Biological Conservation **26** (1983) 65–77

Sea Turtles Nesting at Melbourne Beach, Florida, I. Size, Growth and Reproductive Biology

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ABSTRACT

From 1972 to 1978, 2910 loggerheads Caretta caretta *and 18 green turtles* Chelonia mydas *were tagged as they came ashore to nest on Melbourne Beach, the area with the greatest density of sea turtle nesting in Florida. The nesting loggerheads averaged 92·0 cm in straight-line carapace length and grew at a mean rate of 0·57 cm per year. The most common remigration intervals observed for loggerheads were two and three years. In 46 cases, turtles tagged on Melbourne Beach moved to other beaches in later nesting seasons, and 82 Melbourne Beach turtles shifted to other beaches during the same season. Interseasonal nesting movements spanned 700 km of coastline; intraseasonal movements ranged over 290 km. The 18 green turtles nested from early June to late August. The mean straight-line carapace length was 110 cm. A two-year remigration interval predominated. No green turtle tagged on Melbourne Beach has been seen on other beaches.*

INTRODUCTION

The population of the loggerhead *Caretta caretta* of the southeastern United States has been estimated to be the second largest in the world,

Biol. Conserv. 0006-3207/83/0026-0065/$03.00

exceeded only by that of Masirah Island, Oman (Ross, 1982). The range of concentrated nesting is from South Carolina to the lower Gulf Coast of Florida. Nesting is not continuous along the coast but is interrupted by both natural and man-made barriers. During the past decade, turtle-tagging projects have been initiated at numerous localities within the nesting range. The present paper reports results of a tagging project conducted from 1972–1978 on an 11·2 km stretch of beach at Melbourne, Florida.

Aerial surveys of Melbourne Beach in 1977 (Carr & Carr, 1978) and 1979 (L. Ogren, pers. comm.) revealed it to be an extremely important site for loggerhead nesting. In the 1977 nesting season it was found to exceed all others in the state in terms of average nesting density (Carr & Carr, 1978). Melbourne Beach is situated on a narrow barrier island and offers little suitable habitat for raccoons. As a result, raccoon predation, which can destroy up to 97% of all loggerhead nests on other beaches in the southeastern US (Stancyk, 1982), is low. In 1973, the tagging team estimated that only 5% of the nests on Melbourne Beach were destroyed by raccoons. Larry Ogren of the National Marine Fisheries Service made two overflights along Melbourne Beach in July 1979, during the peak of the nesting season, and saw no evidence of raccoon predation, although on the beach at Kennedy Space Center, just to the north, predation was observed to be heavy (L. Ogren, pers. comm.).

The loggerhead is listed as a vulnerable species by the International Union for the Conservation of Nature (IUCN) and as a threatened species by the United States government. Melbourne Beach, with its low predation and high nesting density, is probably producing more hatchlings per area than any beach in Florida, and is thus very important to the continued survival of the species in US waters. There are, however, several problems that threaten to decrease the productivity of the sea turtles nesting on Melbourne Beach. The beach is undergoing rapid development, and the shoreward-facing lights of these buildings, as well as those on nearby Highway A1A, disorient emerging hatchlings. The harmful effects of lights—both in disorienting hatchlings and in discouraging nesting females from coming ashore—are reviewed by Mortimer (1982). Adult female turtles at Melbourne Beach are occasionally killed by automobiles while crossing the highway in search of nest sites. Foot traffic, a potential threat to emerging hatchlings (Mortimer, 1982), is relatively heavy. Fortunately, vehicles are not permitted on the beach.

The tagging project was initiated and directed by Turner; field work

was carried out by him and local volunteers. Dr Archie Carr provided tags and the initial design of the project. Bjorndal and Meylan analysed the data and prepared the manuscript.

METHODS

Between 1972 and 1978, a total of 2910 loggerheads and 18 green turtles *Chelonia mydas* were tagged between Spessard Holland Park and Floridana Beach in Brevard County. The shore was divided into seven 1·6 km sections for recording nest locations. The beach was patrolled in dune buggies on as many nights as logistics allowed. Beach coverage by the taggers was not complete. Turtles were tagged with monel metal tags (size 49, National Band and Tag Company, Newport, Kentucky) that were inscribed with an identification number, an offer of a reward for return of the tag, and the University of Florida return address. Straight-line carapace length was measured from the middle of the nuchal scute to the pygal notch. Width was measured at the widest point of the carapace. It was recorded whether each turtle had nested.

Because of incomplete beach coverage, we have not attempted to calculate the average internesting interval within a season, or the mean number of clutches laid by a female in one season. Also, we have not tried to present any statistical expression of the degree of site fixity of loggerheads nesting on Melbourne Beach, because of the coarse scale (1·6 km) of the beach subdivisions used. Post-nesting movements of turtles tagged at Melbourne Beach are discussed in Meylan *et al.* (1983).

RESULTS AND DISCUSSION

Loggerhead size and growth

To obtain the mean straight-line carapace length (SCL) of the breeding population, carapace measurements from two randomly selected breeding seasons, 1973 and 1977, were used. Mean SCL is 92·0 cm (SD = 1·96, range 74·9–109·2 cm, N = 661). As expected, the mean length is similar to those found in other segments of the southeastern US loggerhead population: 91·7 cm (N = 194) for the Kennedy Space Center, Florida, population (Ehrhart & Yoder, 1978), 92·4 cm (N = 72) for the population

in Everglades National Park, Florida (Davis & Whiting, 1977), and 95·9 cm (N = 110) for Jekyll Island, Georgia (Caldwell *et al.*, 1959). The southeastern US loggerheads are larger (t-test, $p < 0{\cdot}01$) than those from Natal, South Africa (mean SCL = 79·2 cm, $\hat{\theta} = 4{\cdot}78$, N = 23), and Tongaland, South Africa (mean SCL = 87·2 cm, $\hat{\theta} = 3{\cdot}64$, N = 29; Hughes, 1974*a*). Also, they appear to be larger than those recorded at Buritaca, Colombia (mean SCL = 87·9 cm, N = 78; Kaufmann, 1975), but no variance value was given.

Growth data are available from 67 female turtles for a total of 70 growth intervals ranging from 2 to 4 years. The mean growth rate is 0·57 cm per year (SD = 0·52, range 0 to 0·875 cm year^{-1}). There are no other data on growth rates in adult loggerheads based on straight-line carapace measurements with which to compare our data. Limpus (1979) gives growth rates for two adult female loggerheads from the southern Great Barrier Reef, Australia, of 0·15 and 0·25 cm per year. These are based on curved carapace lengths, however, and the relationship between rates based on straight-line measurements and those over the curve is not known.

The growth rate of loggerheads reported here is similar to rates reported by others for adult female green turtles. Carr & Goodman (1970) measured a mean growth rate of 0·4 cm per year (N = 179) for green turtles nesting at Tortuguero, Costa Rica. Balazs (1980) measured a mean growth rate of 0·50 cm per year (N = 18) for adult female green turtles nesting at French Frigate Shoals, Hawaii. The similarity in growth rates of mature loggerheads and green turtles is surprising, in view of the fact that juvenile and subadult loggerheads are known to grow much more rapidly than green turtles under natural conditions in Florida (Mendonca, 1979) and in the southern Bahamas (Bjorndal, unpublished data). It is clear that growth in sexually mature female loggerheads and green turtles is quite slow.

Remigration intervals

Remigration intervals for turtles tagged for the first time between 1972 and 1975 are shown in Table 1. Turtles tagged in later years were not included, because sufficient time for remigrations had not elapsed. A total of 149 loggerheads remigrated 161 times. As can be seen in the Table, Melbourne Beach turtles exhibit a remigration pattern that is very similar to that of loggerheads nesting on Little Cumberland and Cumberland

islands, Georgia (Richardson *et al.*, 1978). The only striking differences are the smaller number of two-year intervals and the greater number of four-year intervals for the Melbourne loggerheads. Some of the four-year remigrants probably represent two-year remigrations that were missed because of the incomplete beach monitoring.

The remigration pattern of Tongaland loggerheads presented in Table 1 differs considerably from that of the US loggerheads in that one-year intervals are much more common, and three-year intervals are, correspondingly, less common. It is not known what factors cause the variation

TABLE 1

Remigration Intervals of Loggerheads *Caretta caretta* from Three Nesting Sites. Data from Georgia are from Richardson *et al.* (1978); Data from Tongaland are from Hughes (1974*b*)

Site	*1 year*	*2 years*	*3 years*	*4 years*	*5 years*	*6 years*	*7 years*
Melbourne,	3	75	56	21	5	0	1
Florida	1·9%	46·6%	34·8%	13·0%	3·1%	—	0·6%
Cumberland,	7	135	75	17	4	4	0
Georgia	2·9%	55·8%	31·0%	7·0%	1·7%	1·7%	—
Tongaland,	40	99	19	15	3	7	0
S. Africa	21·9%	54·1%	10·4%	8·2%	1·6%	3·8%	—

in remigration intervals in sea turtle populations. The relatively shorter remigration intervals of the Tongaland loggerheads may be due to differences in the length of migratory routes, in richness of foraging habitat, or in reproductive output—that is, egg size, clutch size and/or number of clutches per season. Similar variation from one population to another in the length of remigration intervals has been reported for green turtles (Schulz, 1975).

Six loggerheads have been recorded at Melbourne Beach during three different nesting seasons; three were observed in four different seasons (Table 2). In three of these twelve remigrations the interval increased, in three it decreased and in six it remained the same. The pattern is similar to that reported for Georgia loggerheads by Richardson *et al.* (1978), who found that shifts from three-year to two-year intervals were equalled by the reverse shift.

TABLE 2
Multiple Remigration Patterns of Nine Loggerheads *Caretta caretta* Tagged at Melbourne Beach, Florida, 1972–1975

No. of returns	*Intervals unmodulated*	*Intervals modulated*
Two	2–2	2–3
	2–2	3–2
	2–2	3–4
Three	2–2–2	1–2–1
		3–1–1

Interseasonal and intraseasonal nesting beach fidelity

It is generally accepted that loggerheads show less site fixity when returning to nest, either between or within seasons, than do green turtles, and there are some data to support this idea. Ehrhart (1979) recorded a mean distance of 7·99 km (SD = 6·87, N = 37) between nesting sites in different seasons for loggerheads nesting at Kennedy Space Center. Hughes (1974*b*) found mean distances between nest sites of 4·54 km (N = 56) and 3·35 km (N = 29) for two consecutive seasons for remigrating loggerheads in Tongaland. Carr & Carr (1972) reported a shorter mean distance of 1·3 km (SD = 1·35, N = 181) between nesting emergences of remigrating green turtles at Tortuguero, Costa Rica. However, these figures are not directly comparable because of differences in sampling methods.

Our data for Melbourne Beach loggerheads do not allow an analysis of the degree of site fidelity both because of incomplete beach coverage and the long beach divisions used in this study. However, we have had good cooperation with the biologists studying the major loggerhead nesting beaches in Florida, to the north and south of Melbourne Beach, and can report on the movements of Melbourne loggerheads to other nesting beaches. It should be remembered when evaluating these data that the beach boundaries discussed are often arbitrary, man-designated divisions rather than geographic ones. Sebastian Inlet, for example, the site of several of our returns (Table 3), is continuous with Melbourne Beach.

Of the loggerheads tagged on Melbourne Beach, 169 have been seen again in one or more later seasons on Melbourne Beach, and 486

loggerheads have renested on Melbourne Beach in the same season in which they were tagged. If beach coverage had been more complete, more remigrating and renesting turtles would have been recorded. We therefore hesitate to calculate the percentage of remigrants displaying site fixity.

Turtles tagged on Melbourne Beach have been recorded on other nesting beaches, both within a breeding season and between breeding seasons. The navigation and orientation mechanisms may be different for these two types of beach-finding, and different cues may be involved. It is useful, therefore, to consider the two separately.

Forty-six loggerheads that were seen on Melbourne Beach between 1972 and 1978 have been reported on other beaches in Florida in a different nesting season (Table 3). The 25 turtles that are known to have nested on both beaches did not move predominantly to either the north or the south—12 shifted to the north, 12 shifted to the south, and 1 shifted south, then north (from Sanibel Island). The record distance for an interseasonal shift in nesting beaches involved a loggerhead that nested on Sanibel Island, on the West Coast of Florida in 1968 and was not seen again until 1972 when she nested on Melbourne Beach (LeBuff, 1974). The distance between the two sites is 550 km, following the coastline. Turtles that have been seen on Melbourne Beach have, in emerging to nest in other seasons, ranged over a coastline distance of 700 km, from Canaveral National Seashore to Sanibel Island. If the Sanibel Island record is omitted, the shifts in remigrant emergences span 255 km.

Records of intraseasonal beach shifts are more numerous than interseasonal shifts, both in the literature and for the Melbourne Beach population. The longest distance travelled between successful nesting emergences within a season involved a loggerhead that nested on Cape Island, North Carolina, in June 1979, and at Kennedy Space Center, Florida, in July 1979 (Ehrhart, 1979). LeBuff (1974) reported that a loggerhead nested at Morgan Beach, Florida, and reappeared 42 days later on Sanibel Island, Florida, 83 km to the north. Twelve loggerheads (of 260 tagged) that nested on Hutchinson Island, Florida, moved south to Jupiter Island to nest again (Worth & Smith, 1976).

Eighty-two loggerheads that were recorded on Melbourne Beach between 1972 and 1978 have been seen on other beaches within the same season (Table 3). Data from Canaveral National Seashore, Kennedy Space Center, Hutchinson Island and Jupiter Island were kindly supplied by D. L. Stoneburner, L. M. Ehrhart, D. Worth and F. Lund, respectively. Information from Sebastian Inlet is from LeBuff (1976). LeBuff

TABLE 3

Interseasonal and Intraseasonal Beach Shifts of Loggerheads (*Caretta caretta*) Tagged on Melbourne Beach, Florida[a]

Location	*Approximate distance from Melbourne Beach (km)*	*No. nested at both beaches*	*No. nested Melbourne Beach only*	*No. nested other beach only*	*No. did not nest at either beach*	*Unknown nesting history*
New Smyrna	182	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)
Canaveral National Seashore	148	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)
Kennedy Space Center	91	5 (7)	5 (2)	1 (3)	1 (4)	4 (4)
Sebastian Inlet	adjacent to south end of MB	5 (12)	2 (3)	0 (5)	1 (1)	1 (9)
12 km north of Vero Beach	26	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)
Hutchinson Island	99	6 (14)	2 (1)	2 (4)	1 (0)	1 (0)
Jupiter Island	107	7 (1)	0 (0)	0 (3)	0 (0)	0 (0)
Sanibel Island	550	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)

[a] This summary disregards the order in which each beach was visited. Numbers without parentheses represent interseasonal values; those in parentheses are intraseasonal values.

(1974) reported a tendency for the loggerheads on the Gulf Coast of Florida to move northwards throughout the nesting season. The 38 Melbourne turtles that are known to have nested successfully on two different beaches showed no such directional bias—21 moved north and 17 moved south. The range of renesting sites of loggerheads seen on Melbourne Beach is from New Smyrna, Florida, to Jupiter Island, Florida—a distance of 290 km.

In addition to the above references that distinguish interseasonal from intraseasonal movements, there are several papers that do not distinguish between the two. Bell & Richardson (1978) reported that 13 loggerheads that nested on Little Cumberland Island, Georgia, have nested on other beaches. Eleven of these renestings were on Jekyll and Cumberland islands, Georgia; the sites of the other two were not given. Also, Talbert *et al.* (1980) noted that of 211 turtles tagged on Kiawah Island, South Carolina, one had previously nested on Fripp Island, South Carolina, and one on South Island, South Carolina.

Many more loggerheads tagged on Melbourne Beach return to nest there instead of moving to other beaches. Nevertheless, the beach shifts reported here and by other authors demonstrate the degree to which, in the Florida rookeries, there is opportunity for gene flow—assuming that copulation takes place off the nesting beaches.

Chelonia mydas

The Florida green turtle breeding population is a remnant of a much larger population that suffered a severe decline at the end of the 19th century due to over-exploitation (Carr, 1952). After the adult green turtles had been nearly extirpated, the fishery continued to take sub-adult (4·5–50 kg) turtles from the coast of Florida (Caldwell & Carr, 1957). The source of these small turtles is not known (Carr & Caldwell, 1956).

True (1884) reported that the green turtle nesting season in Florida was from April to July. Carr (1952) gave May to June as the nesting season of Florida green turtles. The 18 green turtles tagged on Melbourne Beach between 1972 and 1978 were seen a total of 23 times. The sightings were between 9 June and 19 August during the seven years. These dates, although they differ from the early reports, agree with those recorded by other Florida workers: 18 June to 10 September on Hutchinson Island (N = 51 nests; Worth & Smith, 1976); 7 June to 14 August in Broward County (N = 20 nests; Fletemeyer, 1980); and 12 June to 8 September in Kennedy Space Center (N = 33 nests; Ehrhart, 1981).

Twelve green turtles were measured at Melbourne Beach when they came ashore to nest. The mean straight-line carapace length (SCL) was 110 cm (range 102–121 cm); the mean straight-line carapace width was 83 cm (range 78–89 cm). Comparisons with other populations are difficult because of variations in the measuring techniques used. Unfortunately, most authors do not say specifically how their measurements are made. Those reported as SCL vary from minimum to maximum lengths, which can differ by 4 to 5 cm. We can say, however, that the Florida green turtle is larger than that of the Pacific Ocean (Cornelius, 1976; Balazs, 1980; Villanueva, 1981), and its mean SCL falls within the range of lengths of Atlantic Ocean green turtle populations: Galibi, Surinam, 109 cm (Schulz, 1975); Ascension Island, 108 cm (Carr & Hirth, 1962); Shell Beach, Guyana, 107 cm (Pritchard, 1969); and Tortuguero, Costa Rica, 100 cm (Carr & Hirth, 1962). Ehrhart (1979) reports a mean maximum SCL of 102·4 cm from 12 green turtles (range 95·5–111·3) nesting on beaches in Kennedy Space Center, Florida.

Only one green turtle has been seen in more than one nesting season on Melbourne Beach, and she remigrated twice—both times at two-year intervals. The prevalence of the two-year remigration interval in the Florida green turtle is supported by the limited information available. Fletemeyer (1980) records one two-year remigrant in Broward County; four two-year remigrants and one three-year remigrant have been recorded in Kennedy Space Center (Ehrhart, 1979).

The breeding population of *Chelonia* in Florida may be increasing (Pritchard, 1982). Green turtle nesting activity was significantly greater in 1980 in Brevard County, which includes Melbourne Beach (Fritts, 1981), than in the past.

ACKNOWLEDGEMENTS

Field work at Melbourne Beach was made possible by a long list of volunteers who generously donated their time. The most constant collaboration and aid were provided by Bernie Turner and T. Hiter, and to both we are deeply grateful. We thank Dr Archie Carr for his help in setting up the project and his continued guidance throughout the study. Frank Lund provided valuable advice in the initial phases of the fieldwork. We are indebted to L. Ogren, National Marine Fisheries Service, for sharing unpublished data from aerial surveys of Melbourne

Beach. L. Ehrhart, D. Worth, F. Lund, and D. Stoneburner kindly provided us with the records of Melbourne turtles sighted on other nesting beaches. Funds for tags and tag rewards were furnished by the Caribbean Conservation Corporation and by a series of grants from the National Science Foundation (OCE 77-09842, A. Carr, Principal Investigator).

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