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Post-Nesting Movements and Behavior of Loggerhead Sea Turtles (*Caretta caretta*) Departing from East-Central Florida Nesting Beaches

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ABSTRACT. – We attached satellite transmitters to four female loggerhead turtles (*Caretta caretta*) between 1988 and 1992, and followed their movements for 27 to 132 days. Each female took a different migration path. Three turtles appeared to move passively with the Florida Current for varying amounts of time; one eventually moved south hugging the southeastern coast of the United States, one eventually swam through the Bahamas, and one remained in offshore habitats south of Cape Hatteras. The fourth turtle swam directly to the Bahama Islands. Two of the four turtles eventually moved to the southern Great Bahama Bank, where one of them was captured by Cuban fishermen. The signal from the other turtle was last detected from the north shore of Cuba. Dive and surfacing activity reflected water depth and swimming behavior. In shallow waters, loggerheads dove less often but remained underwater for longer periods of time than they did over deep waters. Passive turtles in deep water had longer surface times. Tropical storms and hurricanes might have affected the activity of two turtles, causing them to alter their swimming behavior and to seek shelter. Adverse weather also might have led to transmitter failure or detachment. Because loggerheads readily cross national boundaries, international cooperation is necessary to protect migratory pathways and foraging grounds, especially on the Great Bahama Bank.

KEY WORDS. – Reptilia; Testudines; Cheloniidae; *Caretta caretta*; sea turtle; ecology; migration; satellite telemetry; movement patterns; behavior; water temperature; Florida; USA; Bahamas; Cuba

The southeastern coast of the United States is home to one of the world's largest loggerhead sea turtle (*Caretta caretta*) nesting aggregations. The majority of females that nest along the southeastern coast do so in Florida from Cape Canaveral southward to Broward County (Meylan et al., 1995). Nesting is particularly dense from Melbourne Beach south to Sebastian Inlet, where many of the beaches are protected as part of the Archie Carr National Wildlife Refuge (ACNWR) in recognition of the importance of this area for *Caretta caretta*.

Although a great deal of information has accumulated concerning the nesting habits of loggerheads in central and southern Florida (e.g., Bjorndal et al., 1983; Wood and Bjorndal, 2000), little is known concerning their habitats away from the nesting beaches. Females usually disappear for periods of 2 to 3 years or longer before they return to the general vicinity of previous nesting sites. Their foraging habitats and routes of travel to foraging habitats are largely unknown, although tag recoveries suggest that females disperse widely along the Atlantic Coast and into the Gulf of Mexico and Caribbean (Meylan et al., 1983). In Australia, female loggerheads usually travel ca. 500 to 1100 km to feeding habitats, although there is tremendous variation in distances traveled (11 to 2,600 km) (Limpus et al., 1992; Limpus and Limpus, 2001). If similar behavior occurs among Florida loggerheads, they have a vast area to choose from in the thousands of square kilometers of shallow waters off the east coast of the United States, in the Bahamas, and around Cuba.

During the years 1988 to 1992, we attached satellite transmitters to four female loggerhead sea turtles, after they completed nesting in Florida, in order to obtain baseline information on the location of likely foraging grounds and the routes traveled to reach these locations. We were curious to see if the turtles took similar routes to similar foraging sites, especially since they were found nesting in close proximity, albeit in different years. Alternatively, female loggerheads might scatter throughout widespread potential marine overwintering and feeding areas. Satellite transmitters have been used to track a variety of turtle movements (reviewed by Plotkin, 1998), including both localized and long-distance movements of loggerheads in the Gulf of Mexico (Renaud and Carpenter, 1994) and the Mediterranean Sea (Hays et al., 1991).

In this paper, we report on the dispersal of the four female loggerhead turtles as they moved away from their nesting beaches. We plotted their routes of travel and determined likely destinations, and we collected auxiliary data on sea temperatures and turtle diving/surfacing behavior. This information may be useful in developing international conservation and management programs for this threatened marine species in habitats where it spends most of its life, and where it may be facing some of its greatest challenges to long-term survival.

METHODS

Transmitters were attached to randomly chosen females after they had completed nesting on beaches between

Indialantic (ca. 28º27' N) and Sebastian Inlet (ca. 27º52' N), Brevard County, Florida. As each turtle finished nest covering and began moving toward the ocean, she was restrained and measured for straight-line carapace length, and fitted with a transmitter. In 1988, we used a satellite (UHF) transmitter manufactured by Telonics, Inc. (Mesa, Arizona) measuring 11.4 x 7.0 x 1.3 cm powered by three D-cell 3-volt lithium batteries housed within a cylindrical casing measuring 8.5 cm in diameter by 37 cm in length. The positively buoyant package was attached to the turtle by a stainless steel cable with an eyebolt fastened through holes drilled in the pygal bone. The housing was designed to be resistant to pressures in excess of 40 atmospheres (= 400 m in depth) and to detach from the carapace in 9 to 12 months.

In 1989 and thereafter, we used a "backpack" transmitter unit (Telonics model ST-3) measuring 2 x 13 x 9 cm and mounted on the anterior dorsal surface of the turtle's carapace. The turtle was suspended using a net and tripod in such a manner that it was unable to throw sand or unsettle the transmitter as the cement set. The flippers were padded to prevent abrasion. Polyester fiberglass resin was used to attach the transmitter directly to the shell, and fiberglass cloth strips covered by resin further strengthened the attachment to the turtle. The unit, once attached, was painted with a black marine paint to prevent fouling by marine organisms. The attachment procedure lasted approximately 45-50 min. This method of attachment has been used successfully to attach satellite transmitters and to track the movements of post-nesting sea turtles for up to 16 months (e.g., Plotkin et al., 1995); it is described in further detail by Plotkin (1998).

Satellite transmitters were equipped with a temperature sensor and two external electrodes which acted as a saltwater switch. The saltwater switch activated the transmission mode and began the collection of surface and submergence data when it was exposed to air. Data were collected and stored in 12 h periods roughly corresponding to light/dark daily cycles. Loggerhead 7674 had a transmitter with a duty cycle of 6 hrs on/6 hrs off allowing for an intensive amount of data collection. In subsequent trackings, we switched to a duty cycle of 10 hrs on/50 hrs off or 8 hrs on/52 hrs off in the hopes of extending the transmitter lifespan. Such duty cycles, however, decrease the likelihood of a turtle and satellite being in the correct simultaneous position (i.e., on the surface and overhead) for effective signal reception.

Data processed by the transmitter were sent to one of two polar orbiting NOAA Tiros-N satellites. Locations were determined via Doppler shift as the satellite moved toward then away from the position of the transmitter. Data were then transferred to a series of ground communication links and processed and distributed by Argos, Inc. (Argos, 1984). Data processed included transmitter identification code, strength of the transmission, location (latitude and longitude), internal transmitter temperature (ºC), duration of last submergence prior to transmission (sec), mean time submerged (sec), and the number of submergences > 10 sec in duration. Additional details on the operation and processing of satellite transmitter data have been discussed elsewhere (Fancy et al., 1988; Harris et al., 1990; Plotkin, 1998).

The amount of data sent by a transmitter mounted on a turtle's carapace to a passing satellite was dependent on the amount of time available for transmission. Hence, not all signals contained the same number of parameters transmitted. In addition, sometimes the amount of time a turtle was on the surface did not correspond well with the position of an overhead satellite. This resulted in a diminished capacity to determine exact locations using the Doppler shift. In addition, a turtle bobbing at the surface might give the impression of making a large number of dives in a relatively short period of time. For these reasons, the data were carefully screened, and values representing obvious errors in position, dubious indications of diving behavior, or duplicate transmissions were eliminated from analysis.

RESULTS

With one exception (turtle 7666-2), all turtles tagged were adults depositing their last clutch of the nesting season. Signals were received from transmitters for 27 to 132 days (Table 1). The turtle with the lanyard attachment (#7674) was tracked for the longest time period, whereas the turtles with backpack transmitters were only tracked from a little less than one month to approximately two and one half months. In at least one case, humans may have been responsible for removing the transmitter and in several cases severe storms coincided with the end of transmitter signal reception (see below). Because each female behaved differently upon release, their routes of travel are discussed separately. Summary statistics relating to water temperature and dive behavior are presented in Table 2.

Turtle 7674. — This turtle made the most extensive movements of all the turtles tracked (Fig. 1). She was released 31 August 1988 after nesting at Indian River Shores. After initially moving south along the Florida coast and remaining in relatively shallow (< 20 m) waters off Hutchinson Island from September 1 through early to mid-October, she abruptly moved ca. 90 km eastward, crossing the Florida Current on 10 October. She appeared to then move north either in the Gulf Stream or on its eastern side, until 21 October, at which point she was 240 km off the coast of southern Georgia. From ca. 21 October to 5 November,

Table 1. Data on female loggerhead sea turtles (*Caretta caretta*) fitted with satellite transmitters and followed as they dispersed from nesting beaches at the Archie Carr National Wildlife Refuge, Brevard County, Florida. CL = straight-line carapace length (cm).

Turtle No.	CL	Date Nested and Tagged	Date of Last Transmission	Days Tracked
7663	96.3	29 Aug 1989[a]	26 Sep 1989	27
7666-1	90.0	28 Aug 1990[b]	12 Nov 1990	75
7666-2	89.3	29 Jun 1992[c]	27 Sep 1992	90[d]
7674	89.1	30 Aug 1988[c]	12 Jan 1989	132

[a] Deposited 123 eggs, [b] Deposited 101 eggs, [c] Eggs deposited but not counted, [d] 17 days elapsed between the next to last and the last date when the final transmission was received.

Table 2. Water temperature and dive characteristics of dispersing female loggerhead turtles tracked by satellite after they completed their last nest of the season at Archie Carr National Wildlife Refuge. SD = standard deviation; NA = data no longer available.

Turtle No.	Water temperature (ºC)				Mean dive duration 12 hrs prior to last satellite transmission (min)				Number of dives 12 hrs prior to last satellite transmission				Total time submerged 12 hrs prior to last satellite transmission (min)			
	n	$\bar{x}$	SD	range	*n*	$\bar{x}$	SD	range	*n*	$\bar{x}$	SD	range	*n*	$\bar{x}$	SD	range
7663	45	32.7	0.8	29.8-34.1	33	5.0	4.9	0.9-25.1	32	105	61.2	13-316	32	636.0	51.0	454.7-691.2
7666-1		NA			26	6.6	6.7	1.2-29.2	26	102	79.7	12-294	26	664.0	46.9	458.7-705.6
7666-2		NA			18	10.0	10.4	1.1-38.5	18	103	107.4	9-329	18	663.2	29.6	605.9-707.9
7674		NA			155	25.7	25.9	0.4-29.4	152	58	80.8	6-501	152	528.4	212.0	43.2-705.0

she remained 240 to 370 km off southern Georgia in deep water at the eastern side of the Gulf Stream, at which point she entered a clockwise ocean gyre. She moved with the gyre in a broad southeast to south to southwest arc until 19 November, when she was 140 km off the Florida coast at Cocoa Beach. At its farthest point, the gyre took her ca. 420 km east of the coast of northern Florida; her route covered 1500 km over 40 days and took her over the Blake Plateau in waters of 800 to 1000 m in depth. From 19 to 22 November, she swam northwest until ca. 100 km east of

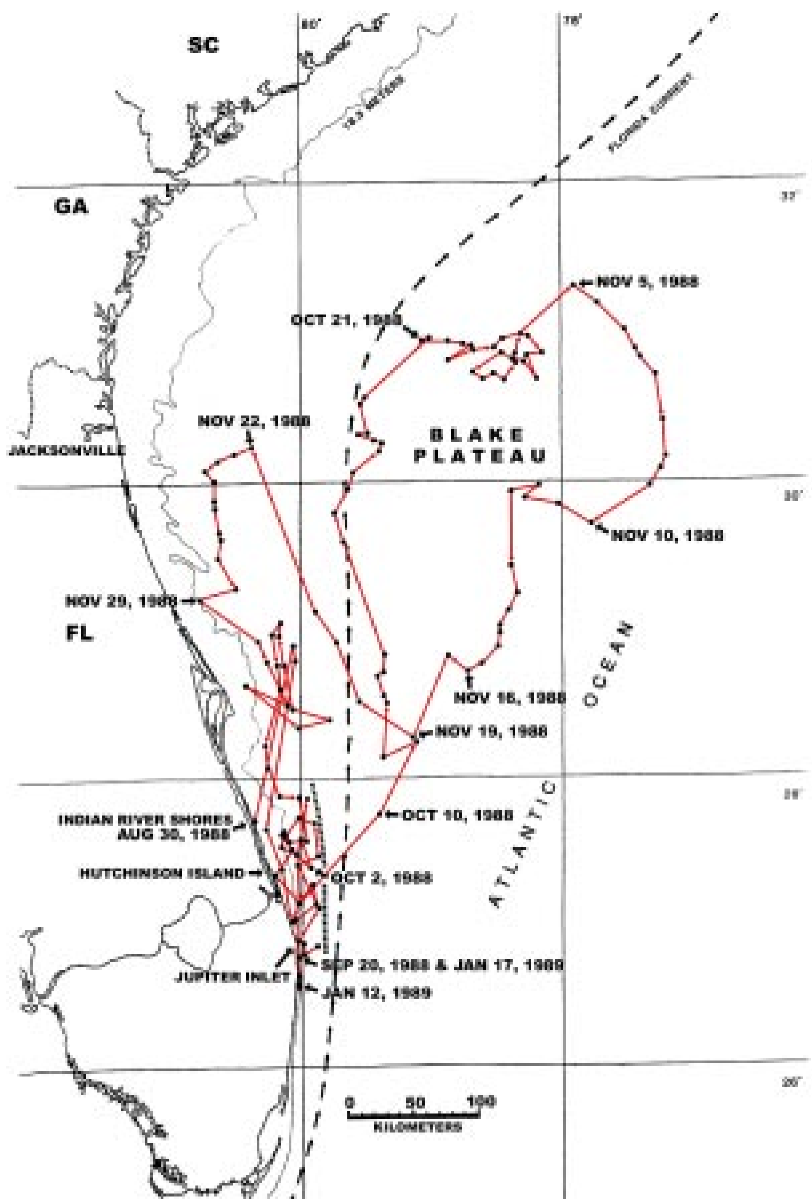

Figure 1. Track of loggerhead 7674, 31 August 1988 to 12 January 1989. The turtle was tagged 30 August 1988 at Indian River Shores, Florida.

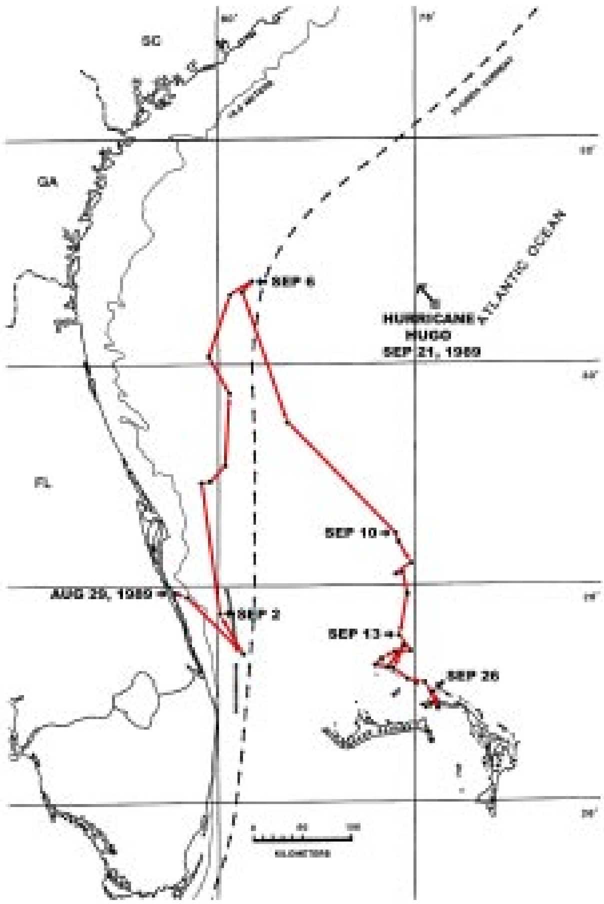

Figure 2. Track of loggerhead 7663, 30 August 1989 to 26 September 1989. The turtle was tagged 29 August 1989 north of Sebastian Inlet, Florida.

Jacksonville, at which point she began moving in a southeasterly direction. She then swam slowly south toward shallow waters, reaching the Atlantic shelf (ca. 18 m depth, 20-25 km offshore) by 29 November. The turtle continued southward until ca. 50 km off the coast just south of Ponce de Leon inlet. She remained off the coast of Cape Canaveral moving slowly south mostly on or near the surface, despite a weak cold front on 2 December. During a second weak cold front on 13 December, however, the turtle turned and moved ca. 50 km back north to the Canaveral Ship Channel in one afternoon. During a strong cold front from 14 to 19 December, she appeared to remain submerged in the Canaveral Ship Channel. Afterward, the turtle began moving south again, hugging the coastline until her transmitter detached ca.12 January near West Palm Beach. The transmitter's last location was from the huge terrestrial landfill at Riviera Beach. The turtle herself was eventually captured on 17 February 1989 at Bahia Honda, Pinar del Rio, Cuba (Ministerio de la Industria Pesquera, Cuba, in letter to José Ottenwalder, October, 1989).

Examination of water temperature data showed that the turtle remained in relatively warm waters (19-27ºC) throughout the tracking period, except for one occasion. During the strong cold front of mid-December 1988, water temperatures dropped below 18ºC, and no transmissions were received for five days. During the previous weak cold fronts, water temperature did not drop appreciably.

In general, loggerhead 7674 spent 73% of her time submerged per 12 hr period (Table 2). However, patterns of submergence changed based on whether the turtle was over shallow (near coast) or deep (far offshore) water. In shallow water, her submergence time averaged 676.2 min ($\bar{x}$ = 43.8 min on the surface) with little variation (SD = 37.3; n = 62); in deep water, she spent an average of 426.5 min submerged ($\bar{x}$ = 293.5 min on the surface) with a much greater degree of variation (SD = 222.6; n = 90). Likewise, the mean duration of a dive was longer in shallow water ($\bar{x}$ = 39.6 min, SD = 31.7, n = 63) compared with deeper water ($\bar{x}$ = 16.1, SD = 15.0; n = 92), but as expected, the number of dives was greater in deeper water ($\bar{x}$ = 66.2; SD = 82.5; n = 90) compared with shallow water ($\bar{x}$ = 45.5; SD = 77.2; n = 62). With the exception of her movement up the Gulf Stream and out over the Blake Plateau, the turtle spent most of her time in shallow coastal waters less than 60 m in depth.

Turtle 7663. — This turtle was released shortly after nesting 18 km south of Indialantic on 30 August 1989. She immediately swam southeast to the western side of the Florida Current ca. 50 km east of Hutchinson Island (Fig. 2). By 2 September, she was ca. 83 km northeast of Hutchinson Island in < 60 m of water moving north. From 2 to 6 September, she moved northward along the western margin of the Gulf Stream until she reached a point ca. 175 km east of Fernandina Beach. At this time, ocean swells in this area were from 1.6 to 2.5 m because of Hurricane Gabriel passing well to the east. She then abruptly began swimming southeast (crossing the Gulf Stream ca. 170 km east of Flagler Beach), then south toward Grand Bahama Island. By 10 September she was ca. 240 km east of Cape Canaveral. She arrived just north of Walker's Cay on the Little Bahama Bank by 13 September. After spending several days in the vicinity of Double Breasted Cay, she slowly moved south, passing Stranger's and Carter's Cays in the central part of the Little Bahama Bank, to the vicinity of Little Abaco Island. It appears as though she briefly swam south of Little Abaco to the vicinity of the Cross Cays before returning to the north side of Little Abaco. Her last signal was received on 26 September from just north of Little Abaco Island shortly after Hurricane Hugo roared by ca. 300 km to the northeast on 20-21 September with winds > 200 km/hr.

Inasmuch as this turtle was tracked for the shortest amount of time, it is perhaps not surprising that there was little variation in water temperature during the tracking period (Table 2). From the time she left the beach, she appeared to be swimming at or near the surface. This is reflected in the very short mean dive duration and in the large number of "dives" during the previous 12 hrs (Table 2). Cumulatively, the total time submerged is rather great but, coupled with the large number of dives, suggests that she remained very close to the surface coming up frequently for air although staying under water for most of the 12 hr period. A visual inspection of this turtle's data suggests no variation

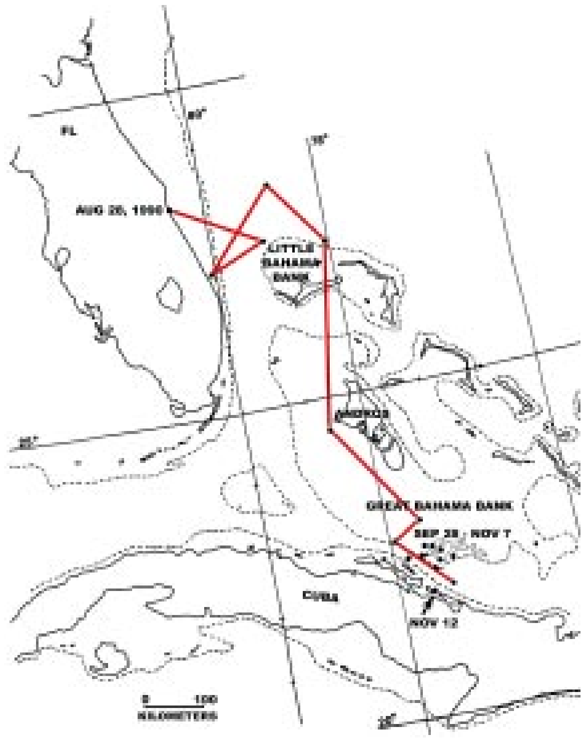

Figure 3. Track of loggerhead 7666-1, 28 August 1990 to 12 November 1990.

in diving behavior regardless of whether she was over shallow or deep water.

Turtle 7666-1. — This turtle was tagged after she nested 9 km south of Indialantic on 28 August 1990. She immediately traveled southeast, crossing the Florida Current seemingly in the direction of the Little Bahama Bank, until 31 August when she abruptly moved back across the Florida Current to ca. 10 km east of Jupiter Island (Fig. 3). In early September, she swam again across the Florida Current well offshore but at approximately the same latitude as her nesting beach. She then swam south to the Little Bahama Bank WNW of Walker's Cay near where loggerhead 7663 entered the Bank. From 10 September to 23 September, she swam south across the Grand Bahama Bank, across the Northwest Providence Channel, and parallel to the west coast of Andros Island across the shallow Great Bahama Bank. In the south-central Great Bahama Bank, she took up residence from ca. 25 September until 9 November in an area roughly 100 x 150 km. Tropical Storm Klaus passed near her on 5 October but she remained in the area. On 26 October, she was ca. 85 km north of Nuevitas, Cuba, but by 30 October she was back on the Bahamas Bank near Cayo Lobos. Her last transmitter signal was received on 12 November from Cayo Guajaba on the northern coast of Cuba.

From the time she was tagged until she arrived in the southern Bahamas (ca. 23 September), the turtle appeared to swim at or near the surface most of the time which resulted in large number of "dives" of short duration. Upon arriving in the southern Great Bahama Bank, her dive pattern changed to a routine of from ca. 3 to 10 dives per hour, each dive lasting ca. 11-20 min. This suggests a pattern of active feeding. On the bank, the total submergence time actually decreased slightly from the submergence times logged during long distance swimming.

Turtle 7666-2. — This turtle was the only turtle followed during the middle of the nesting season. However, she did not return to nest along the east coast after release on 29 June 1992 (Fig. 4). Instead, she made her way northward slowly to the vicinity of New Smyrna Beach, then abruptly swam northeast across the Florida Current to a region ca. 320 km east of the Georgia–South Carolina border. She proceeded directly north for 10 days to just south of Cape Hatteras, then turned southwest to an area off the North Carolina–South Carolina coast where she remained throughout the time that the satellite signal was received. The region off Cape Hatteras where she began her southward movement is an area where the shallow continental shelf falls off precipitously to the deep waters of the Atlantic. In returning southwest, she seemed to follow this line but remained just westward in waters < 100 m in depth. No signals were received between 10 and 27 September, when all transmission ceased. During this quiescent period, it is likely that the turtle took shelter as slowly moving Tropical Storm Danielle formed and passed just east of her from 22 to 25 September.

From release until this turtle reached the vicinity of Cape Hatteras, dives were of rather short duration (< 10 min) and there were many of them ($\bar{x}$ = 222 per 12 hr period) indicating that she was swimming near the surface. After she began her journey to the southwest, however, the average dive increased in duration ($\bar{x}$ = 27 min) and the number of dives decreased to 9 to 95 per 12 hr period. Likewise, her submergence times were greater over deeper water as she swam north, then decreased slightly as she moved southwest in shallower coastal waters. These data are summarized in Table 2.

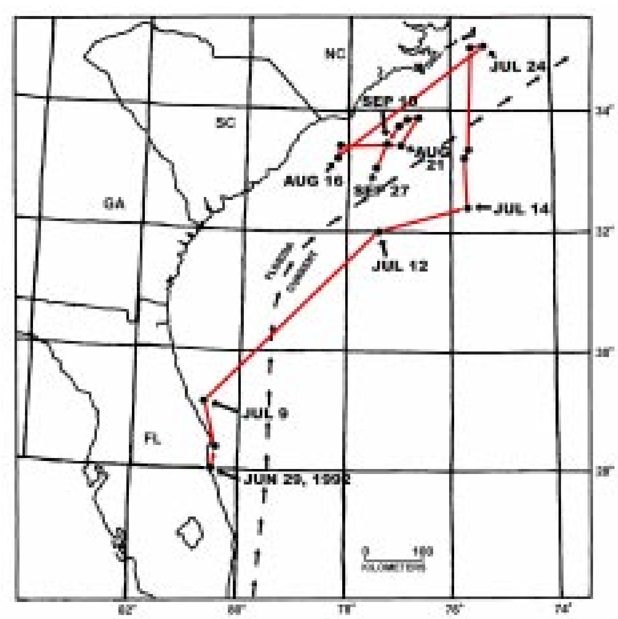

Figure 4. Track of loggerhead 7666-2, 29 June 1992 to 27 September 1992.

DISCUSSION

Prior to our observations, limited tag returns suggested that loggerheads overwintered and foraged along the southeastern United States, Cuba, Hispaniola, the Bahamas, and elsewhere in the shallow waters of the western Atlantic (Meylan et al., 1983). However, the routes of travel to these locations were unknown. The four loggerheads tracked showed four different migration patterns after leaving their nesting beaches. Loggerheads 7674, 7663, and 7666-2 were similar to a limited extent in that initially all remained inshore or moved northward with the Florida Current. Loggerhead 7666-1 showed an entirely different behavior.

No. 7674 remained in the Current and wide-arching oceanic gyres until the onset of cool temperatures in the autumn before venturing back down the coast and eventually to Cuba. She was still off the coast of Florida by mid-winter of 1988-89, but was later taken by fishermen off the north coast of Cuba at Bahia Honda, Pinar del Rio, on 17 February 1989. Her routes of travel and movement patterns suggest that she was responding to water temperatures. When temperatures began to cool, she turned south. During frigid cold fronts in early to mid-December 1988, she sought shelter in the Canaveral Ship Channel, a location where loggerheads are known to bury into the mud during adverse winter conditions (Carr et al., 1980). Henwood (1987) showed that mostly subadult loggerheads overwintered in the Channel, but that adult females were non-resident occasional visitors. No. 7674 seems to fit this profile. When temperatures warmed in late December, she resumed her journey southward.

Loggerhead 7674 had a diving/surfacing behavioral pattern that appeared correlated with the depth of the ocean. In shallow waters, she dove less often but remained underwater for longer periods of time than she did over the deep waters of the Blake Plateau. This suggests that she may have been resting initially after her long nesting season, then feeding as she moved southward in preparation for her continued journey to the Great Bahama Bank.

No. 7663 moved with the current only a short time before moving southeasterly to the Bahamas. This female seemed to be foraging in the northern Bahamas, but her transmitter either malfunctioned or was lost after only a little less than a month. She may have proceeded south or remained in the area, but no further tagging record exists of this turtle (D. Bagley, *pers. comm.*). The malfunction of her transmitter seemed to coincide with the passage of Hurricane Hugo to the northeast, although it cannot be determined if loggerhead 7663 was affected by this massive storm. This turtle seemed to be swimming most of the time near the surface after a brief initial period of resting.

Whereas the preceding turtles rode the Current north but clearly returned south, the other turtles behaved differently. Turtle 7666-1 swam directly to the Bahamas, then onward to the Great Bahama Bank off the north coast of Cuba, without taking any break. Her diving/surfacing pattern suggested that she was swimming directly and rapidly near the surface, but remaining mostly underwater, rather than resting after an arduous nesting season. It is worthy of note that Tropical Storm Klaus passed near her in October 1990 but had little apparent effect on her behavior. Unfortunately, her last signal was recorded from a small island off the north coast of Cuba, where Cuban fishermen may have carried her transmitter after taking the turtle on the Great Bahama Bank. At that time, Cuban fishermen were known to be illegally fishing the Bank (S. Buckner, *pers. comm.*).

It is clear, however, that not all loggerheads depart the shallow coastal waters of the southeastern United States during the winter. In an entirely different pattern from the other females, loggerhead 7666-2 appeared to be taking up residence in the warmer waters of the continental shelf off North Carolina, although her transmitter malfunctioned before it could be determined exactly where she overwintered. No tag recoveries were ever made of this turtle again (D. Bagley, *pers. comm.*). Reports of loggerheads residing year-round in the waters of the Gulf Stream are common off North Carolina (Epperly et al., 1995a, 1995b), where sea temperatures remain above 17–20%C throughout the colder months (Epperly et al., 1995b; Coles and Musick, 2000).

Tropical storms and hurricanes had mixed effects on the behavior of the loggerheads tracked. Turtle 7663 clearly was traveling in a direction which would have put her on a collision course with Hurricane Hugo (Fig. 2). However, her abrupt move to the south occurred at least two weeks prior to the passage of this intense storm. It seems unlikely that she could have sensed the arrival of a hurricane two weeks in advance. On the other hand, turtle 7666-2 clearly took shelter to avoid Tropical Storm Danielle, which formed in the immediate vicinity of her last locations and may have been involved in her transmitter malfunction, occurring as it did immediately after passage of the storm. Conversely, turtle 7666-1 did not appear to alter her behavior in any way as Tropical Storm Klaus passed near her location. Since she appeared to be on her foraging grounds, perhaps she had located shelters which protected her from turbulence.

Females nesting on beaches in east-central and southern Florida undoubtedly interact with females originating from other Atlantic beaches (see Dodd, 1988). Still, central and southern Florida loggerheads can be identified genetically by the presence of a unique combination of haplotypes (Bowen et al., 1993; Bowen and Karl, 1997; Encalada et al., 1998). These genetic markers can be used to separate central and south Florida loggerheads from loggerheads nesting farther to the north and elsewhere in the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea. It therefore should be relatively easy to determine whether loggerheads found on the Great Bahama Bank originate from single or multiple nesting populations and to what extent feeding grounds are used by various populations.

Although we only tracked four turtles, it is noteworthy that one of them was eventually taken by fishermen from Cuba, one probably was taken by Cuban fishermen, and two of the turtles used the shallow waters of the Bahama Islands for foraging, shelter, and migratory routes. It also seems likely that turtle 7663 could have continued southward, possibly to take up residence on the Great Bahama Bank. The Great Bahama Bank is a huge shallow (mostly < 18 m) platform (Sealey, 1985), rich with marine life. However, it is virtually unexplored as possible habitat for loggerhead turtles. We suggest that the shallow Great Bahama Bank could offer significant non-nesting marine habitat for loggerhead and other sea turtles that nest in the western Atlantic. Given the vulnerability of this area due to its remoteness from Bahamian legal authority and its proximity to Cuban fishermen, the taking of sea turtles could pose a significant threat to populations in the region. Research should be directed toward assessing the importance of the Great Bahama Bank as foraging and overwintering habitats for loggerheads and other sea turtles. As the results of so many other satellite tracking and molecular studies have shown (reviewed by Bowen and Karl, 1997; Plotkin, 1998), international cooperation is essential in protecting and managing these migratory animals.

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