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SURVEY AND RECONNAISSANCE OF NESTING SHORES AND COASTAL HABITATS OF MARINE TURTLES IN FLORIDA, PUERTO RICO, AND THE U.S. VIRGIN ISLANDS

Report to

National Marine Fisheries Service

David Carr and Peggy H. Carr

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This is a report of results of surveys and censuses carried out in Florida during the period July 1, 1976 to October 31, 1977 and on three series of reconnaissance flights in Puerto Rico and the Virgin Islands. The work was done under Contract 03 6 042 3519, with the Caribbean Conservation Corporation (A. Carr, Co-Principal Investigator).

Background and Aims

The central objective of the study was to determine numbers, distribution, and seasonality of the breeding, resident, and developmental colonies of marine turtles within the survey areas. Results of such surveys are necessary grounding for accurate delimitation of critical habitats, and for developing management programs that will improve the survival outlook of the species.

Although the sea turtle fauna of the territory surveyed has been drastically reduced from primitive populations levels, no species has been totally extirpated. Five genera and six species are known from the area, as follows.

Dermochelys coriacea - Leatherback. The only concentrated nesting of the Atlantic leatherback occurs in the Guianas, while its only known, regular feeding grounds are off the coasts of New England and Canada, where the jellyfish that it eats abound. There are single or small-group nestings by the leatherback throughout the West Atlantic from

Florida to Brazil. Florida is visited by perhaps 15-30 nesting females each year, and a colony of moderate size has recently been discovered at Sandy Point on St. Croix in the Virgin Islands.

Lepidochelus kempi - Gulf ridley. The only nesting ground of this critically endangered species is in Tamaulipas on the Gulf coast of Mexico, where formerly thousands of ridleys aggregated and emerged *en masse* on short sections of beach near Rancho Nuevo. Florida waters were once important foraging and developmental habitat for the species. The Gulf ridley has undergone drastic recent reduction everywhere. and is clearly on the verge of extinction. In Florida, it has almost disappeared from places where once it was abundant.

Lepidochelys olivacea - Olive ridley. This species, like *L. kempi*, is a mass nester and is widely distributed in the Indo-Pacific. In the Atlantic system it breeds on the coasts of West Africa and in the Guianas. Occasional Gulf Stream waifs have been recorded in the West Indies, but no nesting has been reliably recorded north of the Guianas.

Eretmochelys imbricata - Hawksbill. The nesting of the Atlantic hawksbill is geographically scattered; there are no large breeding aggregations anywhere in the Atlantic system except possibly in the Grenadines and on the Chiriqui coast of Panama. There are no recent records of breeding in Florida, but separate nestings occur throughout Puerto Rican and Virgin Island waters. There is regular, though sparse, reef occupancy by developmental stages and foraging adults throughout tropical Florida and the West Indies.

Chelonia mydas - Atlantic green turtle. This species breeds in good sized aggregations at only two Caribbean localities: Tortuguero, Costa Rica; and Aves Island, in the eastern Caribbean off Monserrat. The nearest other rookeries are in the Guianas.

Single nesting emergences occur through a wide territory. In the survey area green turtles occur mainly as itinerants, temporarily occupying developmental habitats (see Figure 1). The Florida East Coast and the Dry Tortugas were once important nesting grounds, and there are still perhaps 30 or 40 nests on the Florida East Coast each year.

Caretta caretta - Atlantic loggerhead. The chief American nesting places of *Caretta* are on the Atlantic coasts of Florida, Georgia and South Carolina. This region is by far the most important breeding place of the Atlantic loggerhead remaining in the world. Nesting occurs elsewhere throughout much of the Gulf and Caribbean, but nowhere in concentrations. The individual foraging range may evidently be either itinerant or localized. Recent unpublished evidence seems to indicate that a large contingent of the Florida nesting aggregation is recruited *en masse* from West Indian waters (communication from Luis Rivas).

One of the serious obstacles to effective intervention in the survival predicaments of the sea turtles is the lack of quantitatively reliable data on their ecology and population levels. Although Florida appears to be the most important remaining nesting ground of the Atlantic loggerhead, the relative density of nesting of even this species along these coasts has not been clearly shown, and there has been no good basis for a total population estimate. Most sea turtles do not pass their whole life cycles within the boundaries of single countries. The green turtle, for example, is a long-range migrant, usually breeding and residing in widely separated places. Throughout the world, only two closed-system patterns of green turtle ecologic geography have been revealed--one in the western Caribbean, based on the Tortuguero rookery, and another in Brazil, where the resident turtles reproduce in Surinam and Ascension Island rookeries. With this information available, purposeful research can be expected to build bases for effective, cooperative management. However, there has as yet been no effort to achieve international management of these two separate ecogeographic entities. A missing element is reliable data on population levels in the much-dwindled stocks, and a knowledge of their routes of travel, their developmental habitats, and the exploitation they are undergoing in their shifting habitats.

Although the main effort of the present research has been to build a sound quantitative understanding of the breeding density and distribution of the loggerhead, the terms of reference of the study embraced the critical habitats of developmental stages of all the sea turtle species in the area. To systematize and give direction to this field work, it was adjusted to a scheme devised by Carr *et al*. (in press) for subdividing the life cycle. That model is shown in Figure 1. Using it as a basis for the surveys brought some order to the assessment of the region as sea turtle habitat. For one species or another the area furnishes turtles with each of the kinds of living space shown in the figure except the so-called "lost-year" refuge. Where little sea turtles go during the first year of life is not known, for any species anywhere in the world. For the other phases of the life cycle, however, the model serves as a useful check list by which to judge the ecological importance of each hydrographic zone in a given region.

For all the sea turtles, sea beach is the nesting place. Little is known of the internesting habits or habitat, however. Separate studies now being carried out by Anne B. Meylan in Costa Rica and Jeanne Mortimer on Ascension Island support scattered observations all over the world indicating that in the intervals between nesting emergences, the female green turtle moves about within longshore waters adjacent to the nesting beach. Mating activity draws the males into the same zone. The same appears to be true for the other genera, although documentation is meager.

It is the foraging habitat of the sea turtle that shows the greatest variability. The green turtle serves as a model. Being herbivorous, much of its adult life is passed on areas of especially good pasturage--more or less continuous expanses of spermatophyte (or occasionally algal) vegetation. Because such grass flats are usually hydrographically incompatible with the wave-built ocean beaches acceptable as nesting shore, the green turtle has evolved a tendency and ability to make periodic migrations between feeding and nesting places. To some degree all other marine turtles make comparable migrations, although in some the feeding habitat is hundreds of miles or more in extent and might better be designated as foraging range. The Atlantic leatherback, for example, nests chiefly in the tropics, but may feed as far north as Nova Scotia and Labrador. Some loggerheads wander widely in foraging for the crustaceans and mollusks that mainly compose their diet, but there is evidence that others may take up regular seasonal feeding stations on limited patches of rock or coral bottom. Some hawksbills appear to reside on particular coral reef sections, although the degree to which this applies throughout the range of the genus is not known. On the whole, however, the hawksbill is probably the most ecologically parochial of all sea turtles in its ecological geography, mainly because it is not restricted at nesting time to the high-energy shores that the green turtle requires, and thus is often able to nest close by its foraging sites.

The study of Florida sea turtles has accelerated markedly in recent years. Tagging programs are currently being carried out by the following: Dr. Lew Ehrhart, central Brevard Count; Billy Turner (in collaboration with the Department of Zoology, University of Florida), Melbourne Beach to Floridana Beach; Dewey Worth on Hutchinson Island; Clyde Lee, Hobe Sound National Wildlife Refuge; Frank Lund, Jupiter Island; and Caretta Research, Inc. on nearly every stretch of nesting beach in southwestern Florida. The list of references at the end of this report gives titles of some of the publications presenting results of the work of these people. Much of their data are as yet unpublished, however.

Although these projects are advancing knowledge of the demography and post-season movements of the loggerhead, and to a lesser degree the green turtle in Florida, serious gaps remain. One is the lack of data on current occupancy of the non-breeding habitats shown in Figure 1. Since Carr and Caldwell studied the itinerant colonies of the green turtle and the ridley in the Cedar Keys-Waccasassa area during the 1950's, little attention has been paid to the developmental ecology of sea turtles in Florida, and even less in Puerto Rico and the Virgin Islands. Exceptions are current studies of Dr. Lew Ehrhart, which are yielding excellent data on the developmental and forage-ground ecology of the loggerhead and green turtle in Mosquito Lagoon; and a recent report by Tom Carr to the Department of the Interior on the marine turtles of Culebra Island.

Procedure

In the present project it was originally planned to divide the project effort among surveys of the five separate turtle habitats as shown in Figure 1, making whatever quantitative assessment of census of occupancy might prove feasible in each case. It soon became clear, however, that the best use of contract resources would be to put them mostly into intensive track counts at the loggerhead nesting beaches, as the only means of showing density distribution along the coast and of building a basis for an estimate of the total sexually mature loggerhead population of the region.

The nesting census in Florida involved repeated aerial surveys of the 1500 mile coastline, where two kinds of shores were represented. Along parts of the route there were well known rookeries, and current tagging programs underway; on other long sections no known sea turtle nesting had been reported.

Two different sets of surveys were made. One set involved the statewide inspection of all nestable beaches. The flights began on the Atlantic side at the St. Mary's River and ran south to the tip of Key Biscayne. The Marquesas and the Dry Tortugas were included. On the Gulf side, they began at Flamingo and stopped at Anclote Key, resuming at St. Marks and finishing at the Perdido River--the Florida-Alabama line. Data were gathered along all nestable beaches of Florida exposed to the open Gulf of Mexico and open Atlantic ocean. The windward sides of the Florida Keys were surveyed on the first flight, and the number of suitable beaches there determined to be negligible. On the first statewide flight the coastline from Anclote Key in Pasco County north to St. Marks in Wakulla County was also surveyed, but was found to have very few possibly suitable beaches, mostly in the Cedar Keys area. After interviews with local fishermen and others familiar with the coast there, these islands, and this entire portion of the coastline, were eliminated from the periodic surveys.

The other series of surveys were confined to the heavily used loggerhead beaches on the East Coast between the Ponce de Leon Inlet, north of New Smyrna Beach, and Port Everglades Inlet in Fort Lauderdale.

Survey Methods

Florida

The aerial surveys were made from light, highwing single-engine Cessna airplanes. To insure a clear view, unobstructed by people on the beach the flights were made as early in the day as possible. The East Coast surveys took only a part of a day to complete. The statewide surveys were broken into three-day sessions, and the coast was subdivided so that each flight could be completed by the middle of the day. The first survey day ended in Key West; the second in Tarpon Springs; the third in Pensacola.

Counts on each flight were made by a team of two people, one serving as a track counter and the other as recorder. The counter, using a hand-tally machine, registered all crawls in which separate flipper marks could be distinguished. The other member of the team recorded the location of the tracks along the coast, and, at predetermined landmarks--e.g. inlets, causeways or piers--provided a fresh hand-tally machine for the counter. All flights were made at altitudes of approximately 300 feet and at minimum indicated air speed (KIAS) of 60 knots.

A standard set of maps, Xeroxed from USGS 1:250,000 maps, were used for recording the information while in the air. It was later transferred to charts of raw data, and to graphs showing such correlations as tracks per mile of beach per section of beach, and numbers of tracks counted per flight.

Because of the difficulty of separating and tallying individual tracks at times and sites of maximum nesting emergence (see Figures 3 and 4) an effort was made to record these beaches on video-tape. The technique was soon abandoned, however, because it failed to provide the necessary resolution.

A total of 20 aerial nesting surveys were carried out, during two breeding seasons: seven during 1976, 13 in 1977. Eight of the surveys were statewide. Three of these were completed in 1976 and the rest in 1977. The remaining 12 surveys covered only the heavily used nest beaches of the lower East Coast of Florida; four of these were made in 1976 and eight in 1977. The statewide counts were scheduled on an approximately monthly basis; the East Coast counts were made weekly. In the present report, survey results of each season have been tabulated separately. Because the 1976 results are largely reflected in the 1977 data, only the latter are shown in the graphs.

The 1976 surveys covered a span of 84 days of the nesting season, from June 19, which is well into the season, to September 10. Coverage during the 1977 season was both more inclusive and more thorough, extending through a portion of 127 days, from May 13 to September 19.

Specific dates of the surveys were as follows (asterisks indicate statewide surveys):

June 19, 1976	June 18, 1977
July 13, 1976	June 25, 1977*
July 12, 1976	July 1, 1977
July 30, 1976*	July 9, 1977
August 13, 1976	July 16, 1977*
August 22, 1976*	July 23, 1977
September 10, 1976	August 6, 1977
May 13, 1977	August 13, 1977*
May 28, 1977*	August 28, 1977
June 4, 1977	September 17, 1977*

Although the principal emphasis of the aerial surveys was to census nesting beaches, a limited amount of flight time was spent in an effort to learn something of the internesting and post-nesting behavior of turtles off the coast of Florida. A better understanding of this phase of sea turtle ecology will be essential to sound management. In formulating a study procedure two basic questions were considered. First, do marine turtles concentrate in groups offshore between nestings, and if so, at what distances? And second, do the heaviest offshore concentrations occur off the most productive nesting beaches? To get preliminary answers to these questions two offshore aerial surveys were conducted. The first traversed the area between Ft. Pierce, Florida and Grand Bahama Island, then proceeded south to Bimini, then back across the Gulf Stream to Fort Lauderdale. The survey airplane maintained an altitude of about 700 feet. Two spotters recorded exact times at which turtles were observed, thus making it possible to plot positions of the sightings at a later time. The third leg of the first flight, and the entire second survey involved flying parallel to the shore at the distance at which the most turtles were determined to occur. Again two spotters were used, and sightings were recorded in reference to landmarks on the shore.

Puerto Rico and the U.S. Virgin Islands

Although Puerto Rico and the U.S. Virgin Islands were included in the scope of the study, for practical reasons they were given much less emphasis than Florida in the survey effort. This was primarily because (1) the cost of providing comparable coverage there would have reduced the possibility of comprehensive coverage in Florida; and (2) the very dilute nestings in the islands seemed of less critical importance than the uniquely heavy breeding concentrations in Florida. Two surveys were made in the islands during the study period. The islands reconnoitered included mainland Puerto Rico and three satellite islands, and the U.S. Virgin Islands of St. Thomas, St. Johns, and St. Croix. The survey procedure involved flying around each island at low altitude and noting on USGS maps the number and location of each turtle track sighted. While this procedure was found satisfactory for reconnoitering hundreds of miles of generally straight beaches in Florida, it proved hazardous in the islands, particularly the Virgin Islands, because of severe wind sheers created by the high hills overlooking scalloped beaches. Any future surveys of this area should be conducted by small boat or land vehicle.

The Island surveys also included extensive interviews with officials of the Puerto Rican Department of Natural Resources, with other investigators engaged in related research, and with local people who were familiar with various aspects of local marine turtle ecology.

Results

The Nesting Census

The major effort in the investigation was the multiple nest counts made throughout the breeding season on the Florida coast from Jacksonville to Pensacola, and including the Florida Keys, Marquesas, and Dry Tortugas.

The raw data derived from the surveys are presented in Tables 2 and 4, for 1976 and 1977 respectively. Table 2 presents numbers of tracks counted per survey by county. Table 4 shows the number of tracks counted per survey by section of beach. Subdivisions of the nesting beaches into

75 identifiable sections, instead of merely by coastal county lines, seemed a useful way of increasing the specificity of the distribution data. Where the county line falls on a section indicates the proportion of the section that lies in neighboring counties. The data in Table 2 and Table 4 are graphed in Figure 2 to show the limits of the nesting season for both the statewide turtle populations and those of the East Coast alone, during both 1976 and 1977. In each year the season is, of course, more accurately delineated by the East Coast surveys, because more flights were made over a longer period. However, one should question the high survey total for July 30, 1976, which appears significantly out of line with the other totals. Assuming this figure to involve error of unknown origin, the nesting season clearly extends from early May to late September and peaks in mid-July.

In Figure 3, average numbers of tracks per section are plotted against lengths of potential nesting beach in each section. The graph clearly shows the preponderance of turtles nesting on the southeastern coast. Overall, sections located in Brevard County appear to be the most attractive to the nesting turtles, but as the width of the Brevard bar indicates, that county also has the greatest extent of potential nesting beach. The importance of Martin County in which the important Jupiter Island rookery is located, is also evident from the graph, which shows a high density on a relatively short length of shore. While it is clear from the graph that by far the heaviest nesting occurs on the southeastern coast, it is also evident that significantly frequent nesting occurs in the southwestern coastal counties. Cape Sable in Monroe County--a part of the Everglades National Park--is particularly important.

The raw number of turtles for each section permits the following rank ordering of the ten most heavily visited by turtles:

1. Brevard	Indialantic Causeway to Sebastian Inlet (287.9 - 16%)
2. Martin/Palm Beach	Third house to Jupiter Inlet (205.1 - 11%)
3. Volusia/Brevard	Last house to start of hard road (200.5 - 11%)
4. Brevard	Riprap and green track to Port Canaveral (166.3 - 9%)
5. Palm Beach	Jupiter Inlet to Riviera Beach Inlet (105.4 - 6%)
6. Brevard	Start of hard road to posts of beach house (72.7 - 4%)
7. Monroe	Cape Sable (69.4 - 4%)
8. Indian River	Sebastian Inlet to road from Wabasso (68.5 - 4%)
9. Palm Beach	Riviera Beach Inlet to S. Lake Worth Inlet (65.5 - 4%)
10. Brevard	Patrick AFB to Indialantic Causeway (62.4 - 4%)
	(1,303.8 - 73%)

This ranking is reinforced when average totals for the ten top sections representing six of the 29 counties are compared with the average statewide totals. Thirteen percent of all the sections accounts for 73% of the total Florida nests.

In Table 5 the nesting data are analyzed in terms of turtles per mile of beach, as a form of density measurement, and a different ranking results. Again the data are looked at section by section, but the disparity seen in the previous graph due to differences in coastline length is removed. Figure 4 graphically illustrates the wide difference in track densities among the sections. A section ranking showing the average turtles per mile of beach per survey is given in Table 1.

This and other density evidence indicate that if nesting habitat management is undertaken, this will be most productive in the relatively few counties in which the highest number of nests per mile of beach occur. It should be repeated that all but two of the very dense sections fall within the borders of five lower East Coast counties.

In summary it may be said that the nesting season of the Atlantic loggerhead in Florida runs from early May to late September, with the peak of the season falling during late June and July. At least 90 percent of the Florida population nests along the coastal strip from Volusia to Broward County, with Monroe County accounting for much of the balance. Both in terms of absolute numbers and of relative density of nests, Brevard County is by far the most important county in the state. However, Martin County in which Jupiter Island is located is a close second to Brevard in terms of track density.

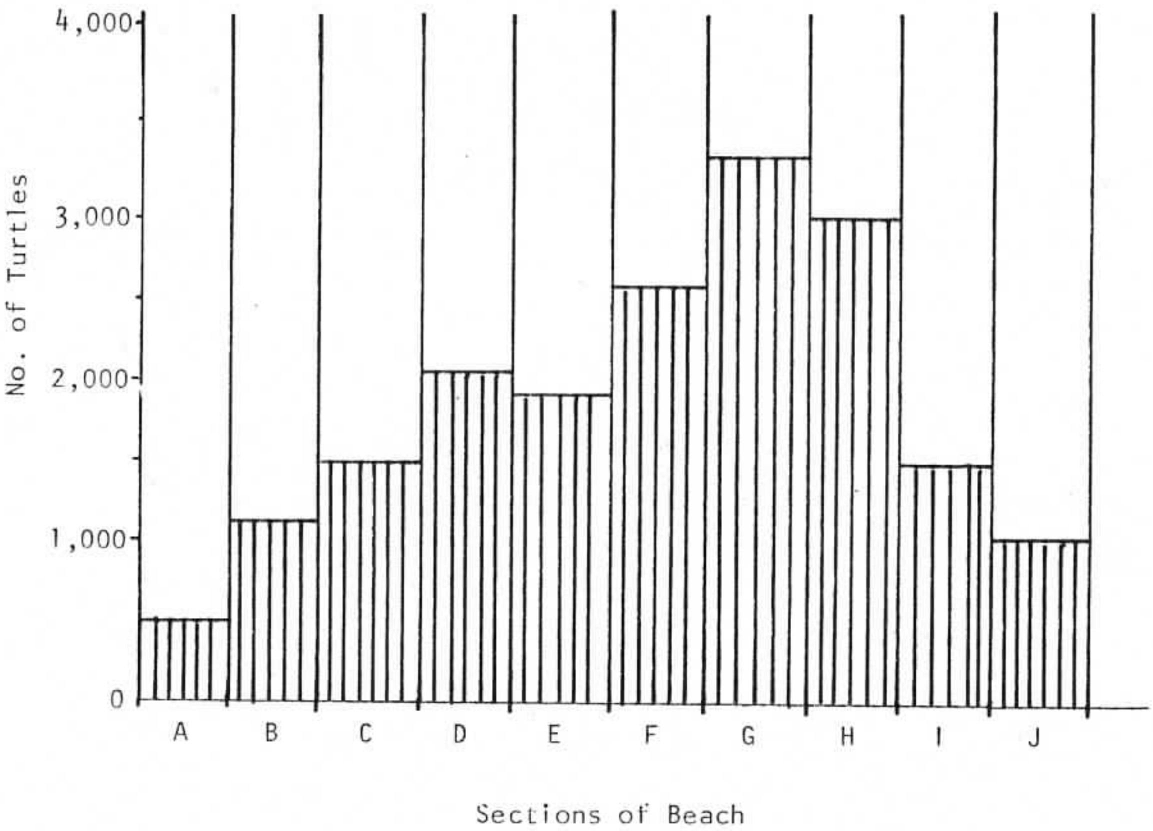
Population Estimates Based on Nesting Survey

One of the serious defects in knowledge of the natural history of sea turtles is our ignorance of population numbers. The only predictable approach to this problem is through the censusing of the nesting population. This usually involves aerial track counts. If every turtle that nested on a given night left only one track, and if all nest tracks remained visible until flight-time and then vanished completely, sampling by aerial survey would provide a reliable census technique. The actual situation is more complicated, however. Turtles often make ventures ashore and return without nesting. Also, in calm, fair weather tracks remain visible for a long time and thus may accumulate and be recounted from one flight to another. With these two sources of error it is obviously impossible to use raw track counts in estimating populations. Even more disruptive is the differential obliteration of tracks by localized rainfall. This factor even lowers the value of the surveys as a way of comparing nesting density on the different sections of beach. If several dry days have allowed tracks to accumulate, a relatively low-density nesting beach may give a higher track count than a high density strip where there were heavy showers the day before--and so on.

The cure for these errors is obviously to make multiple counts, as many as can be managed. Repeated flights obliterate the bias produced by local differences in wind and rainfall. And since the tendency of turtles to make trial crawls may be assumed to be the same from one beach section to another, this in no way affects the plots of relative nest density. Although these errors can be corrected by multiple sampling, this cannot correct the disparity between the numbers of tracks counted on a given flight and the number of turtles that made them. This ratio can only be established by using ground-truth data.

Ground-truth data, gathered on a daily basis, during an entire season, has been used here in calcualting the nesting population of sea turtles visiting Florida's beaches. A constant derived from the ratio of sample population size to average aerial count for the same beach, will be used to modify the average aerial statewide count, giving an estimate of the statewide sea turtle population. The average seasonal aerial count for each section is used instead of the "total seasonal count" in order to reduce the effect of inaccuracies of specific surveys such as detours around active restricted airspace, or localized inclement weather, on the reliability of the seasonal count.

The histogram below might represent the coast of Florida.



If the column J represents the sample beach, then:

K = coefficient for stimating population

$$K \quad \frac{J}{\text{population estimate for sample beach from nightly contact and tagging}}$$

$$K = \frac{1{,}000}{500}$$

$$K = 2.0$$

Then this constant will be used to modify the rest of the figures.
For example:

Column H = 3,000 = avg. no. turtles/aerial count

3,000 x K = nesting population for beach H

6,000 = nesting population for beach H

When all beaches surveyed are combined, a figure representing the estimated statewide sea turtle population is derived.

The ground truth data used in calculating our statewide population estimates were provided by Dr. Lew Ehrhart of Florida Technological University. Throughout the season Dr. Ehrhart and assistants regularly patrolled a 17-mile stretch of beach on Cape Canaveral, tagging and recording every nesting turtle there as part of his own research program. He determined that his coverage averaged out to about 5.5 nights a week or 79 percent coverage. Using the Peterson Index, it was determined that 450 individual turtles plus or minus 116 at a 95 percent confidence level, nested on his stretch of beach. The Schnabel Index produced a figure of 528 nesting turtles, and the Hayne Index generated the highest estimate, 554 turtles. It is of interest that the latter two estimates lie within the 95 percent confidence level of the Peterson Index, although at the upper boundary of the interval. In calculating our population constant, an average of Ehrhart's three figures, or 511 nesting turtles for the year, was used.

Aerial surveys of Dr. Ehrhart's research beach revealed a total of 1,391 tracks for the nesting season. This figure amounts to 111.28 per survey, when averaged over 12.5 surveys. When this average aerial survey figure is divided into Dr. Ehrhart's estimate it provides a constant that can be used to modify the average statewide aerial count to reflect the total number of individual nesting turtles:

$$\frac{511}{111} = 4.60$$

and $$4.60 \times 1{,}794 = 8{,}254$$

Thus there were 8,254 individual female turtles nesting on Florida's beaches this season.

However this figure by no means represents the total of mature female turtles in the Florida-based populations. The tagging programs referred to above have clearly established that the Atlantic loggerhead often and probably usually nests at intervals longer than a single year. It seems likely that two-year and three-year intervals predominate, and that even longer periods may occur. To prove this requires protracted contact with the individual colonies. To be able to use the remigration intervals in calculating population size, proportional frequencies of the different intervals must be known, and this of course requires even longer contact with the tagged individuals.

Carr *et al.* used an equation devised by Dr. T. Carr of the Department of Physics, University of Florida, to incorporate the known remigratory intervals of Costa Rican green turtles into calculations of the total number of mature green turtles represented by a year's nesting arrivals.

The 22-year tagging program at Tortuguero, Costa Rica has shown that the green turtle colony there nests on two-, three- and four-year cycles, with different proportions of each, and with the proportions constant from year to year. Professor Carr derives his equation as follows.

The smallest integral number of years within which the 2-, 3-, and 4-year laying cycles are repeated integral numbers of times is 12; that is, 12 is the least common multiple of 2, 3, and 4. In a 12-year period, each member of the 2-year group will lay 6 times, so these individuals, numbering a_2x, will lay $6a_2x$ times in 12 years. Similarly the a_3x members of the 3-year group will lay $4a_3x$ times in 12 years, since each member lays 12/3 or 4 times, and the a_4x members of the 4-year group will lay $3a_4x$ times.

Thus the total number of layings in 12 years is $6a_2x + 4a_3x + 3a_4x$. But this number must be 12 times the number laying in one year, or 12y; so

$$12y = 6a_2x + 4a_3x + 3a_4x$$

$$y = \frac{(6a_2 + 4a_3 + 3a_4)}{12} x$$

or

$$x = \frac{12}{6a_2 + 4a_3 + 3a_4} y$$

The formula can easily be modified to accommodate any additional laying intervals found to be significant in future investigations. For example, if one-year remigratory periods were also found, the appropriate formula would be

$$x = \frac{12}{12a_1 + 6a_2 + 4a_3 + 3a_4} y,$$

where a_1, a_2, a_3, and a_4 represent the fractions of layings at 1, 2, 3, and 4-year intervals, respectively. In this case, $a_1 + a_2 + a_3 + a_4 = 1$.

Since the proportions of the different remigratory periods are not known for the Florida loggerhead, use of the above formula would be pointless. However, two-year and 3-year cycles appear to predominate and it thus might be reasonable to multiply each year's total nesting arrivals bv, say 2.5, to get a total for mature females in the population.

Then the total for Florida as derived from survey figures would be 8,265 × 2.5, or 20,762 sexually mature female turtles.

If the sex ratio in the Florida loggerhead is 1:1, which likewise has never been proved, then the whole mature Florida population numbers 41,524 individuals.

It is of interest and perhaps it may be significant that two previous estimates of the Florida loggerhead population were not very different from the above figure. In 1968 A. Carr and Steve Bass, using data from one-pass aerial and ground counts, calculated the Florida population to be about 50,000 turtles (unpublished). Six years later Lund (1974) using data from a number of different sources also estimated the state loggerhead population to be 50,000.

Puerto Rico and U.S. Virgin Islands

In comparison with those in Florida, the flights in Puerto Rico and the U.S. Virgin Islands revealed few signs of turtle nesting. Although the spectrum of habitats there is excellent, all sea turtles have been under wholly irrational exploitation for centuries, and those seen today are a mere vestige of the original population. The survey area included both mainland Puerto Rico and the satellite islands of Mona, Vieques, and Culebra, and St. Thomas, St. Johns, and St. Croix of the U.S. Virgin Islands. Two surveys were made during the contract period, the first on September 1, 1976, and the second on June 6, 1977.

The Puerto Rican mainland appeared particularly devoid of turtle nesting, with only two tracks being counted in June 1977, and none in September 1976. This was in spite of the fact that along the north and west coasts of Puerto Rico there are extensive, appropriate looking beaches. Mona Island, located off the west coast of Puerto Rico had five tracks when visited in June. On Vieques, where approximately one-third of the island was off limits to air traffic because of air defense maneuvers, no tracks were seen. There were likewise no tracks on Culebra, although some nesting activity was reported by Tom Carr, who made a sea turtle census there for the Department of the Interior.

More turtle nesting was seen on Virgin Island beaches than in Puerto Rico, although some beaches were inaccessible to aircraft, for reasons described earlier. St. Croix was by far the best of the three islands, with 13 tracks counted in June and 11 in September. No tracks were counted on the mainland of St. Thomas or St. Johns, but several were sighted on this side of Little Hans Lollick Island, located just north of St. Thomas.

Despite the scant nesting that occurs in Puerto Rico and the U.S. Virgin Islands, the islands retain a significant resident population of mature turtles, including green turtles, hawksbills, loggerheads and leatherbacks. All of these could be easily seen from the plane while the nesting surveys were in progress.

Results of the Offshore Reconnaissances in Florida

With the aim of obtaining data on the longshore and offshore inter-nesting and post-nesting behavior of the East Coast turtles, a survey flight was made on September 8, 1977. The plane first flew a transect from Fort Pierce, Florida, across the Gulf Stream to West End, Grand Bahama. This course was selected because it diagonally crossed an area of the sea directly off some of the best Florida nesting beaches, including Jupiter Island. In addition, this particular course provided easily identifiable points of land at each end of the transect, and thus facilitated repetition of the experiment. Unfortunately, it was late in the nesting season before this important series of observations was made. However, it was felt that by surveying an area where turtles concentrated during the peak of the season, late arrivals, or late leavers, or both might still be present.

The ground speed of the plane was clocked and maintained at 110 mph by means of conventional radio navigation aids; the altitude varied from 600 to 800 feet. The first leg of the survey lasted just over 54 minutes, and covered a distance of 98.8 miles.

A total of 16 turtles were located, averaging one turtle every six miles. It was of interest that 13 of the turtles seen were located within a 10.5 mile stretch of water beginning about 5 miles offshore. Thus, 81 percent of the observed turtles were grouped along 11 percent of a transect extending between points 5.5 miles and 15.9 miles offshore. The other three turtles were spotted at 18.8, 23, and 59.7 miles along the transect.

On the following day, September 9, the survey team proceeded from Grand Bahama Island south to North Bimini Island, and then went back across the Gulf Stream to Port Everglades. The purpose of the second transect was to test the converse of the assumption that a majority of the turtles seen would be located off the most concentrated nesting beaches--that is, that few if any turtles would be found off the poor nesting shores. This transect included an area of the Atlantic to the south of the first course and off the Miami-Hollywood area, where few turtles nest. Results were as expected--no turtles were spotted in the area.

Although clearly indicating a need for more such research during the regular nesting season, the two offshore surveys call attention to an important aspect of the reproductive ecology--namely, that turtles tend to congregate from five to 15 miles off the shore, with greatest concentration occurring off the best nesting beaches. What this means to any effort to protect breeding turtles from accidental capture by shrimp trawlers is clearly evident.

Ground Surveys and Interviews

As the project evolved, by far the greater part of the field work was devoted to aerial nesting surveys in Florida, simply because this was the best way to get data usable in censusing the most unique sea turtle resource of the state: the loggerhead nesting colony. Nevertheless, some time was spent pursuing the initial aim of assessing occupancy of the other habitats shown in Figure 1.

Interviews with fishermen and on-site inspections of suspected coastal and estuarine turtle habitats were carried out. Direct search and counts were made in non-breeding habitat in which previous work had built a base for comparative population assessment, and the results were compared with opinions of fishermen, sponge divers and other reliable informants. Finally, more information was sought on the current rates and agents of nest destruction. A question that remained unanswered by aerial surveying techniques included the relative numbers of mature resident turtles that remain in Florida waters after the nesting season. A related phenomenon, reported by Dr. Luis Rivas and badly in need of further investigation, is the mass influx of sea turtles into Florida waters during the spring and summer months.

Although accurate assessment of such a mixture of non-quantifiable survey techniques is impossible, some significant trends emerge. It was the concensus of persons interviewed that no drastic changes in numbers of resident loggerheads could have occurred. Crab fishermen even claim the turtles are growing more abundant, though there could be professional bias here.

With respect to the leatherback, Florida people see them at three different times: (1) when a sprinkling of them nest on the East Coast; (2) when they appear in the Gulf off the Panhandle in March and April (Yerger, 1965); and (3) when they are incidentally taken by shrimp trawlers. There is no way of judging whether any change in the frequency of any of these encounters has occurred.

As regards the other three species--hawksbill, green turtle and Gulf ridley--both interview data and our own observations clearly indicate strong decline, and in each case these local trends are merely a glimpse of the overall degradation of the species.

The hawksbill has disappeared from much of the reef habitat in which it could frequently be seen up to a couple of decades ago. While hawksbills have not nested in Florida for a long time, until the advent of SCUBA they could be found along most reef and rock outcrops in the Keys and up along the southeasternmost coast. All the local divers agree that this is no longer the case.

The situation with the green turtle is somewhat different. There is a remnant of what appears to have been once an important nesting colony. There also are three significant areas of what, until lately, was well-populated developmental habitat. These are: the Indian River Mosquito Lagoon System; Florida Bay and the Florida Keys; and the Gulf

Coast of mid-peninsular Florida, especially the strip from the mouth of the Suwannee River south to the mouth of the Waccasassa. All informants agree with our own observations in these regions that the stocks there have dwindled drastically since the 1950's. The work of Carr and Caldwell (1956) provides strong corroborative background for judging the losses in the Cedar Key-Waccasassa area.

Although the three above areas of grass flat habitat have in recent decades been used only by young and submature stages, old records show clearly that these places once served also as forage grounds of mature, and perhaps resident, green turtles. During the period of field work in which Carr and Caldwell based their report no sexually mature turtle was taken. Much the same could be said for Florida Bay and the Indian River system.

The most desperate survival outlook of any marine turtle is that of the Gulf ridley. Results of our field work in Florida, once a key station in the ecologic geography of the species, clearly confirm its dangerous plight. During the above mentioned study of Carr and Caldwell in the 1950's, ridleys turned up on nearly every netting trip, incidentally caught in nets set primarily for green turtles. When an effort to resume this work was made 15 year later, nets set in the same places for equal lengths of time yielded almost no turtles, and the project had to be abandoned. It was the opinion of nearly every knowledgeable informant interviewed that the ridley has declined markedly along the Gulf Coast and in Florida Bay. Even more telling evidence of the decline was the ignorance of the younger commercial fishermen and divers interviewed that ridleys even exist.

Recommendations

Although the anecdotal nature of the foregoing evidence precludes quantitative presentation, its implications make inescapably clear a need for the designation and effective protection of critical habitat, as follows:

(1) All reefs and craggy bottom areas in and along the Florida Keys.

(2) All major grass-flat bottom, especially that of the Cedar Key-Waccasassa areas, the Indian River-Mosquito Lagoon system; and vegetated bottom of Florida Bay, inside and outside of the Everglades National Park.

(3) All the beaches shown in our tables and figures to be important as nesting ground. The East Coast beaches are not only the best existing nesting places of the Atlantic loggerhead but also the site of the only nesting by the green turtle and leatherback on the U.S. mainland coasts.

Besides the protection of critical habitat, additional research will be required as grounding for any effective management. Of high priority are the following investigations:

(1) A study of the routes and schedules of migratory travel through and into the waters of Florida, and of the longshore distribution of loggerheads off the critical nesting shores before, during and after the nesting season.

(2) Continued tagging at Florida nesting beaches, to extend knowledge of remigration periodicities as grounding for population estimates.

(3) Investigation of the degree of territoriality in occupancy of rock pits, wrecks and other live bottom habitat by resident loggerheads.

(4) Extension of the study of the ecologic geography of the Florida sea turtles to include entire ecologic ranges, whether or not these are wholly contained within U.S. waters.

(5) To monitor and tag the small but important, recently discovered leatherback colony on St. Croix, in order to judge its survival outlook; and by establishing a scientific presence there, to encourage local stewardship.

(6) To investigate actual and potential obstacles to sea turtle reproduction on Florida beaches, and to seek remedies. Although considerable attention has been given the problem of nest and hatchling predation, this remains a serious threat to the remaining critical nesting beaches of Florida.

The historical cause of loss of the beaches was the robbing of nests by poachers. Human nest predation has declined, but natural destruction of nests appears to have increased. The raiding of nests by raccoons occurs all over the state. Reports from the Hobe Sound National Wildlife Refuge and the Cape Canaveral area indicate that over 90 percent of the nests on beaches there are destroyed by raccoons. The superintendent of the Refuge has initiated a program to trap and remove raccoons, and the project appears to have been reasonably effective. Relatively few nests were preyed on during the 1977 nesting season. However, it will require continued work to prevent the raccoons from returning to their old egg-hunting grounds. At Cape Sable in the Everglades National Park the loggerhead nesting population has been monitored since 1964, and incidence of raccoon predation has been recorded. In 1964, of approximately 270 nests on one stretch of beach there, 70 percent were destroyed by raccoons. As a result of raccoon control in 1966, less than 25 percent of the approximately 300 loggerhead nests on the same stretch of beach were destroyed by raccoons. Observations during subsequent seasons showed a dramatic increase in the number of destroyed nests. In 1972, 85 percent of the Cape Sable loggerhead nests were destroyed, and in 1976 the loss was 75 percent. Reports of similar problems around the state are common. While personally visiting Ponce de Leon Bay at the mouth of the Shark River, Tom and David Carr found ten closely spaced loggerhead nests that had all been destoryed by raccoons.

While raccoon damage may be the main obstacle to successful loggerhead nesting, there are other calamaties confronting the successful reproduction of loggerheads. At Wiggins Pass State Park, rangers reported six nests on a one-mile stretch of state-owned beach eleven miles north of Naples. Hatchlings from two of these were attracted by the parking lot lights of a motel, and all eventually died. The other four nests produced no hatchlings because they were unable to dig out through compacted beach sand. With intense use of the beach by human beings, the sand becomes too compact for successful emergence.

The most unique sea turtle resource in Florida is the large nesting colony of the loggerhead. This should be protected in every possible way. The nesting beaches should be off-bounds for trespass and development. Vigorous research to devise antipredator treatment should be pursued. Trawling should be excluded from the vicinity of the major nesting beaches during, just before and just after the nesting season. If these things are done, it may be possible to avert the loss of the Atlantic loggerhead; and motivation to do them should be reinforced by the fact that the nesting leatherback and green turtles of Florida will be directly benefitted.

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Table 1

Rank order of the lower East Coast counties as loggerhead nesting beaches.

County	Section	Length of Beach (miles)	Turtles per Mile
1. Brevard	Riprap & Green Tank/ Port Canaveral	8.5	19.6
2. Martin/Palm Beach	Third House/Jupiter Inlet	13	15.8
3. Brevard	Indialantic Causeway/ Sebastian Inlet	22	13.1
4. Martin	Hobe Sound National Wildlife Refuge	5.0	9.8
5. Monroe	Dry Tortugas	1.5	7.7
6. Indian River	Sebastian Inlet/Road from Wabasso	9.0	7.6
7. Brevard	Posts beyond beachhouse/Riprap and Green Tank	5.0	7.6
8. Monroe	Cape Sable	9.5	7.3
9. Palm Beach	Jupiter Inlet/Riviera Beach Inlet	5	7.0
10. St. Lucie	Hutchinson Island Power Plant/ Jensen Beach Causeway	8.5	6.8

Table 2. Total tracks per county; based on 1976 surveys.

County	6/19/76	7/3/76	7/12/76	7/30/76	8/13/76	8/22/76	9/10/76	Average Number of Tracks per County
Nassau	0		0			0		1
Duval	4		5			1		2
St. Johns	9		3			1		5
Flagler	9		6			0		6
Volusia	18	125	126	201	35	10	5	92
Brevard	509	1104	1143	1638	436	272	63	711
Indian River	128	144	225	350	134	56	6	137
St. Lucie	82	458	296	440	75	42	6	168
Martin	128	280	529	1012	153	89	32	304
Palm Beach	175	731	565	416	135	19	15	284
Broward	28	94	79	72	30	0	0	36
Dade	8		11			0		7
Monroe	49		69			7		79
Collier	70		182			92		100
Lee	39		58			25		29
Charlotte	17		6			0		6
Sarasota	37		41			10		26
Manatee	3		4			2		3
Hillsborough	0		0			0		2
Pinellas	2		6			1		3
Pasco	0		1			0		1
Fernando	0							
Citrus	-							
Levy	-							
Dixie	-							
Taylor	0							
Jefferson	0							
Wakulla	0		0			0		.5
Franklin	26		26			2		13
Gulf	6		9			3		4
Bay	3		2			0		.75
Walton	3		2			0		.5
Okaloosa	1		4			2		2
Santa Rosa	0		0			0		0
Escambia	6		0			0		.5

Table 3. Track density per mile of beach by county, based on 1976 surveys.

County	Miles Per County	6/19/76	7/3/76	7/12/76	7/30/76	8/13/76	8/22/76	9/10/76	Average Density Per County
Nassau	17.0	0		0			0		.06
Duval	18.5	.24		.27			.05		.11
St. Johns	50	.22		.06					.10
Flagler	23.5	.5		.26					.25
Volusia	60.5	.37		2.08	3.32	.58	.17	.08	1.51
Brevard	90	7.07	16.98	17.58	25.20	6.71	4.18	.97	9.70
Indian River	20.5	6.65	7.02	10.98	17.07	6.54	2.73	.29	6.67
St. Lucie	29	3.9	15.59	10.21	15.17	2.59	1.34	.21	5.81
Martin	27	5.59	10.27	19.59	37.48	5.67	3.30	1.19	11.26
Palm Beach	55.5	3.89	13.17	10.17	7.50	2.43	.34	.27	5.12
Broward	23.5	1.19	4.0	3.36	3.06	1.28	0	0	1.52
Dade	33	.39		.33			0		.21
Monroe	30	.73		2.3			.23		2.63
Collier	40	1.32		4.58			2.30		2.51
Lee	61	.91		.95			.41		.49
Charlotte	15.5	1.48		.39			0		.37
Sarasota	43.5	1.03		.94			.23		.61
Manatee	17.0	.24		.24			.12		.19
Hillsborough	2.5	0		0			0		.70
Pinellas	45.5	.05		.13			.02		.07
Pasco	2.5	0		.40			0		.40
Hernando		0							
Citrus		-							
Levy		-							
Dixie		-							
Taylor		0							
Jefferson		0							
Wakulla	1.25	0		0			0		0
Franklin	67	.38		.39			.03		.19
Gulf	30.5	.23		.30			.10		.14
Bay	74	.07		.03			0		.01
Walton	31	.12		.06			0		.02
Okaloosa	31	.04		.13			.06		.22
Santa Rosa	3	0		0			0		0
Escambia	50	.15		0			0		.01

Table 4. Tracks per section of beach by county based on 1977 surveys.

County	Section	5-13	5-28	6-4	6-18	6-25	7-1	7-9	7-16	7-23	8-6	8-13	8-28	9-17	Avg.
Nassau	St. Marys River - Nassau River		1			3			3			0		1	1.6
	Nassau River - Mayport Inlet		1			0			6			0		0	1.4
Duval	Mayport Inlet - Jacksonville Beach		0			0			3			0		0	0.6
St. Johns	Jacksonville Beach - St. Augustine Inlet		0			13			6			1		0	4.0
	St. Augustine Inlet - Matanzas Inlet		0			2			0			0		0	0.4
Flagler	Matanzas Inlet - Flagler Beach		9			8			9			1		0	5.4
Volusia	Flagler Beach - Ormond Beach		3			3			13			0		0	3.8
	Ormond Beach - Ponce de Leon Inlet		2			1			0			0		0	0.6
	Ponce de Leon Inlet - Last House	0	2	3	0	9	4	10	18	10	4	0	0	0	4.6
Brevard	Last House - Start of Hard road	4	18	87	285	411	492	448	524	201	87	41	8	0	200.5
	Start of Hard road - Posts beyond beach house	3	32	23	68	140	173	179	181	61	152	10	2	0	72.7
	Posts beyond beach house - rip rap & green tank	4	3		109	108	50	53	50	35	152	6	0	0	38.0
	Rip rap & green tank - Port Canaveral	9	15		233	254	335	308	322	279	152	20	4	0	166.3
	Port Canaveral - Patrick AFB (long runway)	0	14	5	13	23	16	0	16	28	1	2	0	0	9.1
	Patrick AFB (long runway) - Indialantic causeway	10	33	32	114	119	73	92	145	106	59	27	0	1	62.4
	Indialantic causeway - Sebastian Inlet	29	90	288	520	597	503	397	629	269	342	131	8	0	287.9
Indian River	Sebastian Inlet - Road from Wabasso	5	17	43	154	131	155	83	153	28	87	30	3	1	68.5
	Road from Wabasso - Vero Beach Pier	7	10	5	58	80	63	72	64	36	18	38	1	0	34.8
St. Lucie	Vero Beach Pier - Ft. Pierce Inlet	5	20	5	84	68	39	32	47	39	11	10	0	0	27.7
	Ft. Pierce Inlet - Hutchinson Island Power Plant	1	15	16	75	63	99	57	75	52	22	13	1	0	37.6
	Hutchinson Island Power Plant - Jensen Beach Causeway	2	17	48	111	102	96	70	131	68	49	53	3	0	57.7
	Jensen Beach Causeway - St. Lucie Inlet	9	19	28	85	75	71	50	225	73	15	4	0	0	50.3
Martin	St. Lucie Inlet - Hobe Sound National Wildlife Refuge (N. Boundary)	0	5	5	24	16	32	23	31	35	10	6	0	0	14.4
	Hobe Sound National Wildlife Refuge (N. Boundary) - 3rd House	5	25	28	56	115	111	81	76	89	29	24	0	0	49.1
Palm Beach	3rd House - Jupiter Inlet	18	20	108	345	327	430	329	513	238	159	123	7	0	205.1
	Jupiter Inlet - Riviera Beach Inlet	20	57	104	250	176	222	118	150	128	83	62	0	0	105.4

Table 4 (cont.)

		5-13	5-28	6-4	6-18	6-25	7-1	7-9	7-16	7-23	8-6	8-13	8-28	9-17	Avg.
Palm Beach	Riviera Beach Inlet - S. Lake Worth Inlet	7	28	27	125	103	112	108	173	118	31	21	0	0	65.6
	S. Lake Worth Inlet - Boca Raton Inlet	12	17	27	104	47	43	55	154	128	23	15	0	0	48.1
Broward	Boca Raton Inlet - Hillsboro Inlet	3	24	24	16	10	19	7	53	51	2	3	0	0	16.3
	Hillsboro Inlet - Port Everglades Inlet	3	17	14	6	8	6	6	10	2	1	0	0	0	5.6
	Port Everglades Inlet - Tip of Miami Beach		9			4			3			0		0	3.2
Dade	Key Biscayne		2			6			1			0		0	1.8
Monroe	Marquesas		4			2			0			1		0	1.4
	Dry Tortugas		4			14			32			8		0	11.6
	Cape Sable		50			127			104			50		16	69.4
	Key McLaughlin		0			16			0			0		0	3.2
	Wood Key - Pavilion Key		0			6			1			0		0	1.4
Collier	Ten Thousand Islands		1			18			1			0		0	4.0
	Cape Romano - Collier City		8			45			22			30		9	22.8
	Collier City - Big Marco Pass		1			2			2			0		0	1.0
	Big Marco Pass - Gordon Pass		11			23			29			10		0	14.6
	Gordon Pass - North Naples Pass		2			6						2		0	2.0
	North Naples Pass - Wiggins Pass		2			5			12			0		0	3.8
Lee	Wiggins Pass - Big Carlos Pass		0			3			3			5		0	2.2
	Big Carlos Pass - Ft. Myers Beach		0			2			0			0		0	0.4
	Sanibel Island		6			6			2			0		0	2.8
	Captiva Island		1			5			5			0		0	2.2
	North Captiva Island		0			3			2			0		0	1.0
	Cayo Costa		0			5			0			0		0	1.0
Charlotte	Gasparilla Island		2			5						0		0	1.4
	Gasparilla Pass - Stump Pass		1			2						0		0	0.6
Sarasota	Stump Pass - Venice Inlet		0			53			15			0		0	13.6

Table 4 (cont.)

County	Segment	5-13	5-28	6-4	6-18	6-25	7-1	7-9	7-16	7-23	8-6	8-13	8-28	9-17	Avg.
Sarasota	Venice Inlet - Midnight Pass		0			7			1			0		0	1.6
	Midnight Pass - Big Sarasota Pass		0			2			4			0		0	1.2
	Big Sarasota Pass - New Pass		0			1			0			0		0	0.2
Manatee	New Pass - Long Boat Pass		4			4			1			0		0	1.8
	Long Boat Pass - Passage Key Inlet		3			0			0			0		0	.6
Hills-borough	Egmont Key		0			7			1			1		0	1.8
Pinellas	Cabbage Key		0			2			0			0		0	0.40
	Passa Grille Channel - Clearwater Pass		0			2			0			0		0	0.40
	Clearwater Beach Islands		0			1						0		0	0.2
	Caladesi Island		0			0						0		0	0
	Honeymoon Island		0			0						0		0	0
Pasco	Anclote Key		1			2						0		0	0.6
Franklin	Ochlocknee Bay - Peninsular Point		0			0			0			0		0	0
	Dog Island		0			0			3			0		0	0.6
	St. George Island		0			21			2			1		0	4.8
	St. Vincent Island		1			1			0			0		0	0.4
Gulf	Indian Pass - St. Joseph Point		0			5			0			0		0	1.0
Bay	St. Jospeh Point - Alligator Point		0			1			0			1		0	0.4
	Alligator Point - Miramar		0			1			3			0		0	0.8
Walton / Okaloosa	Miramar - Destin Inlet		0			0			0			1		0	0.2
Santa Rosa	Destin Inlet - Navarre		0			3			2			2		0	1.4
Escambia	Navarre - Pensacola Inlet		0			1			0			0		0	0.2
	Pensacola Inlet - AL/FL Line		1			0			0			0		0	0.2
	Eastcoast Totals	156	549	860	2835	2982	3144	2578	3740	2074	1185	689	37	2	1602
	Statewide		679			3431			4031			803		28	1794

Table 5. Tracks per mile, by beach section and county, based on 1977 surveys.

County	Section	Miles/ Section	5-13	5-28	6-4	6-18	6-25	7-1	7-9	7-16	7-23	8-6	8-13	8-28	9-17	Avg.
Nassau	St. Marys River - Nassau River	17		.1			.2			.2			0		1	.4
	Nassau River - Mayport Inlet	7		.1			0			.9			0		0	.2
Duval	Mayport Inlet - Jacksonville Beach	9.5		0			0			.3			0		0	.1
St. Johns	Jacksonville Beach - St. Augustine Inlet	33.5		0			.4			.2			0		0	.1
	St. Augustine Inlet - Matanzas Inlet	17.5		0			.1			0			0		0	0
Flagler	Matanzas Inlet - Flagler Beach	21.0		.4			.4			.4			.1		0	.3
Volusia	Flagler Beach - Ormond Beach	17.0		.2			.2			.0			0		0	.2
	Ormond Beach - Ponce de Leon Inlet	20.5		.1			.1			0			0		0	0
	Ponce de Leon Inlet - Last House	7.0	0	.3	.4	0	1.3	.6	1.4	2.6	1.4	.6	0	0	0	.7
Brevard	Last House - Start of Hard road	35.0	.1	.5	2.5	8.1	11.7	14.1	12.8	15.0	5.7	2.5	1.2	.2	0	5.7
	Start of hard road - Posts beyond beach house	12.0	.3	2.8	1.9	5.7	11.7	14.4	14.9	15.1	5.1		.8	.2	0	6.1
	Posts beyond beach house - rip rap & green tank	5.0	.8	.6		21.8	21.6	10.0	10.6	10.0	7.0		1.2	0	0	7.6
	Rip rap & green tank - Port Canaveral	8.5	1.1	1.8		27.4	29.9	39.4	36.2	37.9	38.2		8.2	.5	0	19.6
	Port Canaveral - Patrick AFB (long runway)	14.5	0	1.0	.3	.9	1.6	1.1	0	1.1	1.9	.1	.1	0	0	0.6
	Patrick AFB (long runway) - Indialantic causeway	13.5	.7	2.4	2.4	8.4	8.8	5.4	6.8	10.7	7.9	1.4	2.0	0	.1	4.6
	Indialantic causeway - Sebastian Inlet	22.0	1.3	4.1	10.3	23.6	27.1	22.9	18.1	28.6	12.2	15.6	6.0	.4	0	13.1
Indian River	Sebastian Inlet - Road from Wabasso	9.0	.6	1.9	4.8	17.1	14.6	17.2	9.2	17.0	3.1	9.7	3.3	.3	.1	7.6
	Road from Wabasso - Vero Beach Pier	9.5	0.7	1.1	.5	6.1	8.4	6.6	7.6	6.7	3.8	1.9	4.0	11	0	3.7
St. Lucie	Vero Beach Pier - Ft. Pierce Inlet	16	.3	1.3	.3	5.3	4.3	2.4	2.0	2.9	2.4	.7	.6	0	0	1.7
	Ft. Pierce Inlet - Hutchinson Island Power Plant	12	.1	1.3	1.3	6.3	5.3	8.3	4.8	6.3	4.3	1.8	1.1	.1	0	3.1
	Hutchinson Island Power Plant - Jensen Beach Causeway	8.5	.2	2,0	5,7	13.1	12,0	11.3	8.2	15.4	8.0	5.8	6.2	.4	0	6.8
	Jensen Beach Causeway - St. Lucie Inlet	8.0	1.1	2.4	3.5	10.6	9.4	8.9	6.3	28.1	9.1	1.9	.5	0	0	6.3
Martin	St. Lucie Inlet - Hobe Sound National Wildlife Refuge (N. Boundary)	2.5	0	2.0	2.0	9.6	6.4	12.8	9.2	12.4	14.6	.4	2.4	0	0	5.8
	Hobe Sound National Wildlife Refuge (N. Boundary) - 3rd House	5.0	1	5	5.6	11.2	23.0	22.2	16.2	15.2	17.8	5.8	4.8	0	0	9.8
Palm Beach	3rd House - Jupiter Inlet	13	1.4	5.4	8.3	26.5	25.2	33.1	25.3	39.5	18.3	12.2	9.5	5	0	15.8
	Jupiter Inlet - Riviera Beach Inlet	15	1.3	3.8	6.9	16.7	11.7	14.8	7.9	10	8.5	5.5	4.1	0	0	7.0

Table 5 (cont.)

		Miles/ Section	5-13	5-28	6-4	6-13	6-25	7-1	7-9	7-16	7-23	8-6	8-13	8-28	9-17	Avg.
Palm Beach	Riviera Beach Inlet - S. Lake Worth Inlet	19.5	.4	1.4	1.4	6.4	5.3	5.7	5.5	8.9	6.1	1.6	1.1	0	0	3.4
	S. Lake Worth Inlet - Boca Raton Inlet	18.0	.7	.9	1.5	5.8	2.6	2.4	3.1	8.6	7.1	1.3	.8	0	0	2.7
Broward	Boca Raton Inlet - Hillsboro Inlet	7.0	.4	3.4	3.4	2.3	1.4	2.7	1.0	7.6	7.3	.3	.4	0	0	2.3
Broward	Hillsboro Inlet - Port Everglades Inlet	13.0	.2	1.3	1.1	.5	.6	.5	.5	.8	.2	.1	0	0	0	.4
	Port Everglades Inlet - Tip of Miami Beach	28.5		.3			.1			.1			0		0	.1
Dade	Key Biscayne	6.5		.3			.9			.2			0		0	.3
Monroe	Marquesas	2		.2			1			0			.5		0	.7
	Dry Tortugas	1.5		2.7			9.3			21.3			5.3		0	7.7
	Cape Sable	9.5		5.3			13.4			11.0			5.3		1.7	7.3
	Key McLaughlin	6		0			2.7			0			0		0	.5
	Wood Key - Pavilion Key	10		0			.6			.1			0		0	.1
Collier	Ten Thousand Islands	10		.1			.2			.1			0		0	.4
	Cape Romano - Collier City	5.5		1.5			8.2			4.0			5.5		1.6	4.2
	Collier City - Big Marco Pass	5.5		.2			.4			.4			0		0	.2
	Big Marco Pass - Gordon Pass	9.0		1.2			2.6						1.1		0	1.6
	Gordon Pass - North Naples Pass	6.0		.3			1.0						.3		0	.3
	North Naples Pass - Wiggins Pass	9.5		.2			.5			1.3			0		0	.4
Lee	Wiggins Pass - Big Carlos Pass	12.5		0			.2			.2			.4		0	.2
	Big Carlos Pass - Ft. Myers Beach	9.5		0			.2			0			0		0	0
	Sanibel Island	17.0		.4			.1			0			0		0	.2
	Captiva Island	7.0		.1			.7			.7			0		0	.3
	North Captiva Island	4.5		0			.7			.4			0		0	.2
	Cayo Costa	9.0		0			.6			0			0		0	.1
Charlotte	Gasparilla Island	8.0		.3			.6						0		0	.2
	Gasparilla Pass - Stump Pass	8.5		.1			.2						0		0	.1
Sarasota	Stump Pass - Venice Inlet	20.5		0			2.6			.7			0		0	.7

Table 5 (cont.)

		Miles/ Section	5-13	5-28	6-4	6-18	6-25	7-1	7-9	7-16	7-23	8-6	8-13	8-28	9-17	Avg.
Sarasota	Venice Inlet - Midnight Pass	9.0		0			.8			.1			0		0	.2
	Midnight Pass - Big Sarasota Pass	10.0		0			.2			.4			0		0	.1
	Big Sarasota Pass - New Pass	3.0		.3			0			0			0		0	.1
Manatee	New Pass - Long Boat Pass	13.0		.3			.3			.1			0		0	.1
	Long Boat Pass - Passage Key Inlet	10.0		.3			0			0			0		0	.1
Hills-borough	Egmont Key	2.5		0			2.8			.4			.4		0	.7
Pinellas	Cabbage Key	1.5		0			1.3			0			0		0	.3
	Passa Grille Channel - Clearwater Pass	28.0		0			.1			0			0		0	.0
	Clearwater Beach Islands	4.0		0			.3						0		0	.1
	Caladesi Island	2.5		0			0						0		0	0
	Honeymoon Island	2.0		0			0						0		0	0
Pasco	Anclote Key	3.0		.3			.7						0		0	.2
Franklin	Ochlocknee Bay - Peninsular Point	11.0		0			0			0			0		0	0
	Dog Island	10.0		0			0			.3			0		0	.1
	St. George Island	36		0			.6			.1			.0		0	.1
	St. Vincent Island	10.0		.1			.1			0			0		0	0
Gulf	Indian Pass - St. Joseph Point	30.5		0			.2			0			0		0	.0
Bay	St. Joseph Point - Alligator Point	49.5		0			0			0			.0		0	.0
Walton	Alligator Point - Miramar	52.5		0			.0			.1			0		0	.0
Okaloosa	Miramar - Destin Inlet	11.5		0			0			0			.1		0	.0
Santa Rosa	Destin Inlet - Navarre	26.0		0			.1			.1			.1		0	.1
Escambia	Navarre - Pensacola Inlet	34.0		.0			.0			0			0		0	.0
	Pensacola Inlet - AL/FL Line	15.5		.1			0			0			0		0	.0

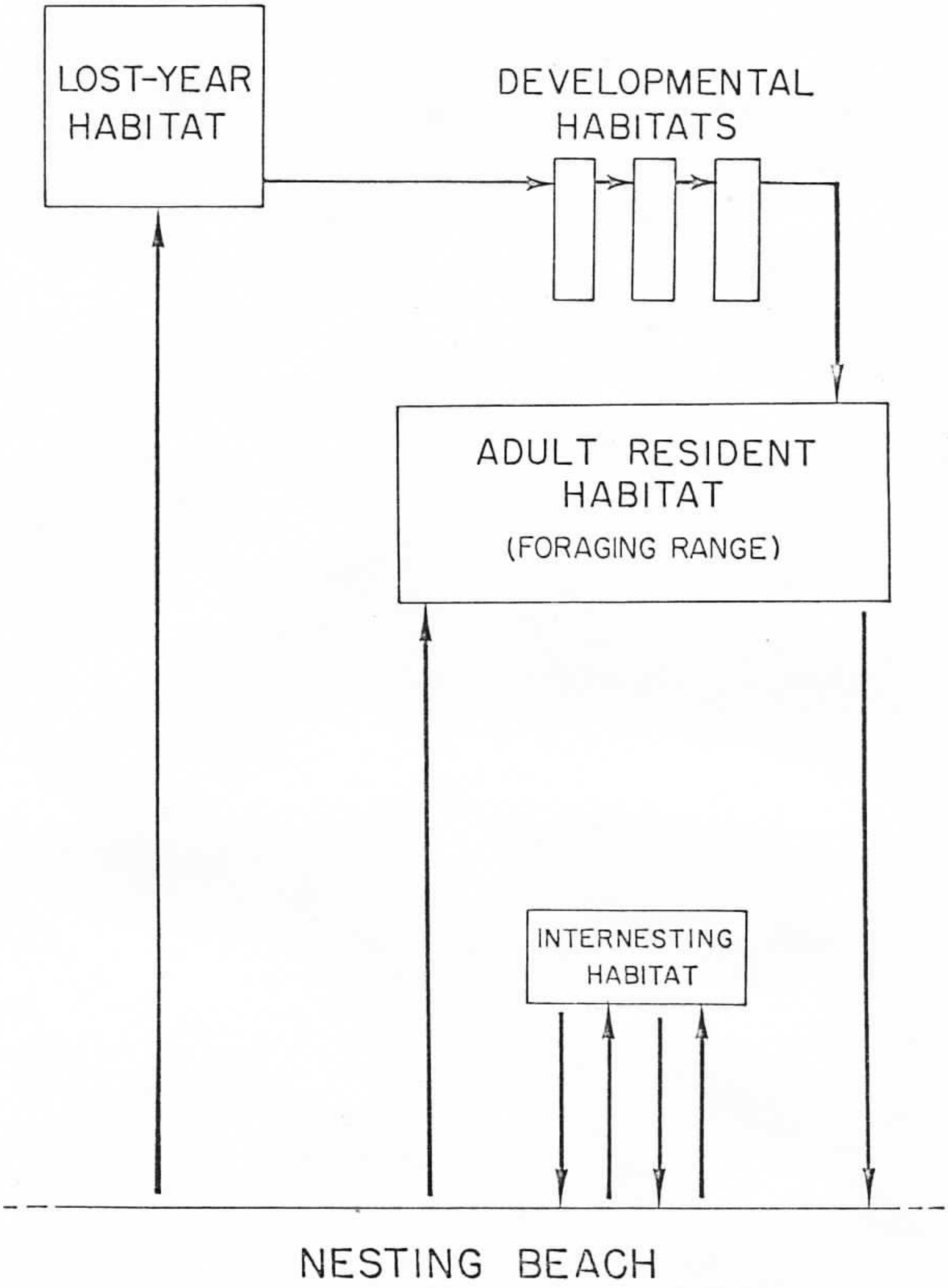


Figure 1. Seasonal and developmental changes in the ecologic geography and habitat of *Chelonia*. The "lost-year" actually a period from seven to about 14 months in duration--is almost certainly passed in a pelagic habitat, probably drifting sea weeds. On reappearing, the juveniles turn up in various inshore estuarine or reef-system habitats, often on a regular schedule of arrival and departure times. The resident habitat is protected, warm water not too deep for photosynthesis, where the turtles feed on bottom vegetation. The internesting habitat, occupied for the periods between seasonal nesting emergences, is not yet well known.

Figure 2. Nesting season of the loggerhead turtle in Florida, shown by statewide and separate East Coast aerial track counts; 1976 and 1977.

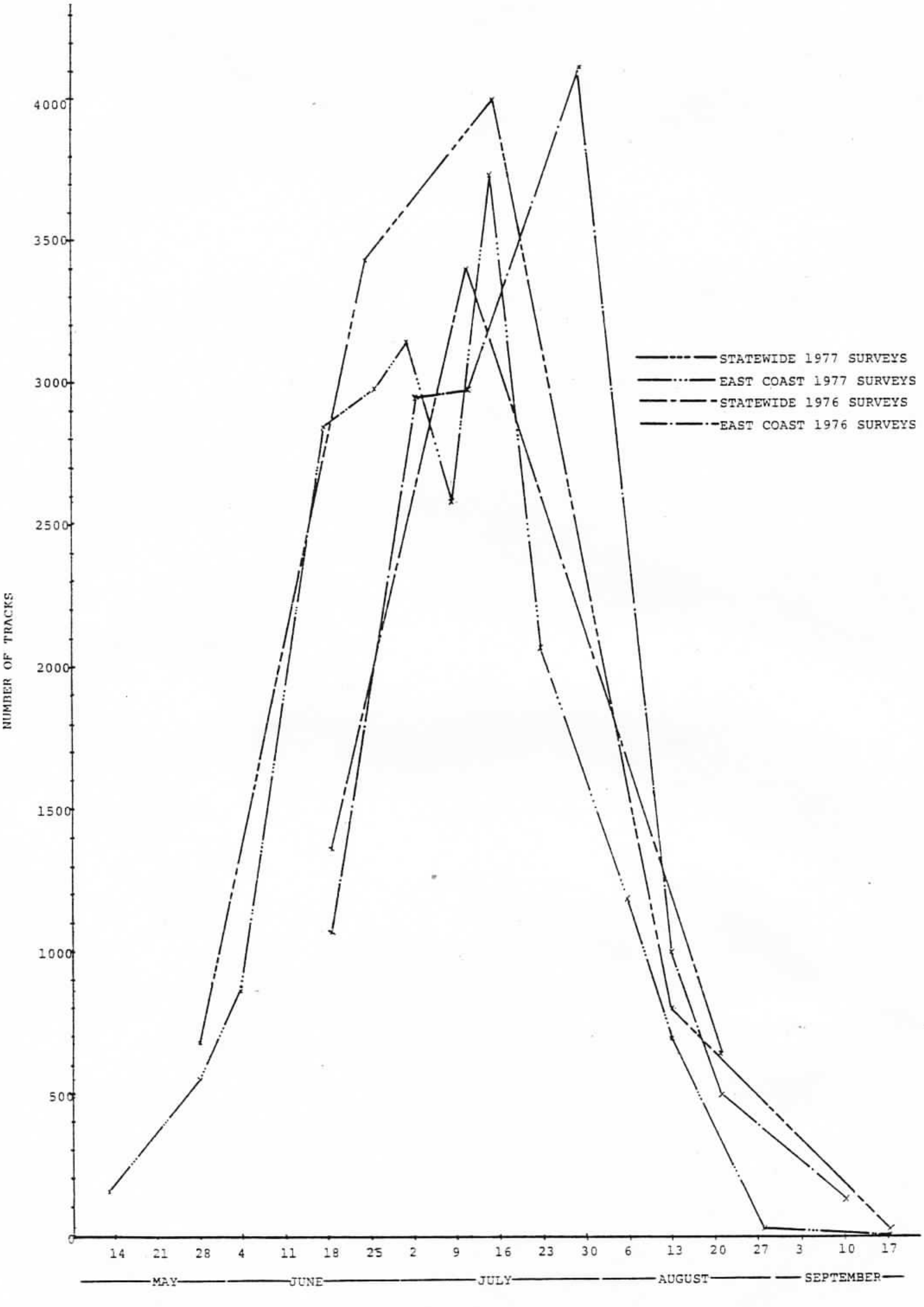
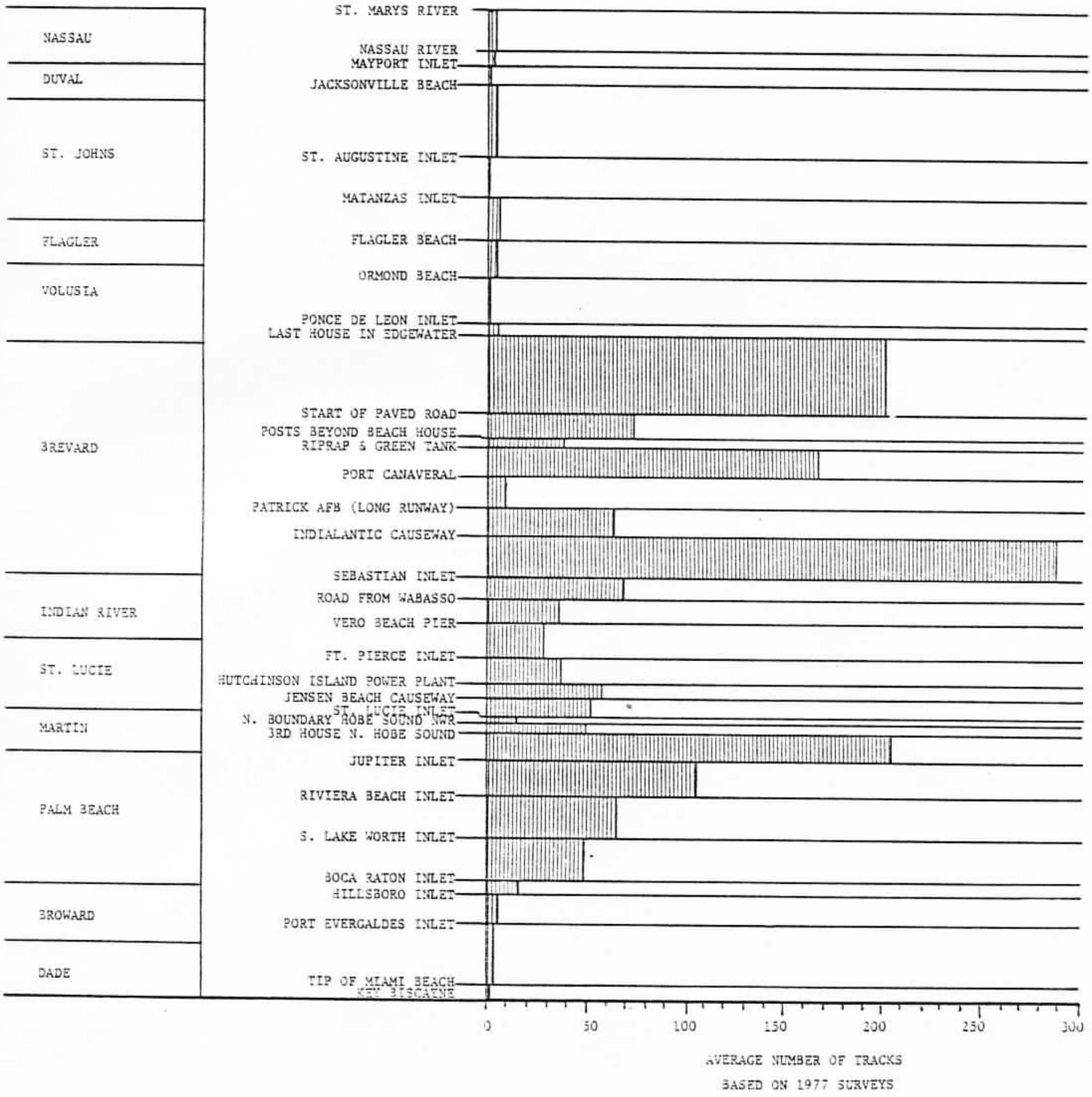

NUMBER OF TRACKS
4000
3500
3000
2500
2000
1500
1000
500
0
14 21 28 4 11 18 25 2 9 16 23 30 6 13 20 27 3 10 17
MAY
JUNE
JULY
AUGUST
SEPTEMBER
STATEWIDE 1977 SURVEYS
EAST COAST 1977 SURVEYS
STATEWIDE 1976 SURVEYS
EAST COAST 1976 SURVEYS

Figure 3. Average number of tracks per beach section based on the 1977 surveys. The relative extent of sections in indicated by widths of columns; the absolute extents are shown in Table 5. Relation to county lines is indicated at left.



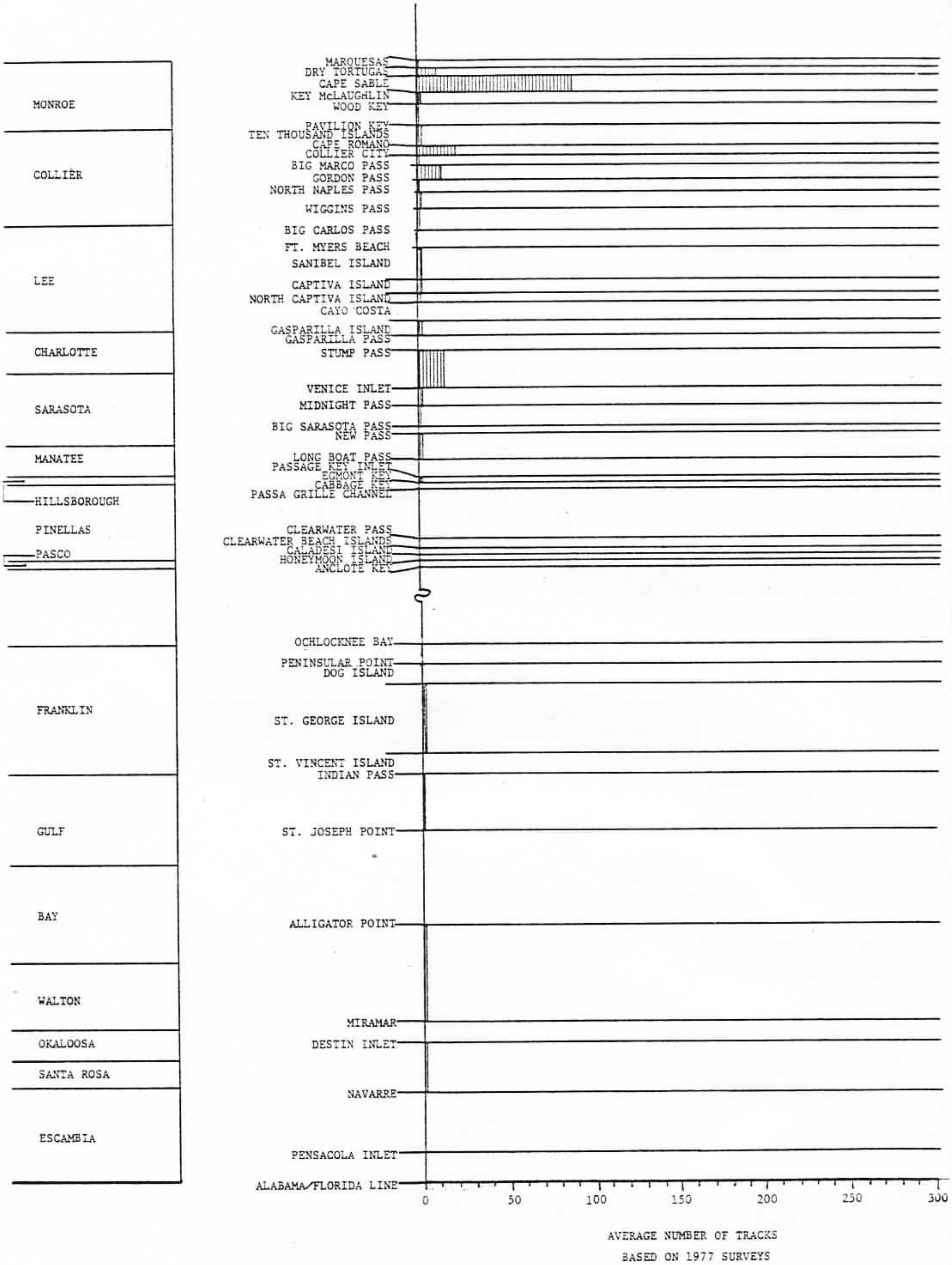
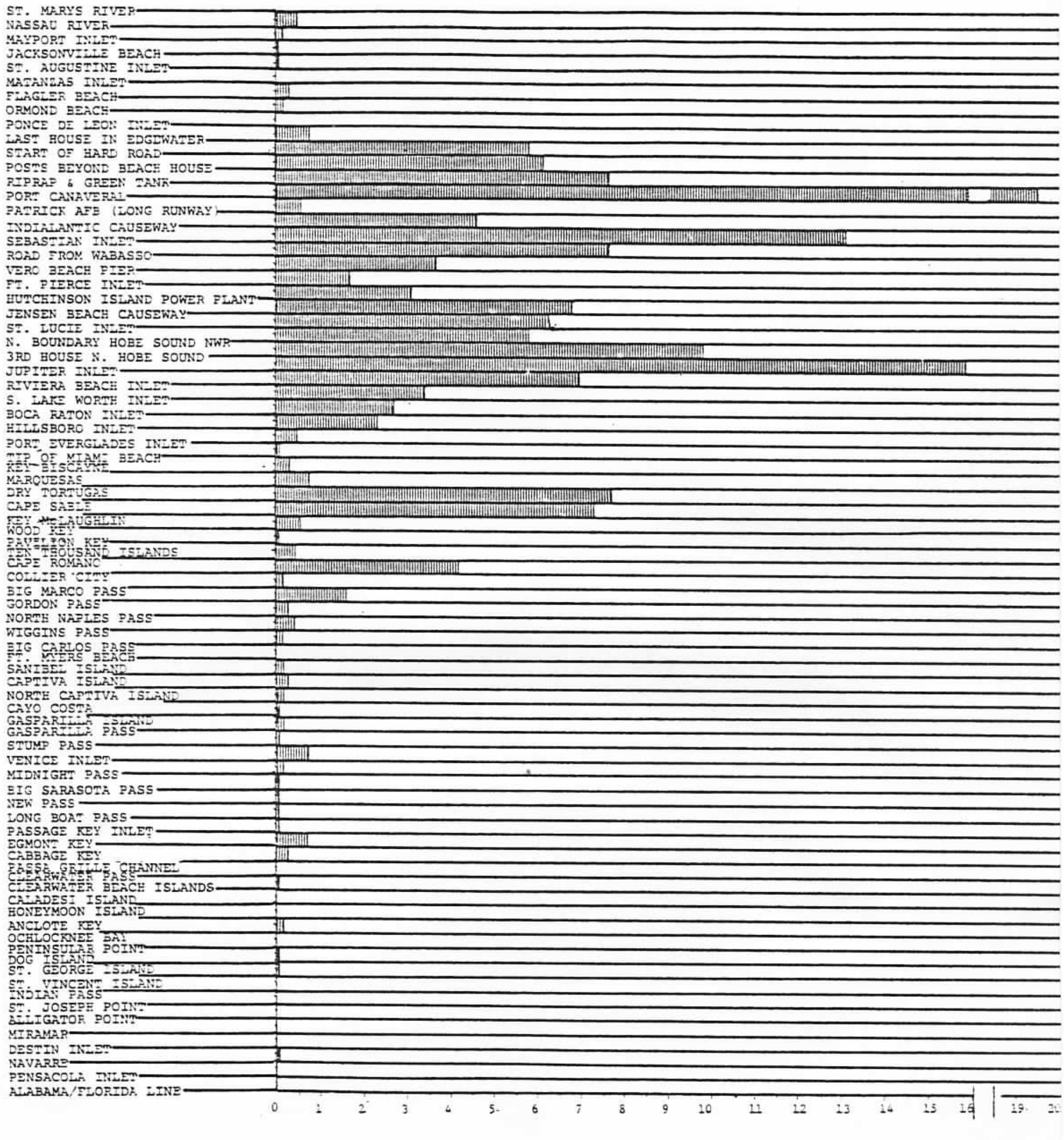

MONROE
COLLIER
LEE
CHARLOTTE
SARASOTA
MANATEE
HILLSBOROUGH
PINELLAS
PASCO
FRANKLIN
GULF
BAY
WALTON
OKALOOSA
SANTA ROSA
ESCAMBIA
MARQUESAS
DRY TORTUGAS
CAPE SABLE
KEY McLAUGHLIN
WOOD KEY
PAVILION KEY
TEN THOUSAND ISLANDS
CAPE ROMANO
COLLIER CITY
BIG MARCO PASS
GORDON PASS
NORTH NAPLES PASS
WIGGINS PASS
BIG CARLOS PASS
FT. MYERS BEACH
SANIBEL ISLAND
CAPTIVA ISLAND
NORTH CAPTIVA ISLAND
CAYO COSTA
GASPARILLA ISLAND
GASPARILLA PASS
STUMP PASS
VENICE INLET
MIDNIGHT PASS
BIG SARASOTA PASS
NEW PASS
LONG BOAT PASS
PASSAGE KEY INLET
EGMONT KEY
CABBAGE KEY
PASSA GRILLE CHANNEL
CLEARWATER PASS
CLEARWATER BEACH ISLANDS
CALADESI ISLAND
HONEYMOON ISLAND
ANCLOTE KEY
OCHLOCKNEE BAY
PENINSULAR POINT
DOG ISLAND
ST. GEORGE ISLAND
ST. VINCENT ISLAND
INDIAN PASS
ST. JOSEPH POINT
ALLIGATOR POINT
MIRAMAR
DESTIN INLET
NAVARRE
PENSACOLA INLET
ALABAMA/FLORIDA LINE
0
50
100
150
200
250
300
AVERAGE NUMBER OF TRACKS
BASED ON 1977 SURVEYS

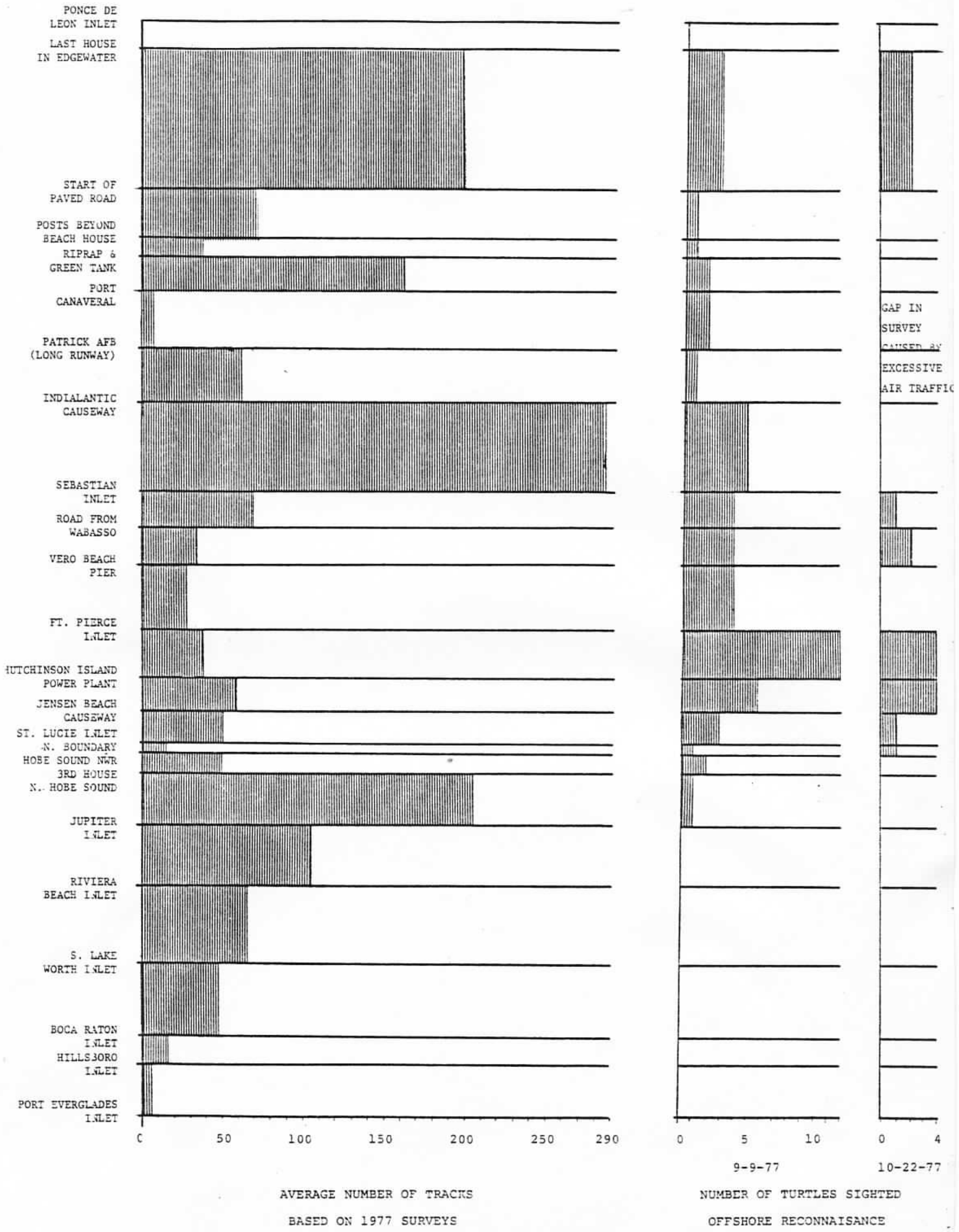
Figure 4. Average statewide track density per mile, by beach section, based on 1977 aerial surveys.



AVERAGE NUMBER OF TRACKS PER MILE

BASED ON 1977 SURVEYS

Figure 5. Average track density per mile, Florida East Coast, 1977; with comparative distribution of turtles sighted off the same shore on two late-season flights shown at right.


PONCE DE LEON INLET
LAST HOUSE IN EDGEWATER
START OF PAVED ROAD
POSTS BEYOND BEACH HOUSE
RIPRAP & GREEN TANK
PORT CANAVERAL
PATRICK AFB (LONG RUNWAY)
INDIALANTIC CAUSEWAY
SEBASTIAN INLET
ROAD FROM WABASSO
VERO BEACH PIER
FT. PIERCE INLET
HUTCHINSON ISLAND POWER PLANT
JENSEN BEACH CAUSEWAY
ST. LUCIE INLET
N. BOUNDARY HOBE SOUND NWR
3RD HOUSE N. HOBE SOUND
JUPITER INLET
RIVIERA BEACH INLET
S. LAKE WORTH INLET
BOCA RATON INLET
HILLSBORO INLET
PORT EVERGLADES INLET
0
50
100
150
200
250
290
0
5
10
0
4
9-9-77
10-22-77
GAP IN SURVEY CAUSED BY EXCESSIVE AIR TRAFFIC
AVERAGE NUMBER OF TRACKS
BASED ON 1977 SURVEYS
NUMBER OF TURTLES SIGHTED
OFFSHORE RECONNAISANCE