfall in Martin County on 26 September 2004 and moving to the west-northwest at 12 mph and maintaining hurricane strength as it crossed Florida (figure 6). In Volusia County, hurricane force wind gusts accompanied the rain bands on the northern side of Jeanne as they moved onshore causing extensive damage estimated at $60 million. Hurricane winds damaged or destroyed thousands of homes and businesses and hundreds of thousands of residences were left without power. Wind gusts of 106 knots were recorded at Vero Beach and 101 knots at Sebastian Inlet. Severe beach erosion occurred compounding the damage from Hurricane Frances just 3 weeks earlier. Estimates of storm tides in Volusia County were 6 feet with New Smyrna Beach losing much of the sand east of the town seawall. The 2004 nesting season started slowly with only 240 nests and ended with all of the remaining turtle nests being swept out to sea.

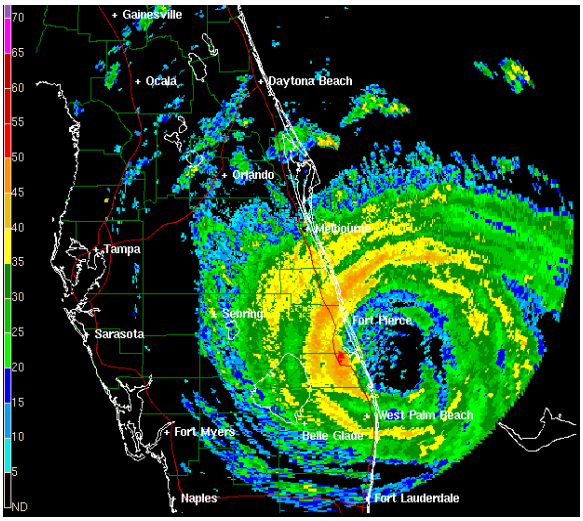

Figure 6. Hurricane Jeanne (NWS)

7. SUMMARY

As of August 2005, 436 nests have been observed in Volusia County, and the first of the hatchlings are emerging, which is cause for optimism provided the hurricane season does not resemble that of 2004 (figure 7). While the amount of good nesting habitat remains severely reduced due to erosion from the 2004 hurricanes, summer is typically a period of recovery as sea breeze driven sand accretion helps reduce the threats to nests from wave action. At the present, a number of sea turtle conservation organizations are initiating campaigns to address the threats to Florida's nesting sea turtles posed by coastal development, construction of sea walls, and endless beach nourishment projects that are degrading Florida's coastline. These organizations seek to eliminate or reduce the continued destruction of Florida's remaining sea turtle habitat by addressing poorly designed coastal management policies and ineffective enforcement of existing laws and regulations. Perhaps by raising national awareness and advocating the protection of sea turtles and their habitat, citizens will be compelled to learn more about sea turtle biology, the threats they face, and the ways in which everyone can contribute to the protection of marine turtles.

Figure 7. Turtle hatchlings race to the sea

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