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Movements and Seasonal Changes in Loggerhead Turtle *Caretta caretta* Aggregations in the Vicinity of Cape Canaveral, Florida (1978–84)

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ABSTRACT

Capture records from loggerhead turtles Caretta caretta, *tagged in the vicinity of Cape Canaveral, Florida (1978 to 1984), were analysed to determine seasonal distributions and movement patterns. Three distinct groups of turtles (adult males, adult females and subadults) occurred in the study area, and each was dominant at different times of the year. Adult males were most abundant in April and May, adult females were most common from May to July, and subadults constituted over 80% of the population during the remainder of the year. Separate treatment of the three groups was necessary, because movement of one group into the area was apparently correlated with the emigration of the remaining two. The data suggest that nesting females are short-term residents who migrate into the area on two- and three-year intervals and reside elsewhere during non-nesting years. Adult male turtles apparently do not migrate with the females, but may reside in the vicinity of nesting beaches throughout the year. Subadult turtles forage opportunistically along the Atlantic seaboard, possibly moving northward as waters warm in the higher latitudes and southward with the onset of winter. Evidence suggests that a resident population of subadults overwinter in the Canaveral area each year.*

INTRODUCTION

In the western Atlantic, loggerhead turtles *Caretta caretta* occur throughout the Gulf of Mexico and the Caribbean Sea northward to Nova Scotia (Carr, 1952). Seasonally, loggerheads are common as far north as the Canadian portions of the Gulf of Maine (Lazell, 1980) but during cooler months of the

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year distributions shift to the south (Shoop *et al.*, 1981). Aerial surveys of loggerhead turtles at sea indicate that they are common in waters less than 50 m depth (Shoop *et al.*, 1981; Fritts *et al.*, 1983) but occur pelagically as well. Shoop *et al.* (1981) speculated that turtles sighted in deep oceanic waters were probably in transit to other areas.

While the occurrence of loggerheads in coastal waters has been well documented, little information on the movements of these turtles is available. Several researchers have analysed movements of adult female loggerhead turtles from recoveries of turtles tagged on nesting beaches (Caldwell *et al.*, 1959; Caldwell, 1962; Bustard & Limpus, 1971; Hughes, 1974; Bell & Richardson, 1978; Ehrhart, 1979; Meylan & Bjorndal, 1983). In general, these studies indicate that turtles may travel considerable distances, but direction and rate of dispersal appears inconsistent. Bell & Richardson (1978) and Hughes (1974) have suggested possible migratory routes followed by post-nesting female turtles, but evidence for these movements is based on a limited number of tag recoveries and remains inconclusive.

Researchers need information on the distributions and movements of turtles and groups of turtles to manage and conserve stocks effectively. At the present time, virtually no data are available from the time hatchlings enter the sea until female turtles return to the natal nesting beaches. In particular, subadult turtles and adult male turtles have seldom been studied because they must be captured and tagged at sea, a costly and time-consuming process. The discovery of large concentrations of turtles in the Port Canaveral, Florida, ship channel (Carr *et al.*, 1980) has made the use of trawling gear effective in this locality, thus permitting the capture and tagging of subadult and adult male turtles in addition to adult females.

Here I present results of continuing studies of loggerhead turtle aggregations in the Cape Canaveral, Florida area. Turtles utilising this unique habitat are primarily subadults, but during the nesting season the population shifts to an adult-dominated assemblage. Recaptures of turtles tagged in the Canaveral area were analysed to determine movement patterns of adult male, adult female and subadult turtles. These studies were conducted as part of the National Marine Fisheries Service (NMFS) Endangered Species Programme in accordance with the Endangered Species Act 1973-16 USC 1531-1543.

Reference to trade names in this paper does not imply endorsement by the National Marine Fisheries Service, NOAA.

MATERIALS AND METHODS

Tagging records from five NMFS sea turtle research projects were used in analyses. Although objectives and sampling methodologies of each project

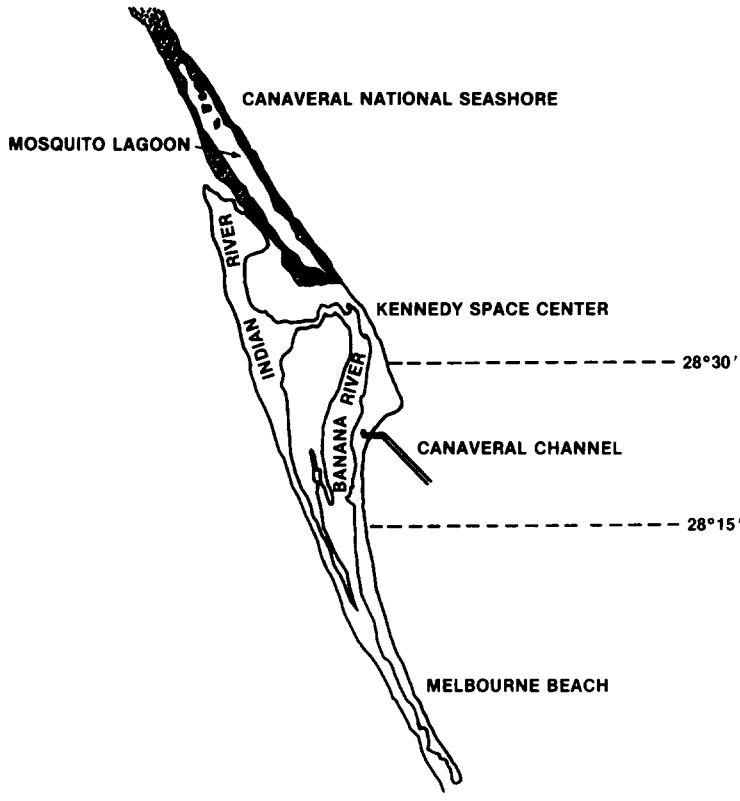

Fig. 1. Description of the Cape Canaveral study area and adjacent nesting beaches.

differed, all used trawling gear to capture turtles, and each project recorded similar capture data: location, date, tag identification numbers, species, sex, total carapace length and width, and condition of captured animals. Nets used in the capture of sea turtles ranged in size from 12·3–24·6 m headrope length, including a wide variety of types and modifications. All turtles were tagged with Monel alloy flipper tags (National Band and Tag Company, Newport, KT) attached to the trailing edge of one or both foreflippers. Tag returns were obtained opportunistically from NMFS projects, commercial shrimp fishermen, gill net fishermen, surf anglers, beach strandlings, power plants, and turtle researchers monitoring nesting beaches.

For the present analyses, only turtle captures in the Cape Canaveral ship channel and adjacent waters (28°15′N to 28°30′N latitude) were considered (Fig. 1). Recaptures of turtles initially tagged in the study area but recovered elsewhere were included for analysis of long-distance movement patterns. To characterise turtle aggregations in the Cape Canaveral area, turtle capture data were pooled and frequency of occurrence by total carapace

length plotted. From this plot it was evident that size distributions were bimodal. To establish the points of inflection of the two distributions, length frequencies were plotted on probability paper according to methods described in Cassie (1954).

To determine if size and sex composition of turtle aggregations changed over the course of the year, data were pooled over all years, separated by month and composition (adult males, adult females and subadults) analysed with a chi-square test for independence. Percent composition of the groups was plotted by month to illustrate monthly changes in Canaveral turtle aggregations.

An unusual opportunity to monitor daily and weekly changes in turtles of the Canaveral area occurred during sea turtle rescue operations from July through December 1980. This effort, conducted jointly by the US Army Corps of Engineers (COE) and NMFS, was undertaken to capture and relocate sea turtles from the Cape Canaveral ship channel prior to dredging. Over a 132-day period, 91 days of trawling were conducted thus providing a chance to study day-to-day movements of turtles.

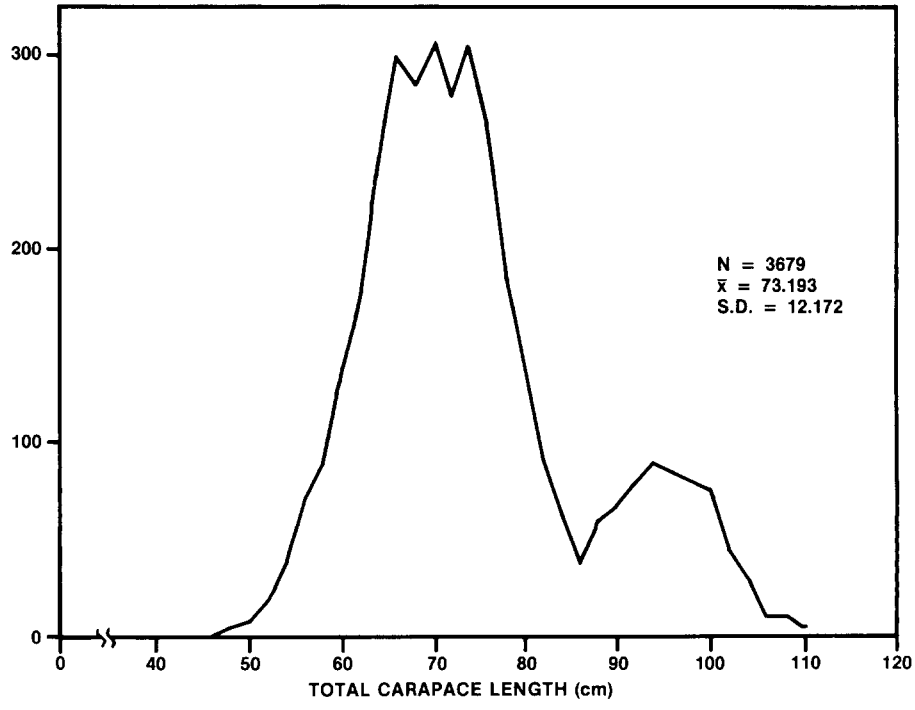

Fig. 2. Length frequency distribution of loggerhead turtles, *Caretta caretta*, captured in the Cape Canaveral area.

RESULTS

Of the loggerhead turtles captured in the study area (including recaptures) 82% were subadults, 9% were adult females and 9% were adult males (Table 1). These totals represent 3132 individuals: 2546 subadults, 271 adult females and 315 adult males.

The plots of frequency of capture by total carapace length (Fig. 2) and of length frequencies by cumulative percent (Fig. 3) indicated that two size groups of turtles inhabit the Canaveral area. An assemblage of smaller animals (mean carapace length = 69 cm) comprise 83% of the total captures, and a group of adult turtles (mean carapace length = 95 cm) make up the remaining 17% of the captures. These findings are in agreement with size distributions from stranding records in the area (Lew Ehrhart, pers. comm.).

The adult size group was separated into male and female components; all remaining turtles (total carapace length ≤ 83 cm) were classified as subadults. The chi-square test of independence of the three sex categories by month was found to be highly significant ($X^2 = 1198{\cdot}2$; $p = 0{\cdot}001$), indicating that ratios changed over the course of the year. A comparison of predicted vs observed number of individuals in each category by month (Table 1)

TABLE 1

Summary of Monthly Occurrence of Loggerhead Turtles *Caretta caretta* in the Cape Canaveral Area by Three Sex Categories (Adult Male, Adult Female, and Subadult). (Predicted number of individuals from X^2 test of independence (in parentheses) are compared with observed number of individuals.)

Month	*Subadult*	*Adult male*	*Adult female*	*Total*	X^2
Jan	84 (70·0)	1 (7·9)	1 (8·1)	86	15·05*
Feb.	679 (630·3)	50 (70·9)	45 (72·8)	774	20·54*
Mar.	442 (435·6)	54 (49·0)	39 (50·3)	535	3·14
Apr.	51 (132·7)	100 (14·9)	12 (15·3)	163	537·05**
May	84 (176·7)	56 (19·9)	77 (20·4)	217	271·16**
June	54 (92·0)	4 (10·4)	55 (10·6)	113	205·61**
July	94 (103·4)	5 (11·6)	28 (11·9)	127	27·22*
Aug.	265 (255·7)	10 (28·8)	39 (29·5)	314	15·67*
Sept.	238 (210·9)	15 (23·7)	6 (24·4)	259	20·55*
Oct.	281 (254·9)	15 (28·7)	17 (29·4)	313	14·44*
Nov.	598 (530·1)	27 (59·7)	26 (61·2)	651	46·85*
Dec.	151 (128·7)	3 (14·5)	4 (14·9)	158	20·96*
Totals	3 021	340	349	3 710	1 198·24**

* $P < 0{\cdot}05$, ** $P < 0{\cdot}01$.

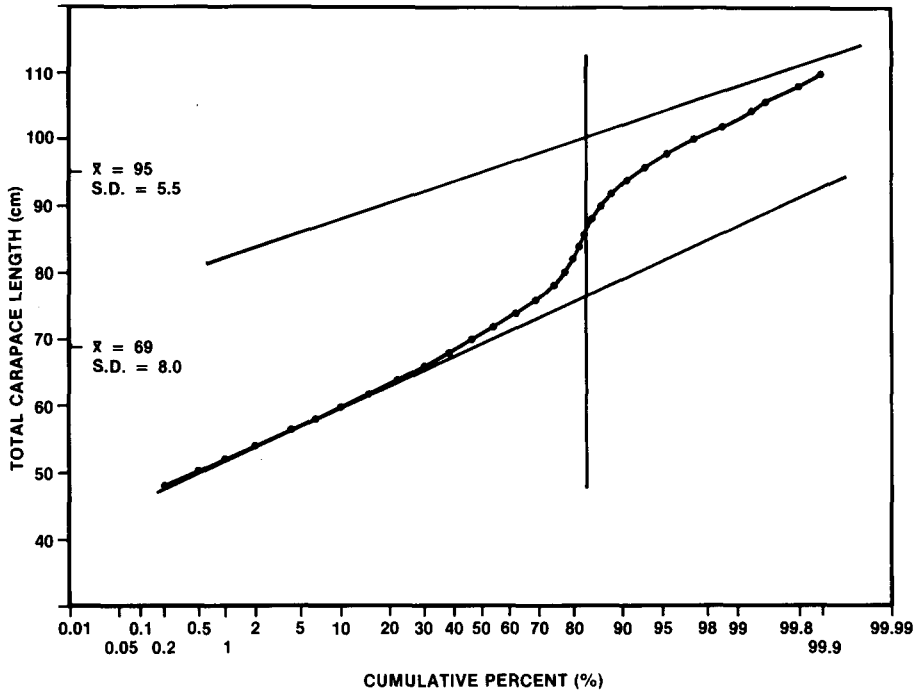

Fig. 3. Length frequencies of loggerhead turtles, *Caretta caretta*, captured in the Cape Canaveral area plotted by cumulative percent.

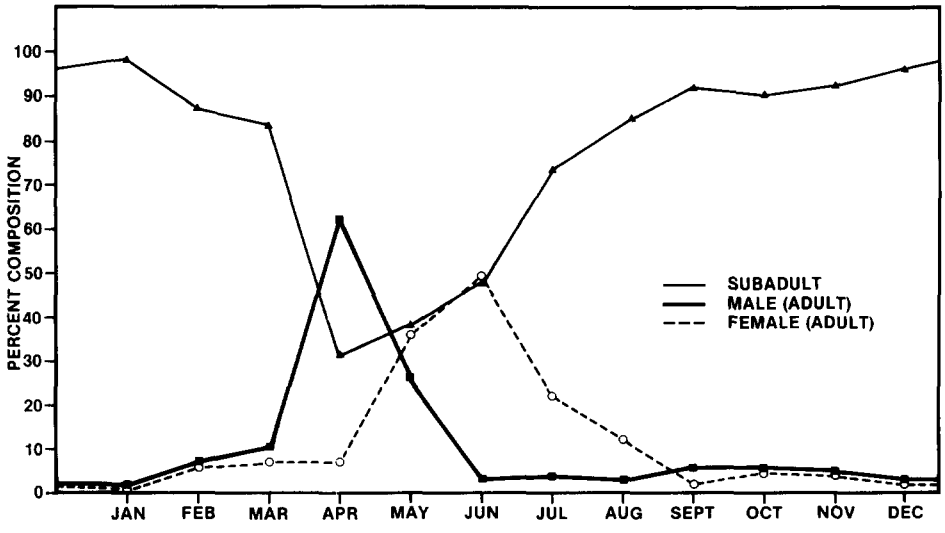

Fig. 4. Percent composition of loggerhead turtles, *Caretta caretta*, in three sex categories (adult male, adult female and subadult) captured in the Cape Canaveral area by month. Data were pooled over years.

indicated that, with the exception of March, all months had significant chi-square values. The months of April, May and June had highly significant values which accounted for 85% of the total. It is during these months that breeding adults are most abundant.

A plot of percent sex composition by month (Fig. 4), illustrates the fact that three groups of loggerhead turtles can be distinguished in the Cape Canaveral study area. Each group is dominant at certain times of the year, and movements of one group into the study area appears correlated with emigration of the remaining two. The numerical abundance of the three groups also changes over the course of the year (Table 1), providing additional evidence of movements into and out of the study area. Separate treatment of the groups was necessary, because movements of the three groups were dissimilar and related to different biological and physical factors.

Adult males

As of December 1984, 7% (25 of 340) of the adult male turtle captures in the Cape Canaveral area (Table 1) were recaptures of animals originally tagged in the same location. Twelve of these recaptures occurred within two months of the initial capture. These recoveries provide evidence that some adult males, at least temporarily, reside in the area.

The remaining 13 recaptures were made after periods ranging from 7 to 26 months, and all occurred between February and June. In seven instances, turtles initially captured between February and May were recaptured during the same time period one or two years after tagging. These turtles are presumed to be members of the breeding population. To my knowledge, no adult male turtles tagged in this study have been recaptured outside the Canaveral area.

Adult females

The months of May through August produced 57% (199 of 349) of the adult female turtle captures recorded in or near the Cape Canaveral ship channel, and these months correspond with peak nesting activity on area beaches (Ehrhart, 1979). Thirty-four percent (67 of 199) of the females were observed nesting on local beaches either before or after capture.

During the remainder of the year (September to April) 150 adult females were captured; 7% (11 of 150) of these had been observed nesting in preceding years. Six of these eleven recaptures occurred in March and April 1980, and may have been early arrivals for the nesting season. Three of the remaining five were from Georgia nesting populations (Jim Richardson, pers. comm.) and one was from the Jupiter Island, FL, nesting population.

Only one adult female captured during the winter months was known to have nested on local beaches of the Canaveral area.

Movements of four adult female turtles were over distances greater than 100 nautical miles (185 km). One animal tagged in the Canaveral area during February 1982 nested on Blackbeard Island, GA the following summer. A second female was washed ashore dead on Cumberland Island, GA during the summer after capture in the Canaveral ship channel. A third female tagged in the Canaveral channel nested on Melbourne Beach, FL and was subsequently recaptured near Key West, FL. A fourth female nested on Cumberland Island, GA in 1975 and was recaptured in the Canaveral channel in February 1978 and again in October 1980.

Subadults

Of 3021 subadult captures in the Canaveral area (Table 1), 91% (2738) occurred during the months of August to March. Sixteen percent of the total (475) were recaptures of turtles originally tagged in the same location. Periods between capture ranged from 0 to 1479 days, and the same turtle was captured as many as six times.

A total of 29 subadult turtles were recaptured more than 100 nautical miles (185 km) from the study area. Twenty-seven of these recoveries were to the north, in coastal waters of Georgia, South Carolina, and Virginia; the remaining two were taken in the Bahama Islands (Fig. 5).

An examination of seasonal trends in long-distance movements indicated that the majority of initial captures in the Canaveral area (27 of 29) occurred from October to March, while the majority of recaptures (22 of 29) were from May to September. This pattern may suggest a northward movement during spring and summer associated with warming waters in higher latitudes.

During the 1980 relocation project, 1161 subadult turtle captures were recorded. Over the five-month period of the project, catch per unit effort (CPUE) of subadult loggerheads increased significantly (Table 2). Examin-

TABLE 2

Summary of Subadult Loggerhead Turtle *Caretta caretta* Captures, Recaptures and CPUE in the Cape Canaveral Ship Channel (July to November 1980)

Month	*Minutes fished*	*Effort (30·5 m net h)*	*Turtle captures*	*CPUE (turtles h^{-1})*	*Recaptures*	*Percent recaptures*
July	1 834	24·45	49	2·00	8	16
Aug.	3 916	52·21	175	3·35	24	14
Sept.	4 657	62·09	178	2·87	40	22
Oct.	4 075	54·33	264	4·86	73	28
Nov.	3 082	41·09	495	12·05	149	30

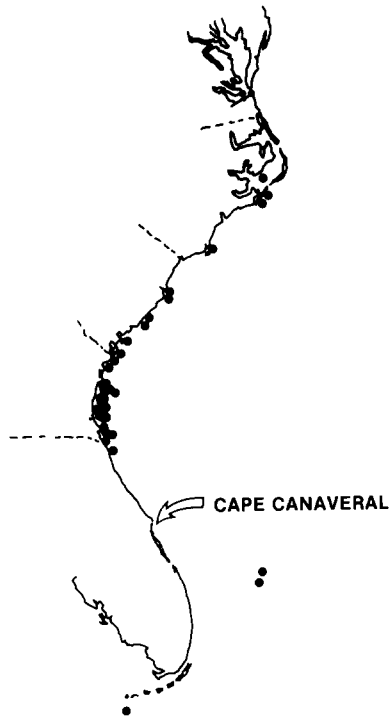

Fig. 5. Summary of long-distance recaptures from loggerhead turtles, *Caretta caretta*, originally captured and tagged in the Cape Canaveral area.

ation of CPUE (standardised to 30·5 m net hours) by month indicated that the catch rates were low but stable from July to September (2·00 to 3·35 turtles h^{-1}). In October the CPUE approximately doubled (4·86 turtles h^{-1}) and doubled again in November (12·05 turtles h^{-1}). This suggests that the number of subadult turtles in the channel by November was four times larger than in summer.

The percentage of tagged animals recaptured also increased steadily in autumn, reaching 30% by November. Seventy-nine percent of these recaptures (233 of 294) were turtles tagged during the relocation project. This indicates that the animals remained in the channel and were not migrating through the area. The other 21% (61 of 294) were animals tagged during prior winter surveys. These recaptures suggest that many individuals overwinter in the channel each year. Of this latter group, 46 were initially tagged in winter 1979–80, 12 in winter 1978–79, and 3 in winter 1977–78.

SUMMARY AND DISCUSSION

Because size and sex composition of sea turtle aggregations in the Canaveral area changed seasonally, the three groups were treated independently. Breeding

migrations of adult turtles into the area during spring and summer months were probably related to reproductive behaviour and do not reflect normal foraging patterns or non-breeding distributions. Subadult turtle movements, however, were probably not related to sexual activities; their distribution patterns may reflect changes in environmental conditions and foraging opportunities.

The bimodal size distribution of turtles in the study area reflects the seasonal influx of breeding adults. During the remainder of the year adult turtles are less common, which indicates that many of these turtles leave the area. The size distribution of turtle aggregations during non-breeding periods is unimodal with larger subadults and adults occurring in low numbers. Movements of older turtles out of the Canaveral channel may be associated with the onset of sexual maturity in one or both sexes, or may reflect differential habitat preferences in larger turtles.

With regard to turtles initially tagged in the Cape Canaveral area and recaptured in the same locality, little can be said about where they moved during periods between capture. These data are useful, however, as an indicator of emigration and immigration over the course of a year. Changes in percent composition of the sexes and CPUE indicate that turtle aggregations are dynamic and that turtles move into and out of the area regularly.

An important consideration in interpreting the data is that recaptures probably reflect changes in relative abundance of the different age and sex classes, but not necessarily absolute changes in abundance. Recapture effort was variable in space and time, and to identify changes in absolute abundance accurately, equal effort would be required.

Adult males

Adult male migratory patterns appear different from those of adult females, with males moving into the Canaveral area prior to the arrival of females. Peak densities were April to May. Most breeding presumably occurs at this time, and males leave the area by June. The same male turtles are sometimes present in Cape Canaveral breeding aggregations during consecutive years and are intermittent members of the overwintering assemblage of turtles. This indicates that adult males may remain in the proximity of breeding areas throughout the year. The presence of the same males in breeding aggregations during consecutive years suggests that males may breed annually and do not migrate with the females. If males breed each year, the sex composition of adult populations could be different from the expected 1:1 ratio, since a single group of males could breed with different females each year.

Adult females

Results of this study suggest that females who nest in the Canaveral area rarely overwinter in the channel. Adult females encountered during the winter in numbers comparable to adult males are either non-breeding adults or members of other nesting populations. The breeding population of female turtles, dominant from May to August, consists of short-term residents which migrate into the area for nesting. At the end of the nesting season, these turtles apparently emigrate to distant foraging and feeding areas and do not return until the next nesting cycle.

Subadults

Subadult turtles are dominant in the Canaveral ship channel from August to March. In the spring, subadults emigrate in some instances as far north as the Chesapeake Bay. The majority of the long-distance recoveries occurred north of Cape Canaveral, but these may represent a biased impression of dispersal patterns because most came from shrimp trawlers or beach washups. Fishing pressure from shrimp trawlers is much greater north of Canaveral and the increased level of fishing effort in these areas could account for the large number of northern records. Without comparable effort to the south, it is difficult to determine whether northward movement patterns exist or whether the recaptures reflect random dispersal.

Results of the joint COE–NMFS study and other NMFS surveys in the Cape Canaveral area indicate that subadult turtles begin to congregate in the autumn, presumably in response to cooling water temperatures and winter conditions. Greatest concentrations occur from October to March, and many of the same turtles may be present each year. Turtles apparently remain throughout the winter, leaving the channel in the spring as improved environmental conditions and foraging opportunities occur. These data indicate the existence of a resident population of subadult turtles in the Cape Canaveral ship channel during winter months, which disperses locally during spring and summer and returns to the channel each winter.

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