H. Thompson

INCIDENTAL CAPTURE OF SEA TURTLES BY SHRIMP TRAWLERMEN IN GEORGIA

Report to

National Marine Fisheries Service

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Miami, Florida 33145

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Prepared by

Southeastern Wildlife Services, Inc.

1060 Gaines School Road

Athens, Georgia 30605

H. O. Hillestad, J. I. Richardson

G. K. Williamson

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PREFACE

This study was conducted for the National Marine Fisheries Service under contract number 03-7-042-35129. We are grateful for the capable liason services provided by Dr. James Tyler, Dr. Donald Ekberg, and Mr. Larry Ogren of National Marine Fisheries Service to Southeastern Wildlife Services during the course of the study.

Numerous agencies and individuals contributed in various ways to the study, greatly facilitating data collection. The Marine Extension Service, University of Georgia cooperated and collaborated on numerous phases of this study. Staff members David Harrington, James Whitted and D. Higgins were especially helpful in establishing contact with shrimpers, assisting in the collection of data of turtle captures in the sounds and freely sharing their observation on the sea turtle resources of Georgia.

We thank the Georgia Department of Natural Resources, Division of Game and Fish for allowing access to shrimp boat registration records. Mr. David Gould, Supervisor of the Division's coastal offices offered helpful suggestions for conducting the field surveys.

The U. S. Fish and Wildlife Service is gratefully acknowledged for providing access to Wassaw and Blackbeard Islands and their sea turtle records. The National Park Service was very helpful in our obtaining sea turtle data pertaining to Cumberland Island National Seashore.

The Little Cumberland Island Association cooperated fully with our survey of nesting activity and turtle strandings on their beaches. Mrs. Clifford West of Ossabaw Island kindly

permitted team members to visit Ossabaw on several occasions for data collection. Ossabaw Island Project Genesis director Al Bradford, and sea turtle conservationist Ishmael Williams, transmitted records of turtle nesting and strandings to us.

In recent years most of Georgia's barrier islands have had tagging teams in residence during the loggerhead nesting season. These outstanding conservationists volunteer their services or are nominally renumerated for their dedicated efforts to tag nesting turtles and compile other records pertaining to sea turtles. We acknowledge their efforts and thank them, collectively, for making their records available to us. However, we are compelled to singularly acknowledge the valuable contributions of Ms. Carol Ruckdeschel of Cumberland Island; sea turtles have no greater ambassador.

Mr. Bobby Moulis, Savannah, Georgia, was employed for much of this study. He is commended and acknowledged for his enthusiasm for conducting portions of this study, often under less than ideal conditions.

It is our pleasure to acknowledge Mrs. Jeanette Johnson for her secretarial input to this study and typing of the numerous drafts and final project completion report.

The success of this study was dependent upon the cooperation of the shrimp trawler owners, captains, and strikers along the Georgia coast. Almost without exception, we received complete cooperation from them during the interview and other phases of the study. As a group, the shrimp trawlermen of Georgia enthusiastically cooperated in the compilation of data, which often was of a sensitive and implicating nature to their industry.

We have attempted to interpret data on the incidental capture of sea turtles provided by the shrimpers in the most scientific manner possible. It is our wish that our treatment of the data is equitable to the shrimp industry of Georgia, and sea turtles.

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I. INTRODUCTION

Sea turtle biology and ecology are poorly known in Georgia and elsewhere along the Southeastern seaboard. Deficiencies in our knowledge of these marine resources became obvious following the proposal that the loggerhead, green and Olive Ridley sea turtles be added to the list of threatened species, as provided in the Endangered Species Act of 1973. Species distribution, population numbers, critical habitat needs and limiting factors of the group are required data for accurate evaluations of the survival status of the species. In Georgia, the shrimp trawling industry has been historically implicated as a limiting factor on sea turtles, principally loggerheads.

The primary objective of this study, conducted for the National Marine Fisheries Service which has regulatory responsibility for sea turtles in their aquatic habitats, was to quantify and evaluate mortality of sea turtles incidentally captured by shrimp trawlers in Georgia. We sought to interpert data on capture as to total impact upon the population dynamics of loggerheads, and as appropriate, for other sea turtles in the state.

II. STUDY AREA

Five species of sea turtles are associated with the Georgia coast. The loggerhead (Caretta caretta) is Georgia's most prevalent species, occurring regularly as juveniles and adults throughout estuarine and offshore waters and nesting at least sparingly on almost every stretch of sandy beach on the coast. The green turtle (Chelonia mydas), the leatherback (Dermochelys coriacea), and the Ridley (Lepidochelys kempi) are incidentally caught in small but regular numbers by shrimp trawlers in Georgia waters. The hawksbill (Eretmochelys imbricata) is a tropical species very rarely encountered in Georgia waters. All species except the loggerhead are non-breeding visitors, although there is at least one unconfirmed report of a leatherback nesting many years ago on Cumberland Island.

The Georgia coast consists of a chain of barrier islands (Figure 1) and estuaries dominated by Spartina alterniflora saltmarshes. Individual islands are separated from each other by a network of river deltas, sounds, and tidal creeks and from the mainland by extensive saltmarshes. The Georgia beaches are part of a dynamic and fluctuating shoreline, closely linked to a complex sand-sharing system (Oertel, 1974). Responding to the inexorable forces of wind, waves, and current, most nesting beaches are either growing or receding, rarely remaining stationary.

The suitability of any beach for loggerhead nesting changes from year to year (Baldwin & Loftin, 1959). A profile of the beach types loggerheads nest on or attempt to nest on is presented in Figure 2. Rapidly receding shorelines (Type 1) provide poor nesting habitat since they are usually littered with fallen trees or bordered by a vertical erosion bluff.

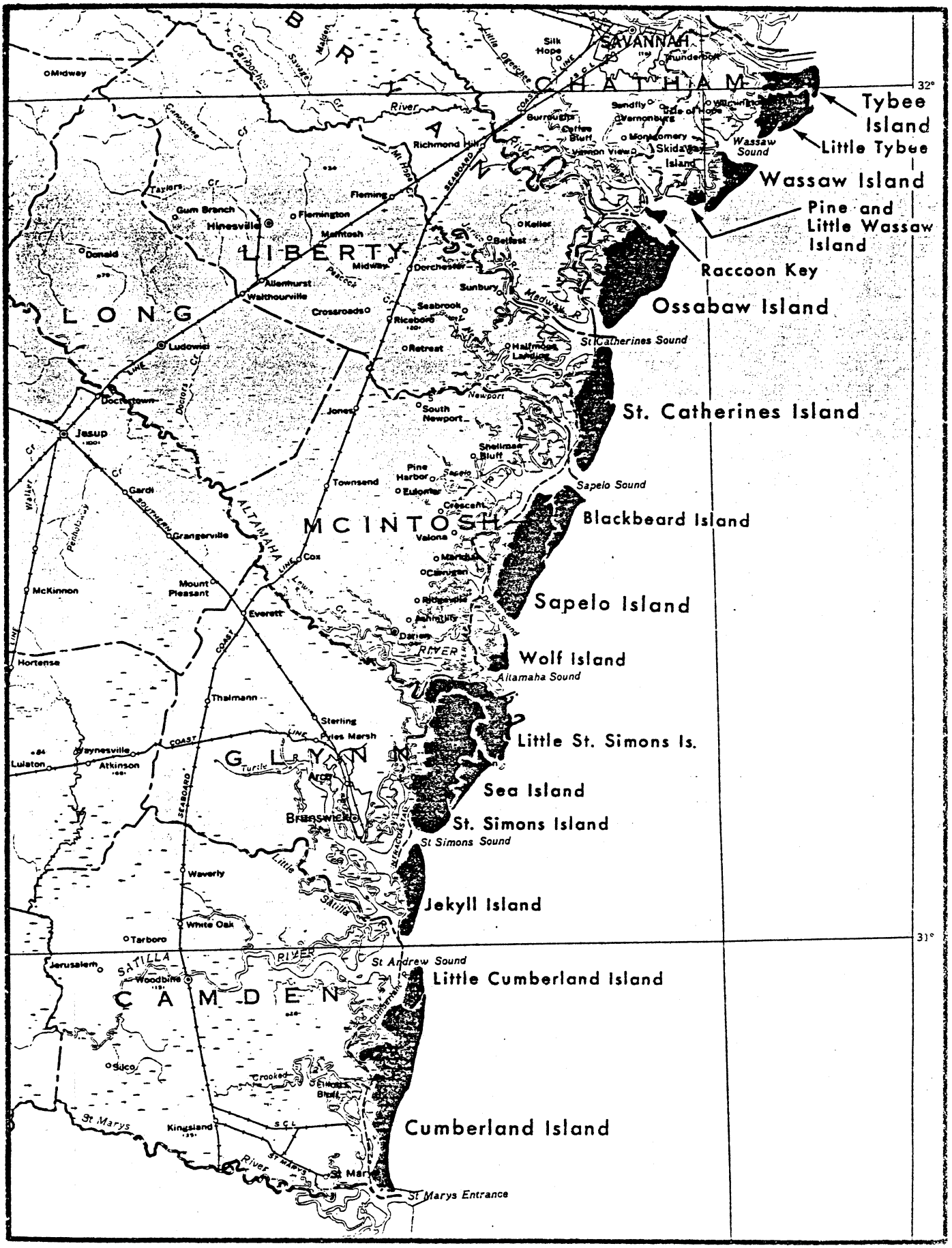

Figure 1. Map of coastal Georgia showing location of island complexes discussed in text.

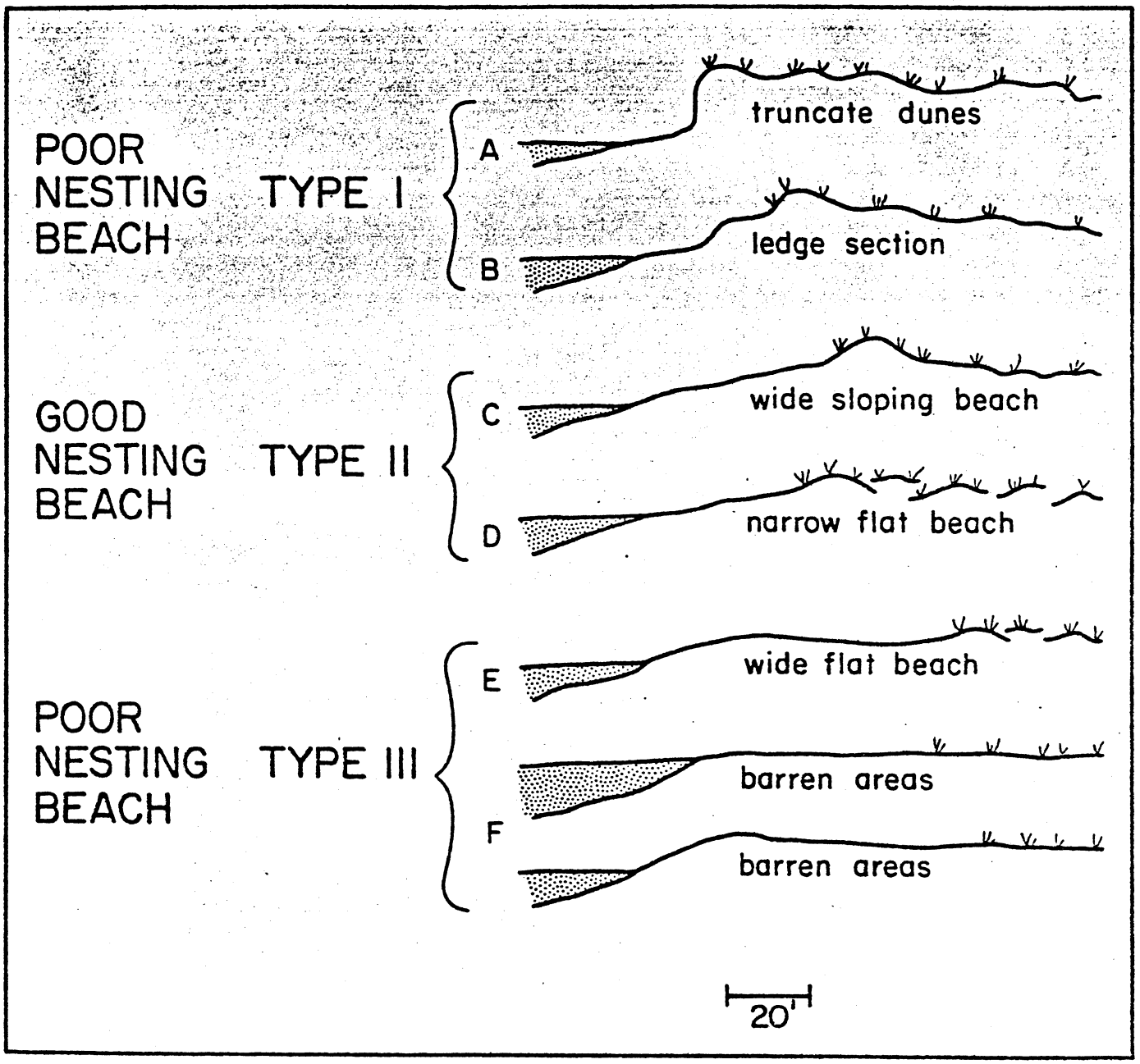

Figure 2. Diagrammatic cross-sections of generalized beach types occurring on the barrier islands. See text for explanation. (Adapted from Baldwin & Loftin, 1959).

Rapidly accreting shorelines (Type III) also provide poor nesting habitat because wide, flat terrain which characterizes these shorelines is poorly drained. Rainwater collects in flat areas on these beaches, inundating the nests, thus killing the embryos (Ragotzkie, 1959). The optimum nesting habitat (Type II) shown in Figure 2 is usually associated with a stationary or gradually shifting shoreline. In general, at least a portion of each of the Georgia islands provides acceptable nesting habitat during any one nesting season, but the exact location of this acceptable nesting habitat will shift from year to year. The transitory nature in the quality of nesting beaches is characteristic of the Georgia and South Carolina coasts in contrast to the more stable nesting beaches of Florida.

Actual beach frontage for a given island is generally longer than its absolute north-south length since portions of the west or inland side of the islands, often used by nesting turtles, have been included in the shoreline estimates. Table 1 quantifies all shoreline types of coastal Georgia and presents loggerhead nest densities for the various types. Total frontage is classified according to five shoreline types: Type I (obstructing features such as trees, eroding conditions, and shell beach), Type II (dunes providing moderate to excellent nesting habitat), Type III (sand bars, blowouts, low and flat beaches), Type IV (sea walls), and Type V (non-beach catagory of water, mud, saltmarsh). Included in Table 1 is the density of nests observed during the aerial surveys. It should be stressed that Georgia beaches are constantly changing and that the quantified classification of beach types for 1977 would be expected to change in subsequent years.

Table 1. Shoreline types, numbers of loggerhead nests, and nests per mile of Georgia coast. Data obtained by aerial survey, 1977.

Island	Shoreline Types (Miles) Total	I Trees, Shell, Erosion	II Dunes	III Dune-Tidal Flats	IV Stone Sea Wall	V Water Mud Marsh	Nests (Aerial Survey)	Density (Aerial Survey)
Tybee	3.52	-	-	.68	2.84	-	1	.28
Little Tybee	5.57	.57	.74	.74	-	3.52	11	1.97
Wassaw	6.59	3.01	3.58	-	-	-	32	4.86
Pine & Little Wassaw	2.39	1.25	1.14	-	-	-	7	2.93
Raccoon Key	1.14	.57	.57	-	-	-	36	31.58
Ossabaw	11.70	-	7.44	3.69	-	.57	80	6.84
St. Catherines	13.18	4.55	5.00	2.27	-	1.36	29	2.20
Blackbeard	8.24	-	7.05	1.08	-	.11	65	7.89
Sapelo	6.08	-	4.72	1.25	-	.11	16	2.63
Wolf	3.52	-	2.50	-	-	1.02	18	5.11
Little St. Simons	7.10	.51	2.56	3.69	-	.34	23	3.24
Sea	6.02	1.02	4.72	.28	-	-	8	1.33
St. Simons	4.09	-	-	.40	3.69	-	0	0
Jekyll	9.15	.51	4.15	.57	3.92	-	24	2.62
Little Cumberland	3.64	1.14	1.53	.97	-	-	39	10.71
Cumberland	18.58	-	14.66	2.22	-	1.70	52	2.80
TOTAL	110.51	13.13	60.36	17.84	10.45	8.73	441	3.99

III. METHODS AND MATERIALS

Several methods were used to study the interaction between sea turtles and the Georgia shrimping industry. Information was accumulated from interviews, on-board observations, aerial surveys, ground surveys, results from Georgia tagging programs, license records, and a survey of recent literature from Georgia research efforts.

License Records

We obtained from the Georgia Department of Natural Resources, Division of Game and Fish, a list of boats for which licenses were granted for 1976, their lengths and state of registration. There are a number of license catagories, including commercial, non-commercial, and live bait, each with individual rules for permissable gear dimensions, areas where shrimping activity can take place, and the method for disposing of the catch. We were unable to obtain a distribution by catagories for the 1976 licenses. We have assumed that all vessels less than 20 feet in length are non-commercial and that all vessels greater than 30 feet in length are commercial. The number and distribution by length of the latter coincide quite closely to a 1975 survey of commercial vessels (Nix et al, 1975). The few vessels in the 20 to 30 foot range could belong to either the commercial or non-commercial catagories.

Interviews

The owners, captains, and strikers of shrimp trawlers represent a source of information about sea turtles which has scarcely been tapped, a source of information which comes from years of shrimping experience. A few of these people are antagonistic toward sea turtles, but many others are genuinely interested in the welfare of the turtles they capture and in the ecology of sea turtles in general. Many of these people are apprehensive about sea turtle legislation and its potential impacts upon their industry.

Interviews from these men are unavoidably subjective and contain individual bias. Many shrimpers understandably wish to minimize negative facts (mortality, for instance) while maximizing positive facts. Such predilection can frequently be identified in the analysis process, providing that the sample size is sufficiently large. If and when a natural bias is identified, future interviews can be structured to minimize its effect. We will consider some of these predilections in following chapters. An example of the questionaire used in our interviews is included with this report (Appendix I).

Between 14 July and 12 October 1976, we obtained interviews from captains and strikers representing 104 commercial vessels which consistently unload their catch at commercial docks in Georgia (Appendix II). The distribution of vessel lengths in this sample is compared to the Nix et al (1975) survey of shrimp boats using commercial docks in Georgia in 1975. The distribution of interviews by county is also compared to the Nix et al (1975) survey.

Fifteen live bait shrimpers were interviewed between 14 September and 15 October, 1976.

On-Board Observations

On-board observations are necessary to locate bias in interview response as well as to provide sampling statistics which are not available from interviews. Two approaches to on-board observations were tested during the present study.

Observers accompanied five vessels for a total of seven days, remaining on-board the vessels from the beginning to the end of each trip. Observations included the length and variability of trawl times, trawls per day, and the frequency of turtle captures as a function of boat activity (Appendix III). The number of animals encountered per hour of observer time is inefficiently low with this method.

We tested a more efficient way to maximize turtle encounters when Georgia sounds were opened to shrimping on 4 October 1976. Within St. Andrew Sound and with the assistance of the University of Georgia Marine Extension Service, radio contact was established with approximately 175 commercial shrimp boats on the first morning of the season. A similar communications network was established in Wassaw Sound. When a shrimp boat signalled the capture of a turtle, a smaller research vessel would proceed to the area to measure, tag, and release the captured turtle. Included in the observations were species identification, carapace dimensions, and physiological condition of the animal immediately after coming on-board and, when necessary, after revival efforts had been completed (see Appendix IV for summary).

Aerial Surveys

We conducted a series of aerial surveys during 1977 prior to and following the opening of the inshore waters to shrimping. Surveys were conducted with a Cessna 150 aircraft. The flights were conducted to count sea turtle crawls, nests, dead turtles stranded on the beaches, and to ascertain the number and location of shrimp boats in offshore and inshore waters.

Fourteen flights were completed from 26 June to 31 July, each lasting approximately three hours and covering all potential nesting beaches on the Georgia coast. Flights over uninhabited beaches were conducted at an altitude of 25-100 feet and at a distance of 20-30 yards from the tide line, with a slightly higher altitude and greater lateral distance from the tide line over inhabited beaches. Personnel consisted of a pilot and an observer/recorder, each with five years of experience conducting sea turtle related work on the Georgia coast.

Flights began as soon after dawn as light would permit in order to minimize the number of crawls erased by an incoming tide. Variation in tide and flight time made determination of nesting crawls and dry runs (false crawls) alternately simple and difficult. On a late receding tide, low tide, or an early incoming tide, nesting crawls would be identified and differentiated from dry run crawls by the comparative length of the approach and departure portions of the crawl. If a nest was constructed, the return crawl would be significantly longer than the approach crawl. Recent nests were also identified by their immediate destruction on many of the islands by feral hogs and raccoons. Crawl locations were plotted on maps during each flight to aid in differentiating old crawls from new.

Surveys were flown on 3-day intervals. This experimental design was based on an analysis of the intervals between consecutive visits to the nesting beach by individual turtles (Bennett and Richardson, 1977) on Little Cumberland Island. Any four consecutive flights (day 0, 3, 6, and 9) taken together form a sample unit which maximizes the number of individual turtles seen (nesting crawls) while minimizing the frequency with which the same turtle could be counted a second time on a following flight (Figure 3).

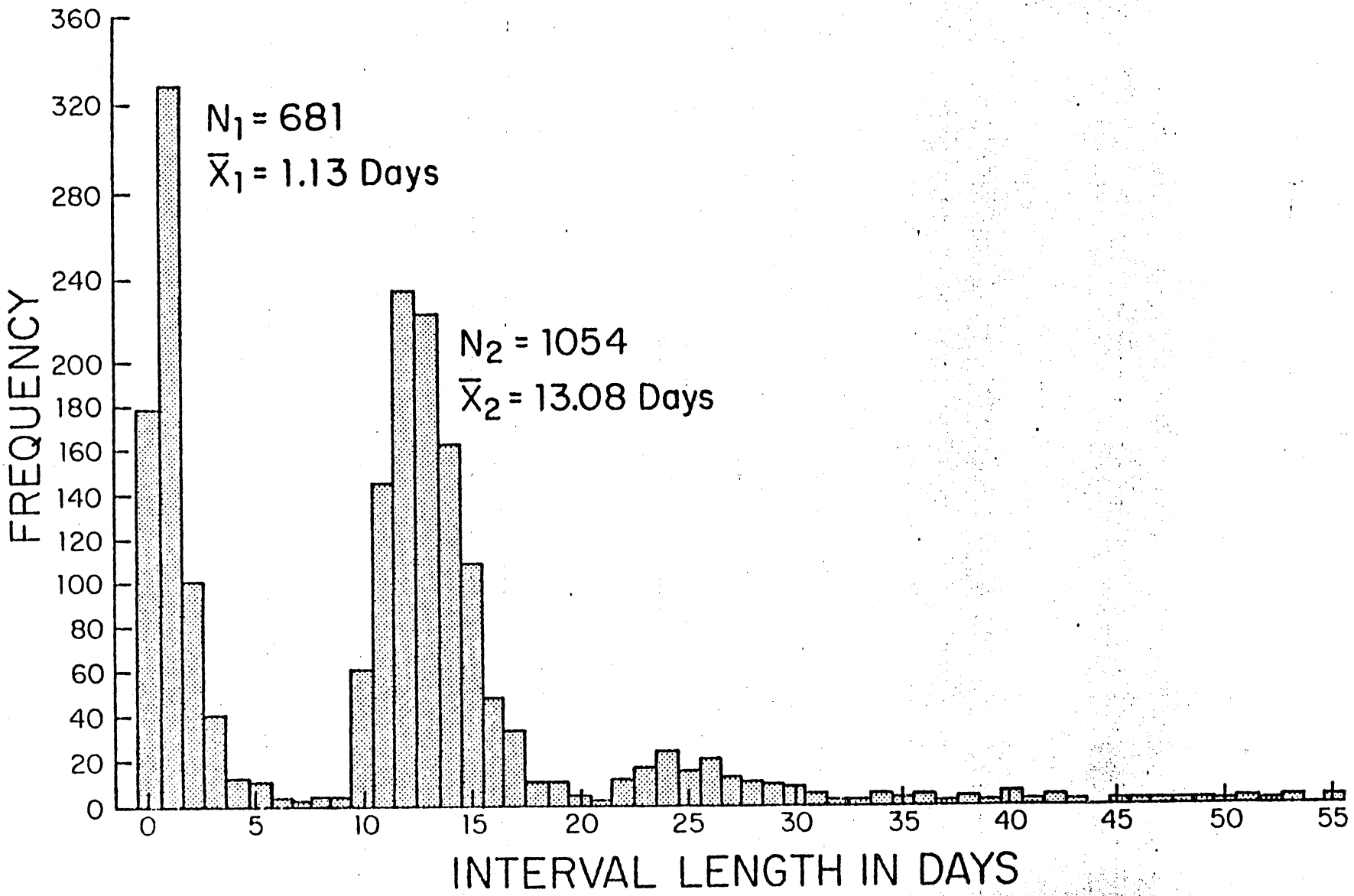

Figure 3. Elapsed days between two consecutive visits by loggerhead sea turtles on Little Cumberland Island, Georgia, 1972 - 1976. (Adapted from Bennett & Richardson, 1977).

The observers felt that the visual quality of a crawl or nest mark seen from the air was sufficiently diagnostic to be able to classify most crawls as having occurred either during the preceeding night or at least within the previous three nights. Aerial counts are compared with counts by tagging crews on the beach.

Ground Surveys

Tagging programs on the nesting beaches of five Georgia islands (Wassaw, Ossabaw, Jekyll, Little Cumberland and Cumberland) were operating concurrently with this study. The results from these five projects, as well as the complete survey of nesting activity on Blackbeard Island, have been made available to us, underlining the cooperative nature of the total research effort in Georgia. In addition, this report has been able to draw on unpublished statistics accumulated during previous years by the above mentioned tagging projects and on recent papers and scientific presentations produced by the same projects. A summary of the Georgia tagging programs may be found in Appendix VII.

IV. THE GEORGIA SHRIMPING FLEET

We have obtained from the Georgia Division of Game and Fish the records of 1388 vessels which purchased Georgia shrimping licenses for the 1976 season. The greater portion (728 craft) of these were vessels less than or equal to 20 feet in length, averaging 17.2 feet. Seven of them were registered in the state of Florida, while the remainder carried Georgia registry. We believe that almost all of these small vessels were non-commercial, the "weekend warriors" so disdained by the commercial shrimpers because of potential competition between the two groups; we did not study the non-commercial segment of the Georgia shrimping fleet because of limitations of time and funds.

Live-Bait Shrimpers

Live-bait shrimpers represent a minor component of the Georgia shrimping industry. The total number of such vessels probably does not exceed 30 craft. A summary of the information gained from interviewing 13 live bait shrimpers is contained in Table 2. The data indicate the live-bait shrimpers do not seriously conflict with sea turtles. Although eight out of thirteen individuals reported having captured a sea turtle, the estimated seasonal average was less than one turtle (.83) captured per boat. There was no turtle mortality because trawl times do not exceed 20 minutes. The size distribution of turtles captured by live bait shrimpers seems to be equally proportioned between juveniles (20"-30" carapace lengths) and larger individuals (30" carapace length).

Table 2. Summary of trawling efforts of live-bait shrimpers in Georgia, 1976, based on interviews.*

Statistic	Mean	Range
Months per year	10.1	8-12
Days Per month	22.6	10-30
Trawls per day	3.4	2.5-4.5
Minutes per trawl	12.6	5-20
Net size (feet)	19.6	15-20
Vessel Length (feet)	16.8	15-20

*Chatham Co., 7 boats; Bryan Co., 1 boat; McIntosh Co., 5 boats.

Table 3. Summary of trawling efforts of commercial shrimpers in Georgia, based on 101 interviews with captains and strikers, 1976.

County	Parameter	Shrimping Patterns: Vessel Length (Feet)	Net Width (Feet)	Month Per Year	Days Per Month	Trawls Per Day	Hours Per Trawl	Trip Length In Days
Camden	Sample	3	3	3	3	3	3	3
	Mean	53.7	58.3	7.5	24.0	4.0	2.0	2.0
	Range	48-60	55-65	7-8.5	23-25	4-4	2-2	1-4
Glynn	Sample	21	20	20	16	17	19	19
	Mean	56.5	55.4	6.3	21.8	4.0	2.1	1.5
	Range	28-75	40-80	3.9	19-27	3-5	1-3.5	1-3.5
McIntosh	Sample	29	28	25	23	24	25	22
	Mean	57.1	59.9	6.3	21.7	4.9	2.1	1.7
	Range	40-72	38-75	2.5-7	13-26	3-7.5	1.3-3	1-5
Liberty	Sample	5	5	4	4	4	4	4
	Mean	61.6	55.0	6.8	22.0	4.4	2.4	4.3
	Range	54-72	45-65	6½-7½	17-30	3.5-5	2-3	2.5-6.5
Bryan	Sample	4	3	4	4	2	4	4
	Mean	67.5	62.3	7.5	23.3	4.0	2.0	5.4
	Range	57-73	57-70	7.5-7.5	18-25	4-4	2-2	3.5-6
Chatham	Sample	39	39	35	31	36	39	38
	Mean	56.1	54.2	6.9	22.5	4.5	2.1	2.1
	Range	16-81	30-75	3.5-8	14-26	3.5-6	0.3-3	1-6
Total	Sample	101	98	91	81	86	94	90
	Mean	57.1	56.5	6.7	22.2	4.5	2.1	2.1 x 321 boats
	Range	16-81	30-80	2½-9.0	13-30	3-7½	0.3-3½	1-6½

7 mnt = 10

Dead nut # = 993

451,195 hrs.

18,800(24 sh. day) × CPUE = × .528

CAUGHT = 9,926

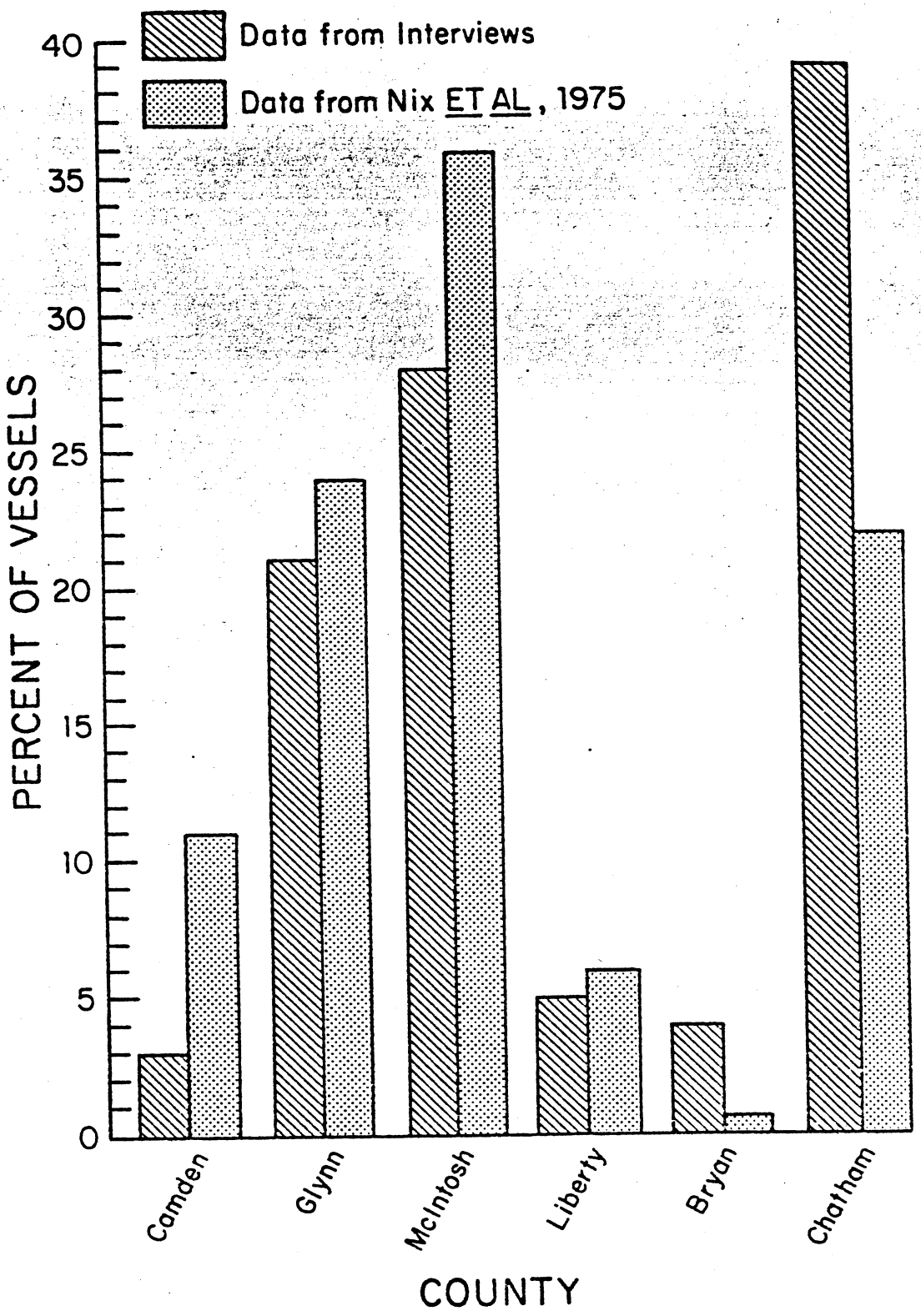

Figure 7. Distribution by county of 104 vessels contacted by interview compared to 307 vessels surveyed by Nix et al, 1975.

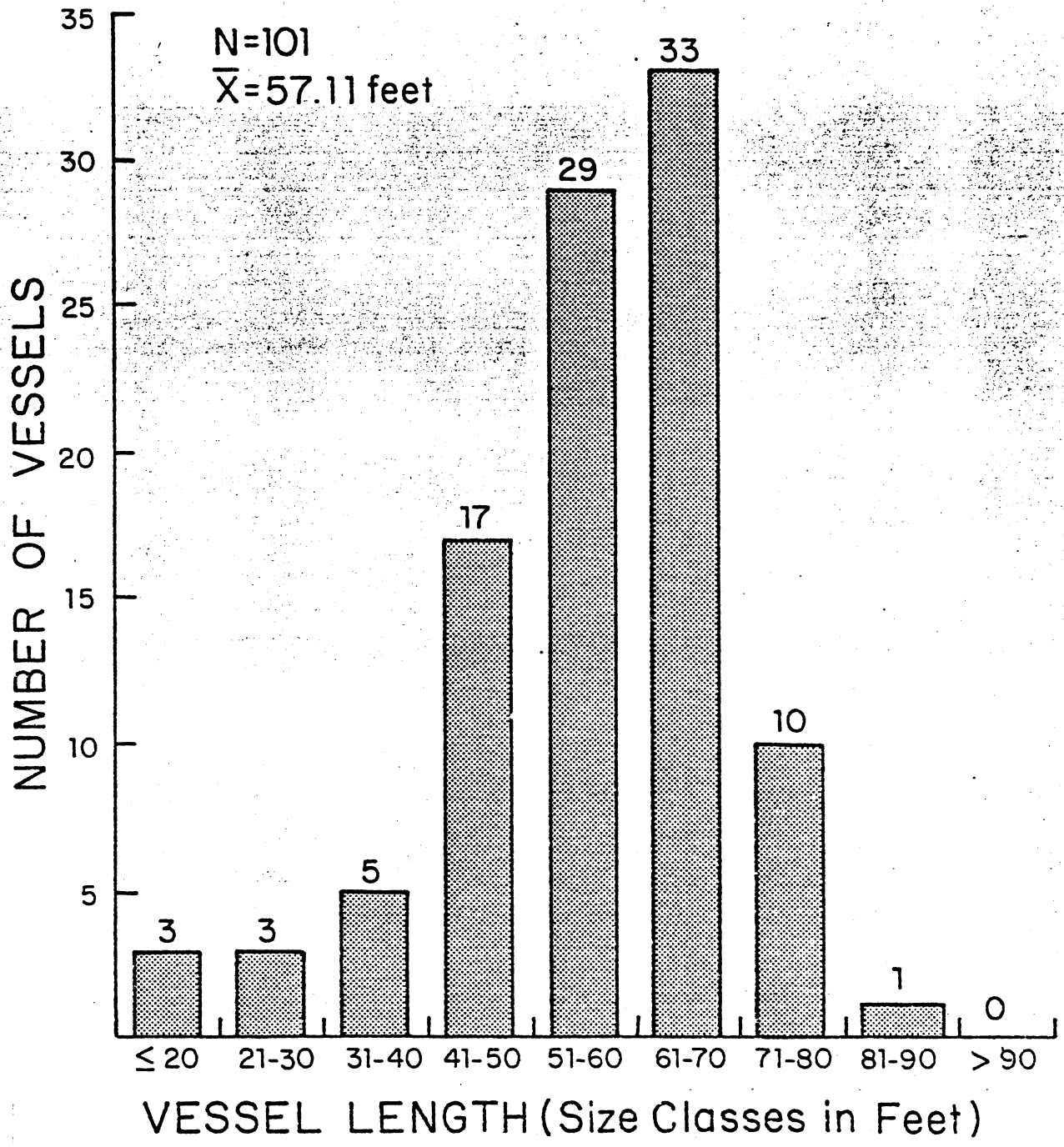

Figure 6. Distribution by length of 101 vessels contacted by interview.

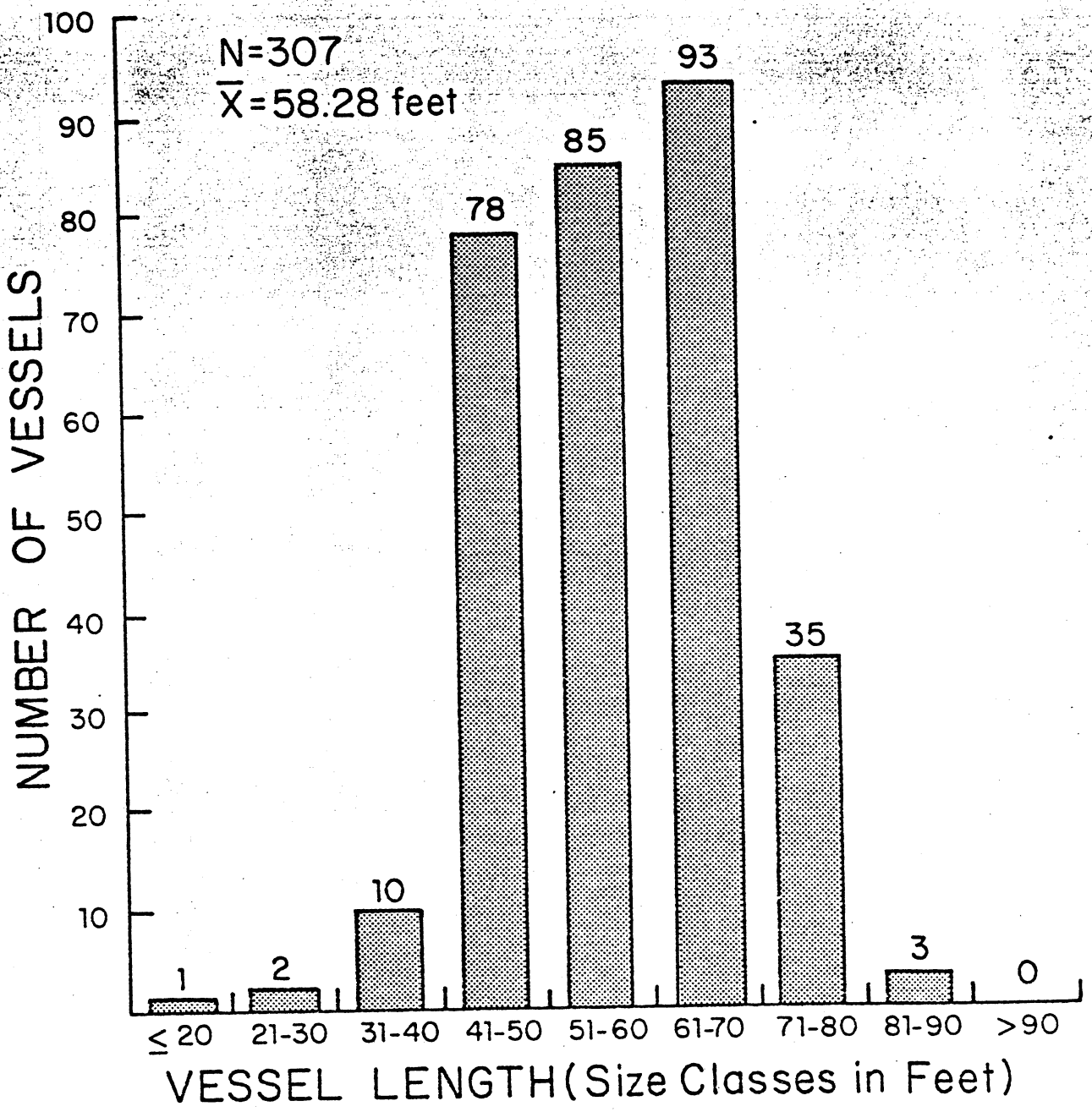

Figure 5. Distribution by length of 307 vessels contacted by Nix et al (1975) survey.

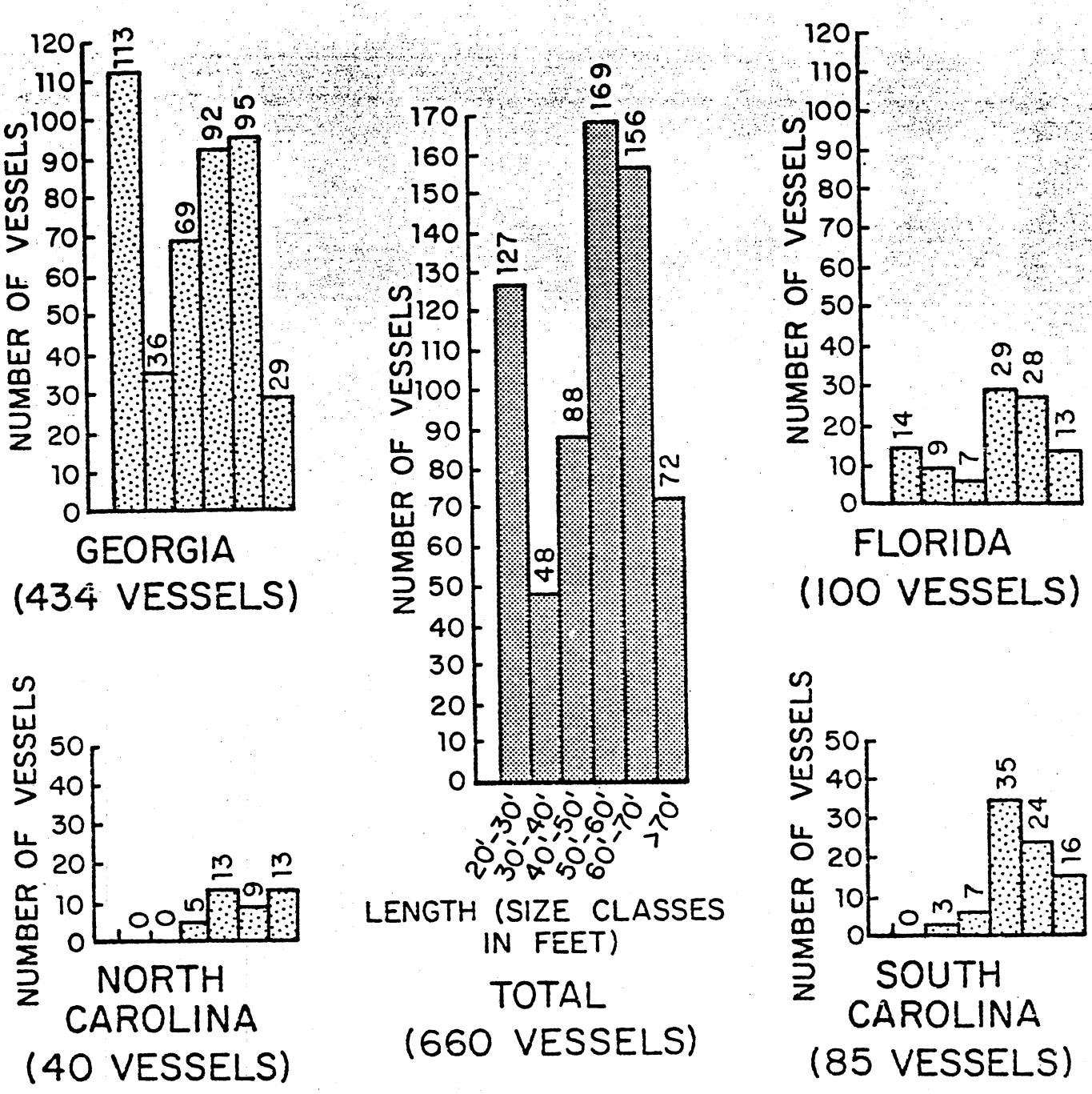

Figure 4. Distribution by length of vessels receiving shrimping licenses for Georgia, 1976. (Includes one vessel from Virginia).

Hillestad et al 1977

None of the shrimpers interviewed has ever captured a turtle with carapace length less than 20", even though the live-bait shrimper frequently trawls in small tidal creeks. No species of sea turtle other than the loggerhead have been identified, and no tagged adult females have been encountered.

Commercial Shrimpers

The survey by Nix et al (1975) listed 307 commercial shrimpers that off-load at the major commercial shrimp docks in Georgia, 1975. Nix's survey, which contained data from three vessels less than 30 feet in length, is comparable to the length distribution of 321 vessels of Georgia registry, larger than 30 feet in length, which purchased Georgia commercial shrimping licenses in 1976 (Figure 4). The Nix survey did not consider vessels with an out-of-state registry, although 226 such boats greater than 20 feet in length (Figure 4) purchased Georgia shrimping licenses in 1976. Note that the distribution of vessel lengths in the Nix survey (Figure 5) compares favorably with a similar distribution of the 104 vessels contacted during our interviews of captains and strikers (Figure 6). The distribution of interviews by county (Figure 7) may also be compared to the Nix et al (1975) survey. Our distribution may over-represent Chatham County shrimpers while under-representing McIntosh and Camden Counties, relative to the Nix survey. A complete listing of the shrimping activity patterns by each of the 103 individual vessels is contained in Appendix II.

Shrimping Patterns

Shrimpers who represent a category of commercial craft greater than 30 feet in length estimate that they fish 22 days per month (Table 3). Our survey of dock records in Chatham

County (Table 4) during August and September of 1976 indicates that those interviewed represent a more active portion of the fleet than normal, that a number of boats spend a great deal of inactive time at the dock, and that activity correlates closely with season. The sample represents 83 vessels from 7 commercial docks in Chatham County, Georgia, 1976.

Because of the high mortality suffered by Georgia shrimp during the winter of 1976-1977, the 1977 season is not representative of normal shrimping activity in Georgia waters. Near-shore waters were not opened until 6 July. On three flight days prior to this date (Figure 8), an average of 51 boats were observed, corresponding to a monthly activity rate for a hypothetical 300 vessel fleet of five days per month per boat for May and June (vessels $\geq$ 30 feet in length). Many of the Georgia boats were fishing out-of-state or were inactive during this time. During eight flight days after inshore waters were opened to within 1,000 feet of the beach, an average of 117 boats were observed for an activity estimate (300 vessel fleet) of 12 days per month per boat during July. The high count of 189 vessels on 6 July would correspond to a 19 days per month per boat activity rate.

When Georgia sounds are opened to shrimping, as in 1976, there is a surge of activity which rapidly dwindles as the shrimp population is depleted within the area. On 4 October, the opening morning of the 1976 season, 175 boats were active in St. Andrew Sound. Seventy-five boats were active on the following morning, but by 1500 hours of the same day, only five boats were still in the area. On the initial day of an open sound season, the number of out-of-state trawlers may swell the Georgia fleet by 50 per cent.

Trawl time, the elapsed time that a shrimp net remains submerged, is a critical statistic in considering sea turtle mortality. Live bait shrimpers deploy their nets for less

Table 4. Commercial shrimping activity based on dock records (number of days per month that commercial shrimp vessels were away from the dock) Chatham county, Georgia, August and September, 1976.

	August	September	Average
Mean days of activity/month	14.4	19.5	17.0
Range of activity (days/month)	0-30	0-30	0-30
Sample size (Boats)	82	83	82.5

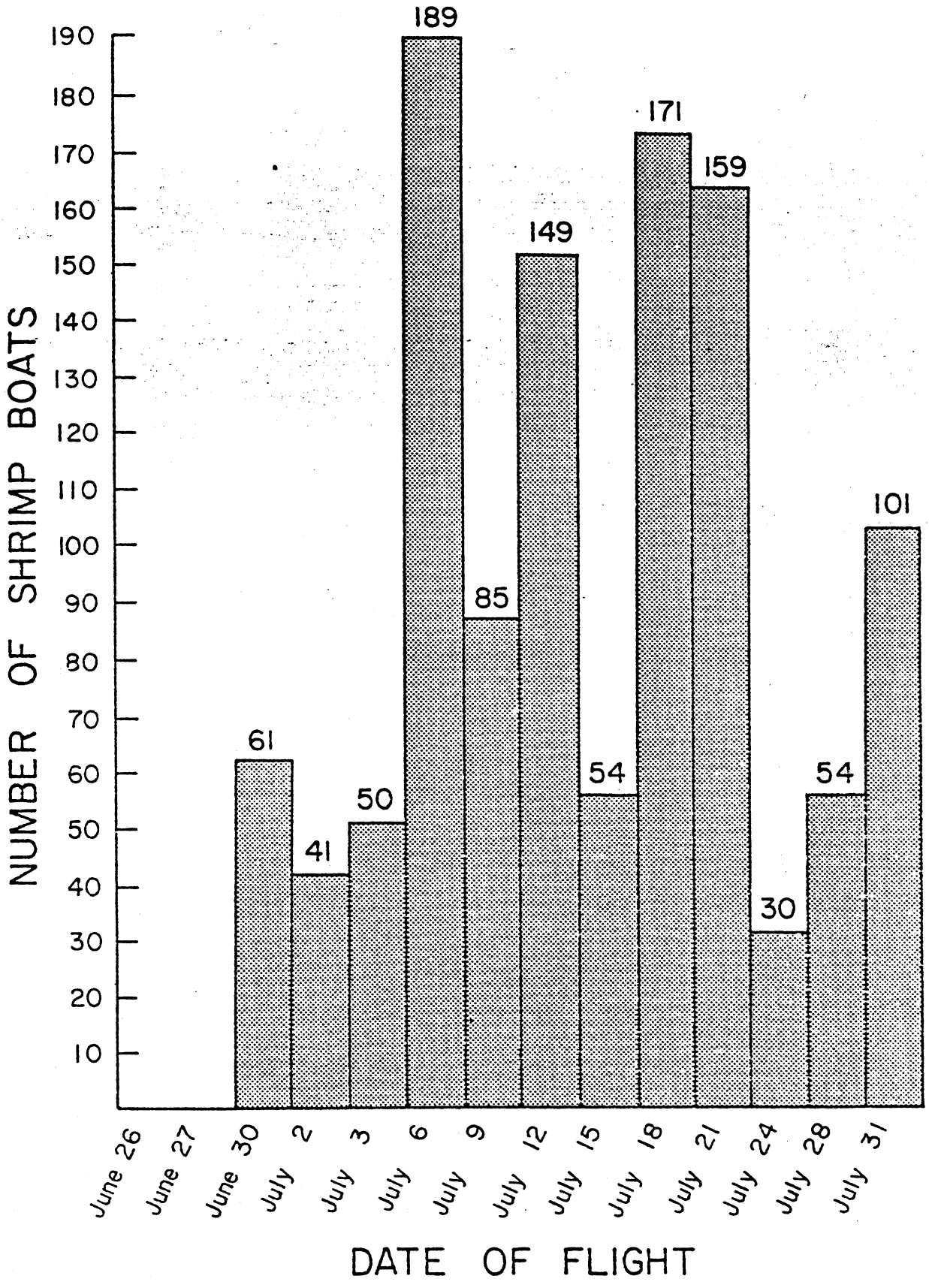

Figure 8. Aerial count of commercial vessels shrimping on the Georgia coast, 30 June - 31 July, 1977.

than 20 minutes at a time; turtles they capture do not experience mortality. Live bait shrimpers do not, therefore, constitute a threat to turtle populations in Georgia, since almost all mortality is a function of drowning.

The estimate of trawl time from interviews of captains and strikers representing commercial boats was 2.1 hours per trawl (sample of 94 boats). Estimates ranged from one hour to 3.5 hours per trawl. In contrast, a mean of 2.6 hours per trawl, with a range of 1.2 to 4.2 hours, was recorded during on-board observations in 1976 of five boats and 19 trawls.

Because of the unusual and unpredictable nature of the Georgia shrimping season in the last two years, we have been unable to accumulate sufficient observations on captured turtles to relate the average physiological condition of captured turtles to trawl time. Therefore, the significance of the 30 minute difference between the estimated and the observed trawl times to turtle mortality remains speculative. We have evidence (Figure 9) that average trawl time is a function of vessel length and is maximum and approximately equal for all vessels over 40 feet in length. We do not know the trawl times preferred by the non-commercial shrimping vessels.

Using the data from Table 5 and assuming an average vessel speed of 3 MPH under load (D. Harrington, pers. comm), the total area trawled in Georgia yearly by a 300 vessel fleet would be equivalent to a circular area with a diameter of 185 miles (27,074 square miles) (Figure 10). The average commercial shrimp boat would trawl a 388 acre area per day. These figures do not consider repetitive drags in the same area, but they should demonstrate the magnitude of the trawling effort expended annually on the coast. Very simply, these data indicate that the incidental capture of sea turtles is a function of a very large effort by trawlermen to harvest shrimp.

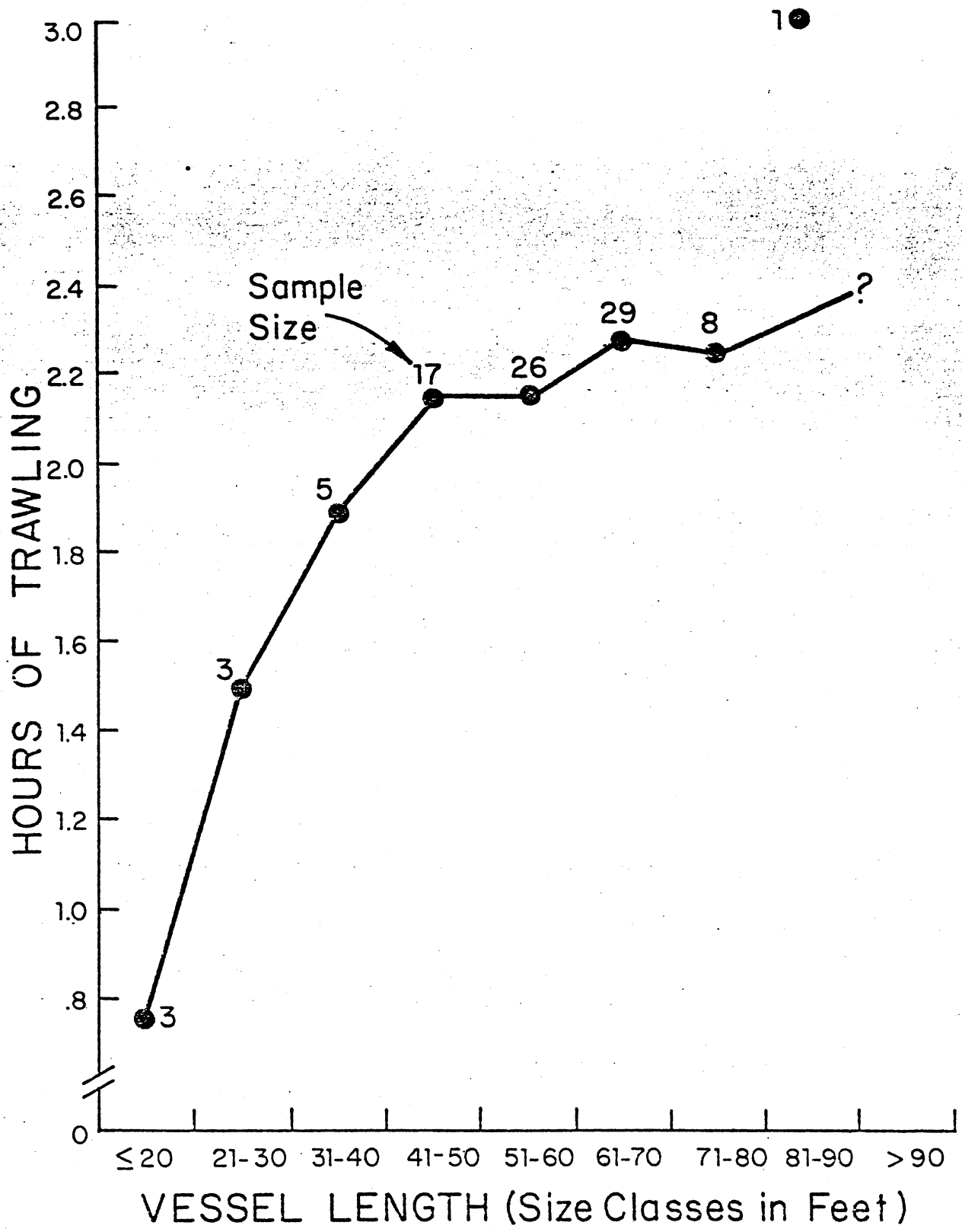

Figure 9. Relationship between shrimp vessel length and hours per trawl.

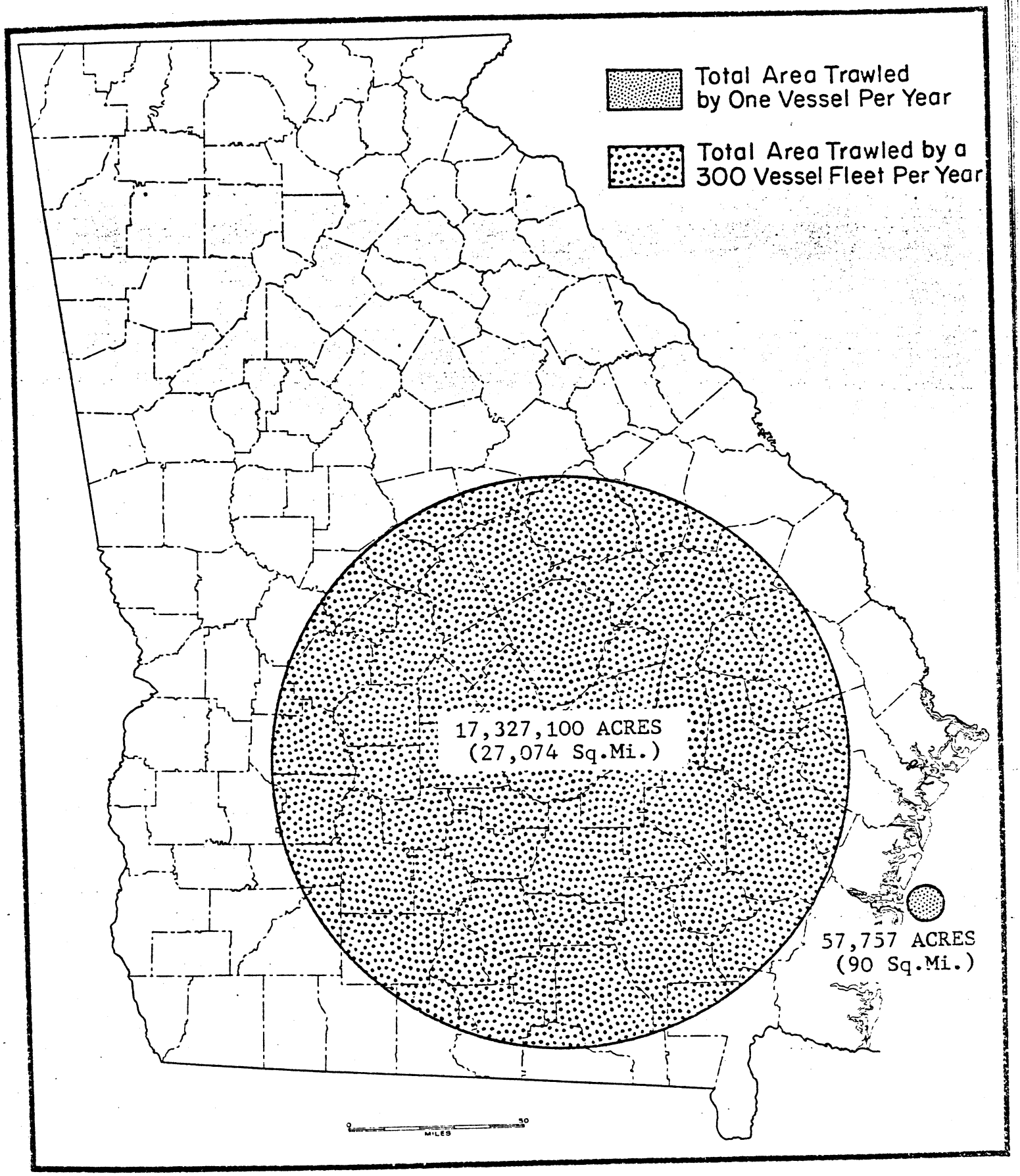

Figure 10. Equivalent area trawled by 300 vessel fleet and single vessel, per year in Georgia.

Table 5. Shrimping activity patterns in Georgia waters by a 300 vessel commercial fleet (vessels greater than thirty feet in length).

Category	Estimates
Vessels in fleet	300
Months in season	6.7
Trawl per month	22.2
Trawls per day	4.5
Hours per trawl	2.1
Total trawling time per year	4.2×10^5 hrs.

V. SEA TURTLES AND THE GEORGIA SHRIMPING INDUSTRY

The total number of turtles captured in trawl nets is the best possible estimate of potential conflict between sea turtles and the shrimping industry. Table 6 summarizes the information gained from our interviews with captains and strikers, representing 103 commercial shrimp boats. Responses listed by individual vessels may be found in Appendix II.

Loggerheads represent most, but not all, of the sea turtles captured by shrimpers in Georgia waters. The Ridley sea turtles resemble loggerheads and undoubtedly are identified as such by most shrimpers. We estimate that loggerheads make up at least 90 percent of turtles captured by trawlers and that Ridleys represent the majority of the remaining animals. When applicable, we specify loggerhead when we include only this species in a statistic. Specific information on the other species of sea turtles is summarized in Chapter 8.

Numbers of Turtles Captured:

Figure 11 gives minimal estimates of turtles captured (total numbers and numbers per boat) in 1975 as reported in our interviews (Table 6). Figure 12 provides similar information for 1976. Several observations can be made from a comparison of data from these two years.

A minimal estimate of 1595 turtles, caught by 52 boats in 1975, is equivalent to 30.7 turtles captured per boat. Using Nix's et al (1975) estimate of 307 vessels, an estimated 9417 turtles were captured by commercial shrimpers in 1975.

Table 6. Estimates of loggerhead sea turtles captured by Georgia shrimp vessels, based on 101 interviews with captains and strikers, 1975 and 1976.

County	Parameter	Percentage Per Size Class 20" - 30"	Percentage Per Size Class 30"	Total Individuals[1] 1975	Total Individuals[1] 1976	Percentage of Catch Which Dies	Percent Contact With Tagged Adults[2]
CAMDEN	Sample	2	2	2	1	3	3
	Mean	62.5	37.5	42.5	20.0	3.7	67
	Range	25-100	0-75	35-50	20-20	0-6	--
GLYNN	Sample	19	19	13	11	15	20
	Mean	59.1	40.9	33.5	36.1	10.7	25
	Range	5-100	0-95	1-100	1-100	0-50	--
McINTOSH	Sample	13	13	8	22	13	29
	Mean	48.8	51.2	29.3	11.5	6.9	3
	Range	0-100	0-100	9-45	3-30	0-25	--
LIBERTY	Sample	3	3	0	5	3	5
	Mean	11.0	89.0	--	7.8	3.3	20
	Range	0-33	67-100	--	6-10	0-10	--
BRYAN	Sample	4	4	1	2	2	4
	Mean	75.0	25.0	10.0	17.5	5.0	0
	Range	25-100	0-75	10-10	15-20	0-10	--
CHATHAM	Sample	36	36	28	33	22	39
	Mean	54.9	45.1	29.6	14.7	8.0	8
	Range	0-100	0-100	1-100	1-50	0-40	--
TOTAL	Sample	77	77	52	74	58	100
	Mean	54.5	45.5	30.7	16.6	7.9	12
	Range	0-100	0-100	1-100	1-100	0-50	--

[1]Minimal estimates.

[2]Percentage of interviews reporting a previous capture of a tagged turtle.

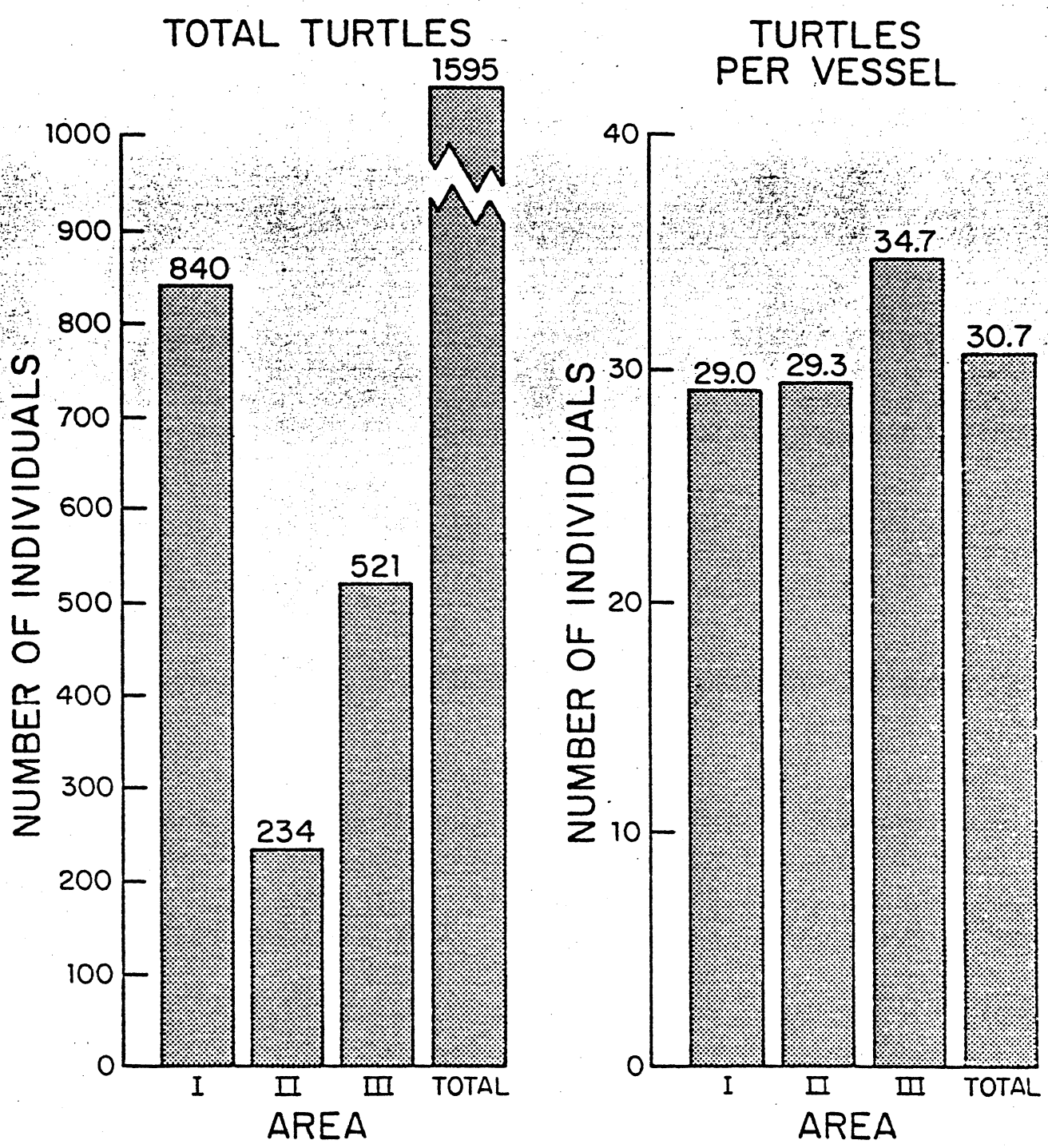

Figure 11. Minimal estimates of total turtles captured by shrimpers based on interview data, 1975.

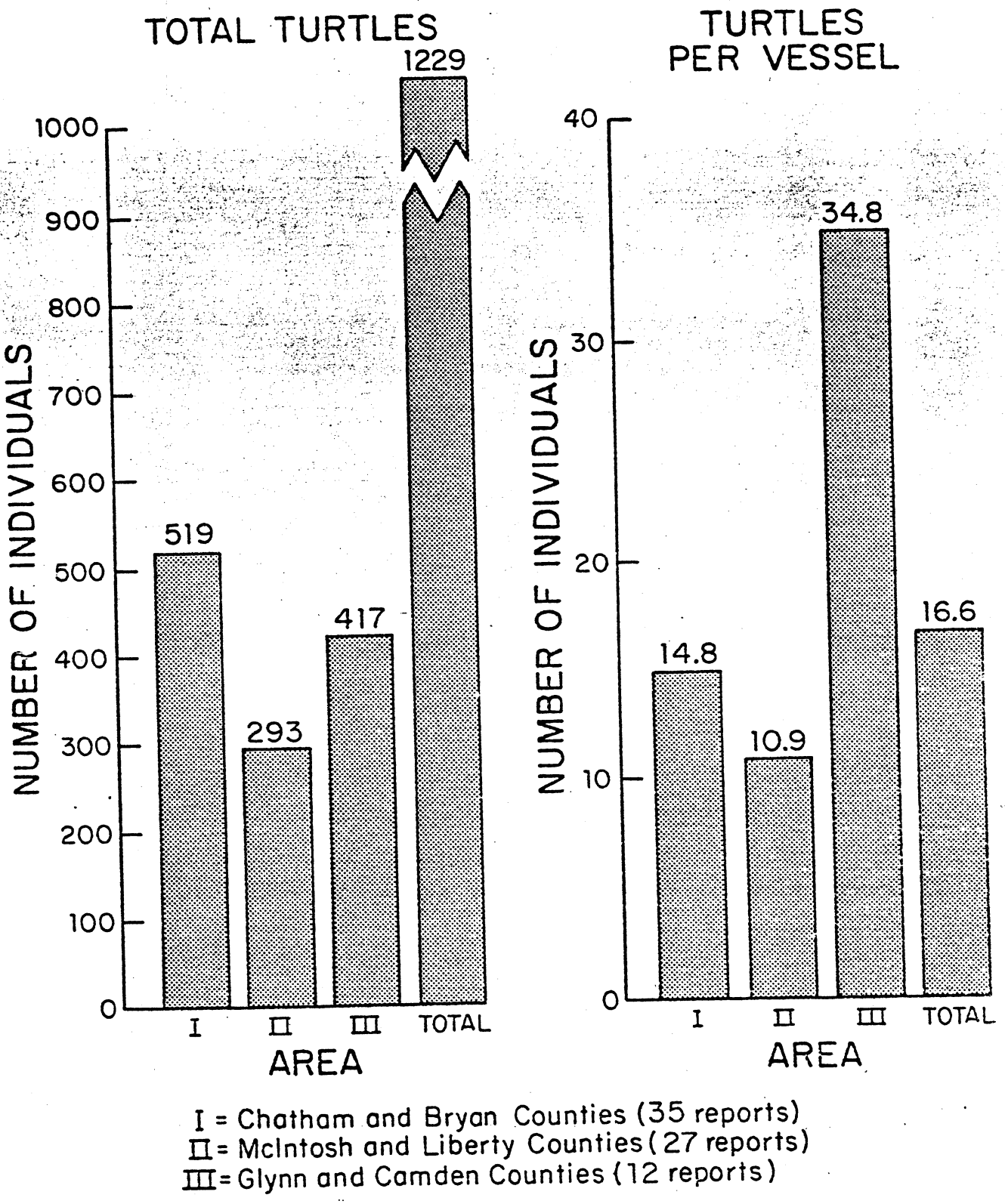

Figure 12. Mid-season minimal estimates of total turtles captured by shrimpers, based on interview data, 1976.

The majority of McIntosh and Liberty interviews were conducted between 5 August and 21 August, 1976. As of that date, the 1976 estimate of turtles caught per boat was approximately one third of the 1975 seasonal total. Chatham and Bryan County shrimpers interviewed between 3 September and 12 October, experienced a 1976 capture rate per boat of approximately one half of the 1975 estimate. In Glynn and Camden Counties, representing boats which fish primarily in St. Andrew Sound, the estimated number of turtles caught per boat in 1976 was three times the number captured in other areas of Georgia at that time and equalling the 1975 total, despite the fact that many interviews were conducted as early as the fourth week of August, well before the end of the season. The unusually high estimates were caused by a number of boats reporting as many as 50-100 turtles captured in 1976. This large reported capture may reflect a hatchery program on Little Cumberland Island (south side of St. Andrew Sound) which has released 6,000 to 10,000 hatchlings annually since 1965.

During on-board observations in July and August of 1976, we recorded the captures of four turtles in 19 trawls averaging 2.6 hours per trawl (Appendix III). This rate is equivalent to .21 turtles per trawl (approximately one turtle per five trawls). The estimate of 30.7 turtles per boat per year obtained from our interviews is equivalent to .06 turtles per trawl or one turtle per 16 trawls (Table 5).

Obviously, the number of turtles captured by shrimp boats varies with season. On 4 October, 1976, 140 vessels in St. Andrew Sound captured seven loggerheads (Appendix IV). One of the seven turtles was recaptured the same day and a second turtle recaptured the following day. Such a recapture rate indicates that virtually all the turtles present in St. Andrew Sound on that particular day were captured by one or another of the trawlers.

The delayed opening of the sounds in 1976 to commercial shrimping occurred after water temperature began to drop and apparently after most of the turtles had moved out of the area; many more turtles would probably have been captured if the sounds had been opened on 1 September instead of 4 October. Thus, the average number of turtles captured per trawl probably varies from one turtle per trawl to one turtle per 100 trawls, depending on season and location; we estimate a minimal seasonal average of one turtle captured per 16 trawls.

Figure 13 summarizes the frequency of capture by net size (width of opening). Most boats pull two matching nets. Glynn County figures have not been included in this figure since a few of the Glynn registry boats were reporting unusually large numbers of turtles being captured in St. Andrew Sound during the 1976 season, confounding the relationship beween net size and total turtles captured. Figure 13 indicates that nets with widths less than 41 feet catch significantly fewer turtles than larger nets. The impact on turtles seems about the same for nets in the 51-75 foot range. Nets in the 41 to 50 foot range appear to be intermediate in effect.

Sizes of Turtles Captured

An analysis of the sizes of turtles captured by trawlers is important to assess that portion of the turtle's life cycle being impacted by trawlers. Using cardboard silhouettes as visual guides, boat captains and strikers were asked in interviews to estimate sizes of captured turtles according to three size classes: less than 20 inches (straight carapace length), 20-30 inches, and greater than 30 inches. The categories were intended to indicate a juvenile class, a subadult class, and an adult (potential breeder) class. Ehrhart (1976), reported that the average carapace (straight line) length of a nesting female loggerhead in Florida was 36 inches, with a range of 31 - 43 inches.

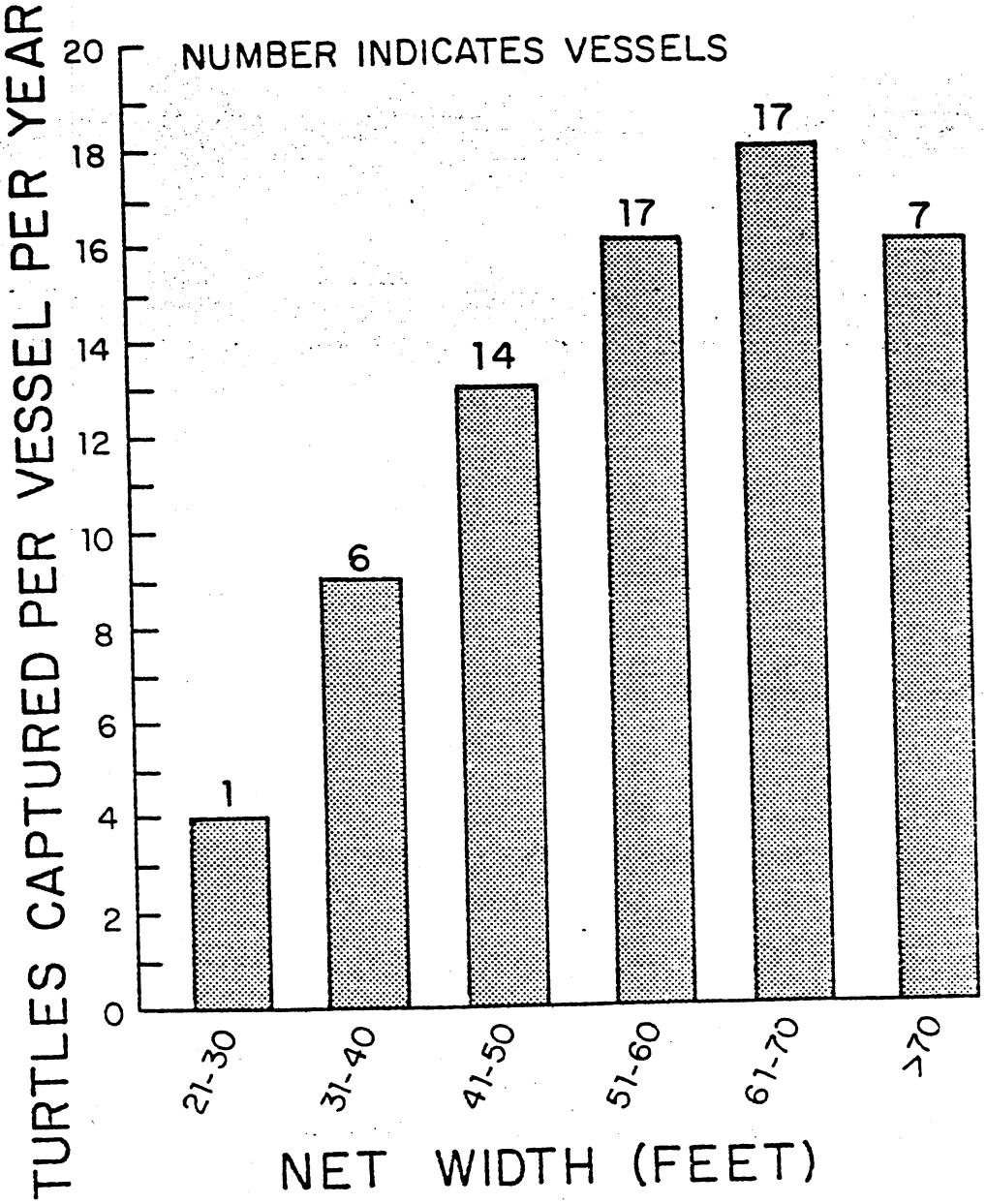

Figure 13. Frequency of turtle captures by net size.

Estimates by shrimp boat-personnel vary in the proportions of captured individuals accorded to each size class. Averaging over all interviews, total turtles captured in the 20 - 30 inch range are approximately equalled by those in the greater than 30 inch range. Shrimpers in McIntosh and Liberty Counties (Figure 14) apparently contact a greater portion of turtles in the greater than 30 inch carapace length class than do shrimpers in the other counties. Most striking is the total absence of reports from all counties of loggerhead turtles less than 20 inches. The only loggerhead turtles of less than 20 inches carapace length which were observed during this study occurred in the Brunswick River near seafood processing factories. There is a major discontinuity in the distribution of the various size classes along the Georgia coast, with small turtles (less than 20 inches) being virtually absent from the sounds and offshore areas. Hatchlings, once they leave the nesting beach, are not captured or seen until they appear with carapace lengths of approximately 20 inches in coastal rivers and creeks.

There is a wide discrepancy among interviews as to when turtles of a particular size class are most frequently captured, primarily because breeding adults and nonbreeding juveniles in the greater than 30 inches carapace length range were not distinguished in the interviews. If a concensus does exist, it is that large turtles are captured from April to June while small turtles (carapace 20 - 30 inches) capture or peak in spring and fall. Some captains report the latter turtles are taken year around.

Eighteen loggerheads were measured during on-board observations (Appendix IV); a summary of the average size of these individuals is contained in Table 7. All but four of the turtles described in Table 7 were captured between 27 September and 5 October, 1976. One individual, a male, was probably an adult (carapace length 39 inches).

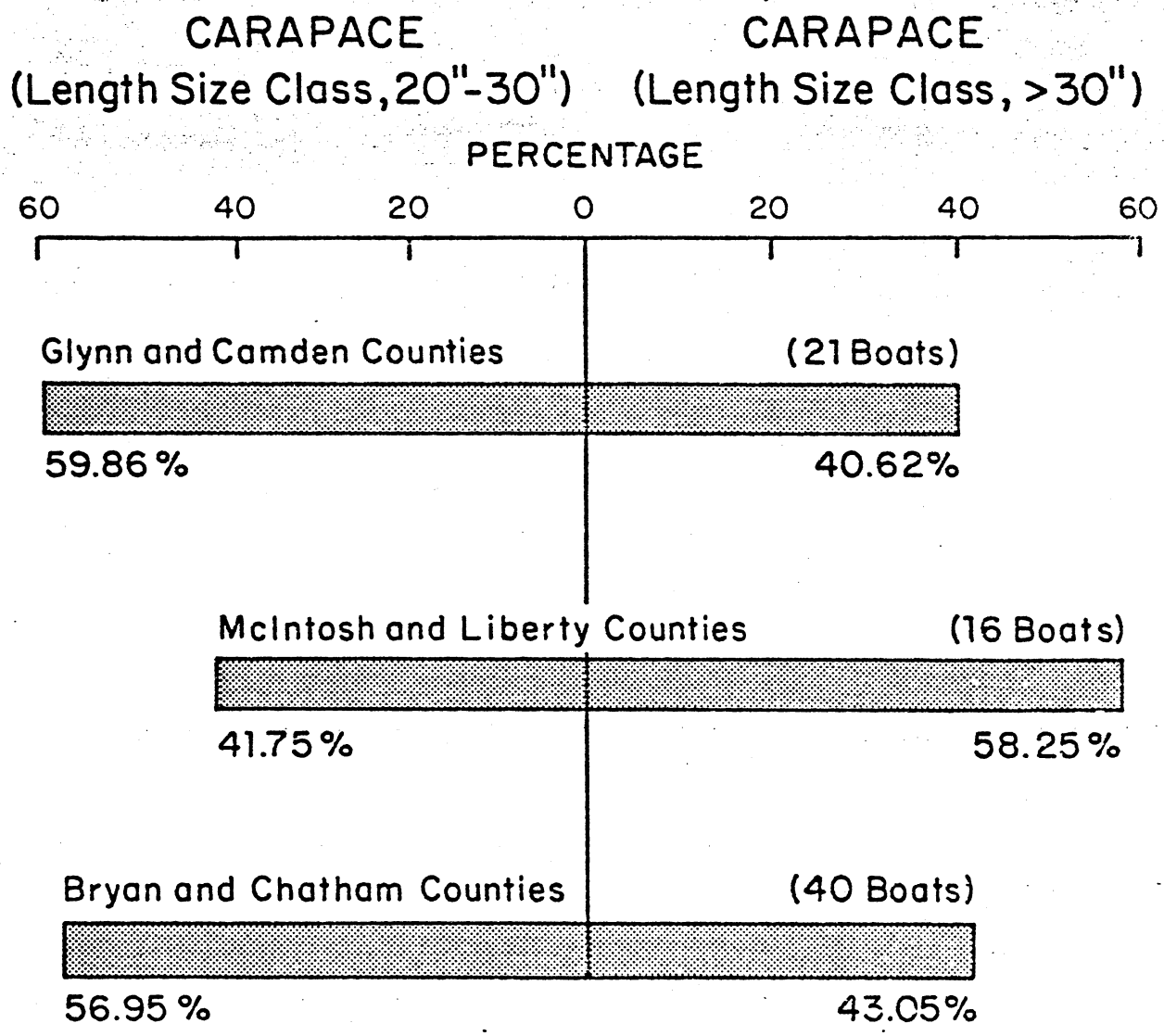

Figure 14. Size classes of captured turtles by coastal region.

Table 7. Measurements of loggerheads captured during on-board studies, Georgia, 1976.

Size Class (Inches)	Individuals	Carapace		Plastron	
		Length	Width	Length	Width
20 - 30	17	23.7	20.2	18.7	17.4
>30	1	39	28	28	26

The remaining 17 individuals seem to represent a typical class of young turtles which frequently appear in shrimp nets. The smallest individual had a carapace length of 19.7 inches. The largest individual in the 20 - 30 inch size class had a carapace length of 29.0 inches. It is quite possible that many of the individuals thought by shrimpers to belong to the 30 inch catagory are close to this largest individual in size and, therefore, part of a predominant subadult size class ranging in carapace length from 20 - 30 inches.

Shrimper Contact with Breeding Adults

Our best estimate of the impact of shrimpers on breeding female loggerheads comes from an analysis of tag returns. Table 8 summarizes the response from interviews when shrimpers were asked if they had ever captured a tagged turtle. Slightly less than 4 percent of shrimpers reported having ever seen a tagged turtle at some time in their career. Seven out of 23 shrimpers (30 percent) from Glynn and Camden Counties recalled seeing a total of eight tagged turtles at some time in the past. This number (high, relative to other areas of the State) probably reflects the thousand turtles tagged in the vicinity of St. Andrew Sound since 1964.

Reference to only eight tagged turtles in the St. Andrew area corroborates the fact that only six tags have ever been returned for reward by shrimpers from the same area and only eight tags from all of Georgia from a thousand turtles tagged. Apparently few breeding adults are being captured by shrimpers in the vicinity of the nesting beaches. The vast majority of turtles captured annually by shrimpers are juveniles and subadults.

Table 8. Percent of commercial vessels capturing tagged adult female loggerheads (responses per interview sample in parentheses) and total number of tagged animals captured on the Georgia coast.

County	Percentage of shrimpers having ever captured tagged female	Percentage of shrimpers catching tagged female, 1976	Total tagged females for all year
Chatham, Bryan	7.7(3/39)	5.1(2/39)	3
Liberty, McIntosh	6.9(2/29)	6.9(2/29)	4
Glynn, Camden	30.4(7/23)	8.7(2/23)	8
Total	13.2(12/91)	6.6(6/91)	15

Distribution of Sea Turtles on the Georgia Coast

Species such as sea turtles are rarely distributed evenly within their range. Therefore, the location and description of high density turtle zones should receive a high priority in the development of long range management plans for this group of marine reptiles.

Shrimp boat captains and strikers were unanimous in reporting the existence of zones of high turtle density but differed greatly on specific locations, frequently contradicting one another's testimony. Their answers reflect considerable bias as to home port as well as preferred habitat for dragging. Figure 15 lists the cumulative number of actively deployed, commercial craft observed during the aerial survey, distributed according to major sounds. This distribution may be compared to the shrimper's responses.

Opinions concerning high density turtle areas within the southern coastal region (Brunswick, St. Mary's, Fernandina) were diverse and evenly divided, including sounds, off-shore areas, "near the nesting beach", and river channels. Several vessels reported unusually high numbers of turtles captured during 1976 within the Brunswick River Channel, a popular area for shrimpers (St. Simons Sound in Figure 15). At least three captains reported visual observations of large numbers of small turtles in the Brunswick River near the seafood processing factories. (This aggregation of juvenile turtles may provide an unbelievably valuable opportunity for capturing, tagging and studying the age classes most severely impacted by the shrimping industry.)

Individual captains from the central coastal region (Darien, Valona, Sunbury, Richmond Hill) experienced a high incidence of turtles captured in a variety of habitats, including channels, sounds, off-shore, "on the beach", and flats. Preferred habitats for dragging undoubtedly biased individual opinions, and there was no concensus among the captains.

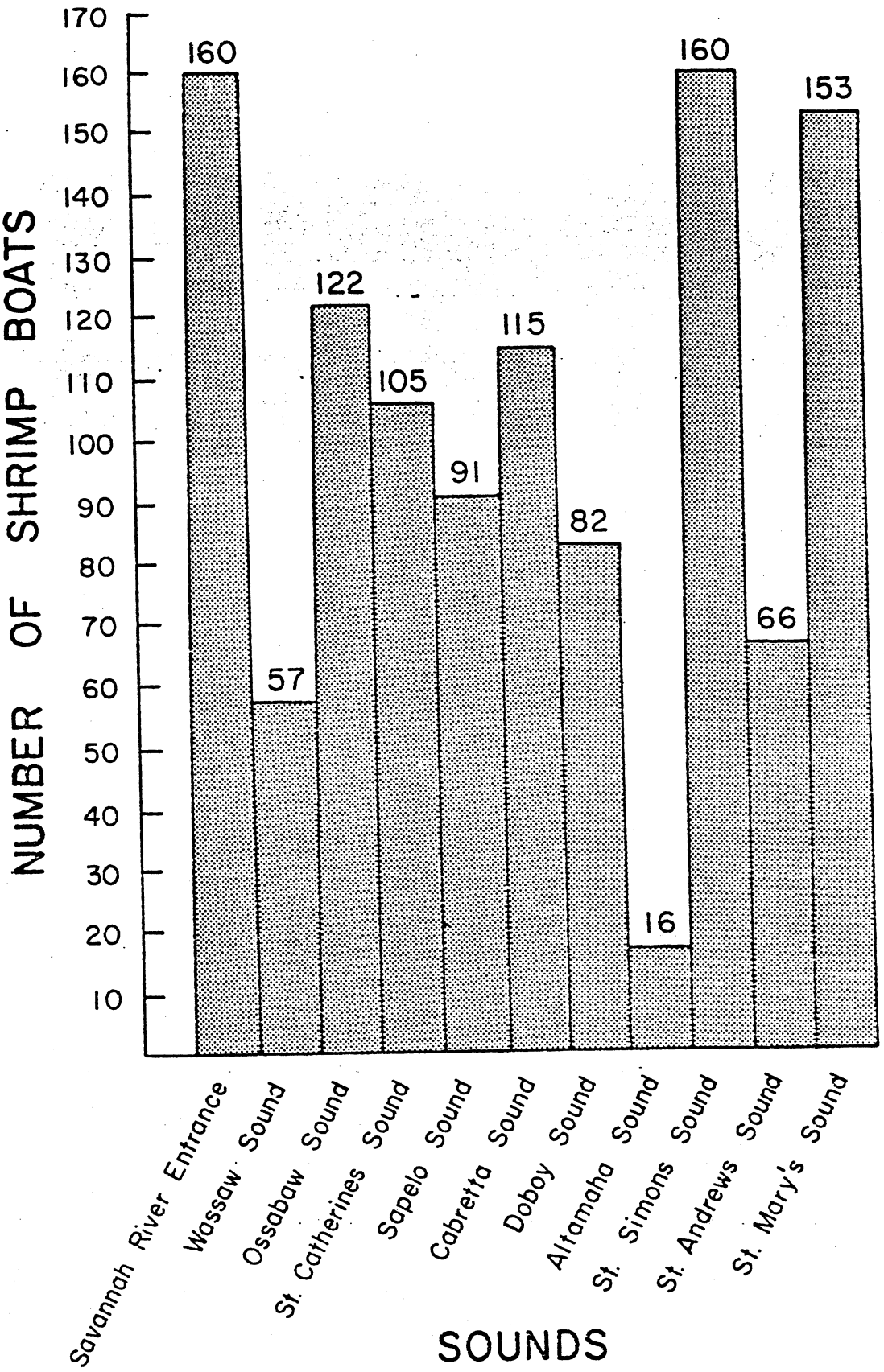

Figure 15. Distribution of shrimp vessel activity by sound, Georgia coast, 27 June - 31 July, 1977, from aerial surveys.

At least two thirds of the captains from the northern coastal region (Savannah, Thunderbolt) specified the Savannah River Channel as an area where sea turtles are most frequently captured. This channel extends from the mouth of the Savannah River to a point several miles offshore and evidently represents a zone of concentrated turtles. Within Ossabaw Sound, the Hole-In-the-Rock Channel was identified by a number of individuals as another important zone of concentration for turtles.

We have been unable to clearly delineate zones of turtle concentrations and areas where shrimpers spend most of their time, and therefore, where shrimpers catch most of their turtles. Large concentrations of turtles and shrimp may occur together, particularly in the deeper channels or holes where a richer variety of food may be available to both organisms. Certain areas, such as the Savannah River Channel, "Hole-In-The-Rock" Channel, and Brunswick River Channel, are clearly areas of high turtle concentrations and are heavily trawled shrimping waters.

Along most of the coast there are no easily defined areas of concentration, although all captains recognize areas where the incidence of turtle capture is high. Additional studies will be required to define boundaries of areas of turtle concentrations.

Table 9. Estimates of turtle mortality for 58 vessels in Georgia, 1976.

	County			
	Chatham, Bryan	McIntosh, Liberty	Glynn, Camden	STATE
Total dead turtles	15	16	41	72
Dead turtles per boat	2.5	1.6	3.2	2.5
Mean percent	2.7	6.3	9.5	7.9
Number of vessels in sample	24	16	18	58

Table 10. Estimated percentage mortality of sea turtles (vessel number in parentheses) according to disposition of turtles.

County	Percentage mortality of turtles temporarily kept on board	Percentage mortality of turtles immediately released	Total
Camden, Bryan	3.2(10)	3.3(3)	3.2(13)
McIntosh, Liberty	7.7(3)	2.5(2)	5.6(5)
Glynn, Camden	8.9(6)	4.0(2)	7.7(8)
Total	5.7(19)	3.3(7)	5.1(26)

VI. TURTLE MORTALITY AND THE SHRIMPING INDUSTRY

Interviews with Shrimpers and Strikers

Fifty-six out of 104 captains and strikers responded to the mortality question, from which we calculated a mean estimated mortality rate of 7.9 percent of all captured sea turtles (Table 9). Twenty-two of these 56 shrimpers (39 percent) stated that they had never seen a dead sea turtle in their nets. The actual mortality experienced by captured sea turtles in Georgia may approximate a normal distribution with a mean of about ten percent loss per boat per year (Figure 16).

Responses to questions on mortality estimates were also analyzed in terms of individual turtles per year rather than percent loss of the catch. Twenty-nine shrimpers responded in terms of total turtles captured and killed. Most were referring at the time to the incomplete 1976 season (Table 9). Results for Glynn and Camden Counties reflect the higher incidence of turtles caught in 1976 in these two counties (Figure 12). Since the 1976 season was incomplete at the date of the interviews, we suggest that the statewide average estimate of 2.5 turtles detected dead in the nets per boat might have risen to 3 dead turtles per boat by December. The independent estimates of approximately 10 percent mortality (Figure 16) times 31 turtles captured per boat per year (Figure 11) indicates a mortality rate of about 3 turtles per boat per year. In both instances, individuals stating that they did not observe any dead turtles in their nets were not considered. (If such individuals (23) are included in the sample, the estimated annual rate in Georgia drops to 1.4 dead turtles per boat.)

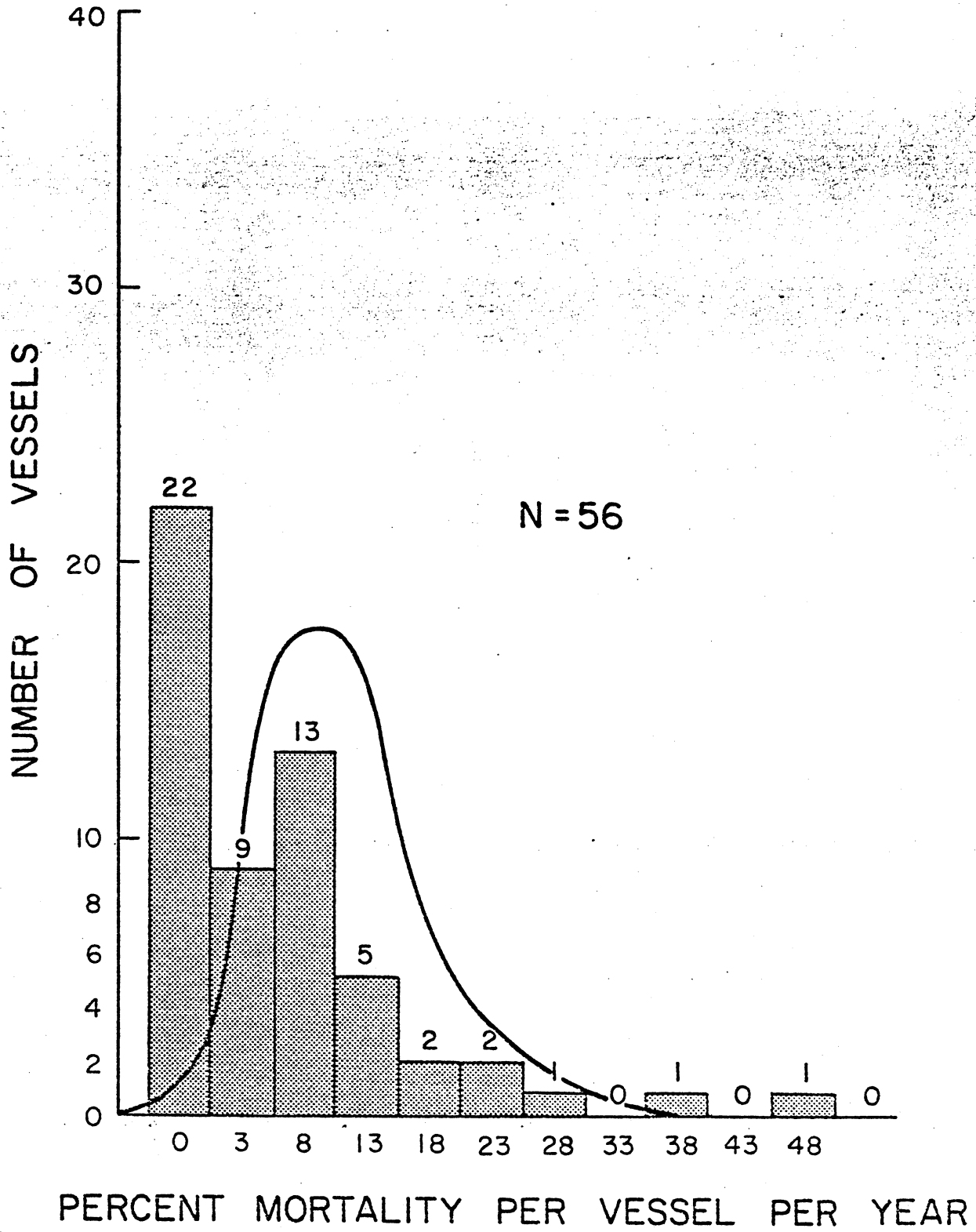

Figure 16. Frequency distribution of mortality estimates from interviews in terms of percentage of captured turtles which die per boat per year, Georgia, 1976.

Little is known of the effectiveness of on-board resuscitation of comatose turtles. Twenty-one shrimpers said they left turtles on board to revive and 17 said they heaved all turtles overboard as soon as possible, regardless of the physiological condition of the turtle. Twenty-six of these interviews also provided mortality estimates which suggest that the different techniques used by the shrimpers for handling comatose turtles result in different estimates of mortality. Table 10 summarizes this information by separate coastal areas as well as statewide. Shrimpers who kept turtles temporarily on board for resuscitation estimated 1.7 times more mortality than those shrimpers who threw their turtles overboard immediately after capture, but differences are slight and the sample size is small. Shrimpers who keep turtles on board for resuscitation might be expected to be most aware of the true numbers of turtles which cannot be revived.

Critical to a continuing study of turtle mortality is an accurate correlation of trawl duration and mortality frequency, but this information is not yet available. The concensus of the interviews was that small turtles are most vulnerable to longer trawl durations, but at least one captain reported that small turtles were more resistant to drowning than larger turtles.

On Board Observations

A complete list of on-board observations is contained in Appendix III and IV, including the physiological condition of 18 loggerheads captured during the observations (Table 11). We do not know how incapacitated a turtle must be before it will drown when released, and we do not know how the preceeding traumatic experience affects the survival to a resuscitated and released turtle. If feeble turtles do in fact drown or are lost to the population and if all turtles had been immediately returned to the water, mortality during our on-board observations could have reached 39 percent of the total turtles captured.

Table 11. Condition of eighteen loggerheads captured in shrimp nets in Georgia, 1976.

Condition	Number of Turtles	Per Cent
alive, released immediately	11	61
comatose or incapacitated but revived	3	17
dead in net	3	17
mortally wounded	1	5
Total	18	100

Beach Strandings

Decomposing carcasses of sea turtles frequently strand on Georgia beaches, and the shrimper is frequently implicated in the deaths of these animals. The following survey of carcass strandings positively reinforces that implication. (The carapace dimensions of these turtles and their distribution on the various beaches are listed in Appendices 5 and 6 at the end of this report.)

Figure 17 depicts the number of carcasses of all sizes reported on Georgia beaches. The correlation of shrimping seasons with the appearance of carcasses is obvious. During typical shrimping years (1973-1975), inshore waters (an area east of the Georgia islands and seaward to the three mile limit) are open to shrimping approximately June 1, while sound waters (estuarine waters west of the coastal islands) are usually opened in early fall, frequently on September 1. This schedule caused the seasonal, bimodal distribution of dead turtles (Figure 17) recorded from 1973 to 1976.

In 1977, the effect on sea turtles of opening the nearshore waters to shrimping on 6 July was dramatically documented (Figure 17). Eight carcasses stranded prior to the in-shore season and 178 carcasses stranded after 6 July. Our aerial survey of 170 carcasses (Figure 18) on all Georgia beaches corroborates the on-the-ground surveys (7 islands) and defines the striking suddeness with which carcasses appeared within three days of the opening of nearshore waters. Figure 18 indicates turtles experience little mortality from shrimp vessels outside the three mile limit, probably reflecting reduced capture rates in these waters.

Figure 19 illustrates the distribution of carcasses by island, based on carcasses observed during aerial surveys. Strandings were centered on the Blackbeard-Sapelo complex and on Cumberland Island. Approximately 68 percent of strandings were observed on these islands. Since the effects of littoral

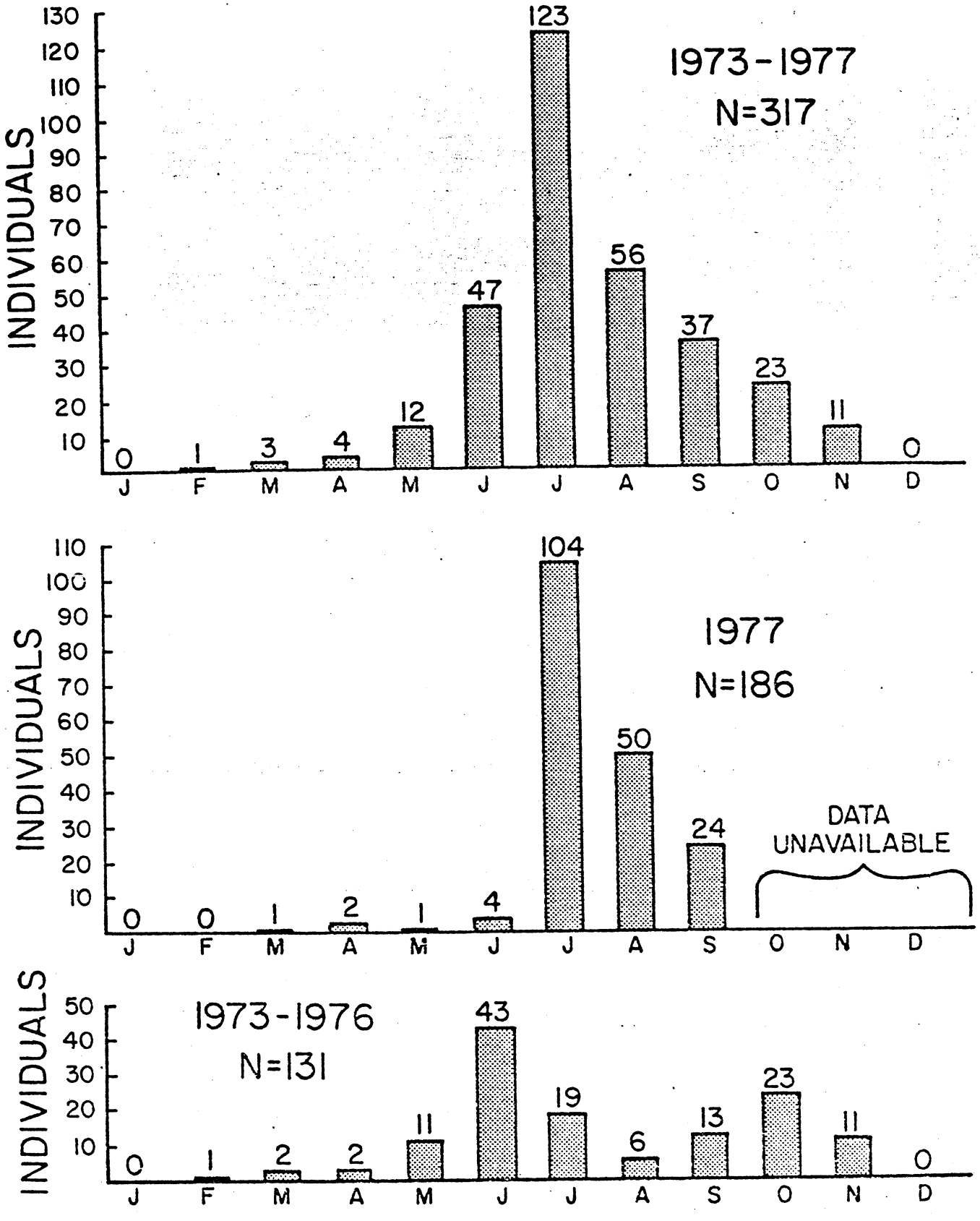

Figure 17. The occurrence of sea turtles found dead on Georgia beaches, distributed by month.

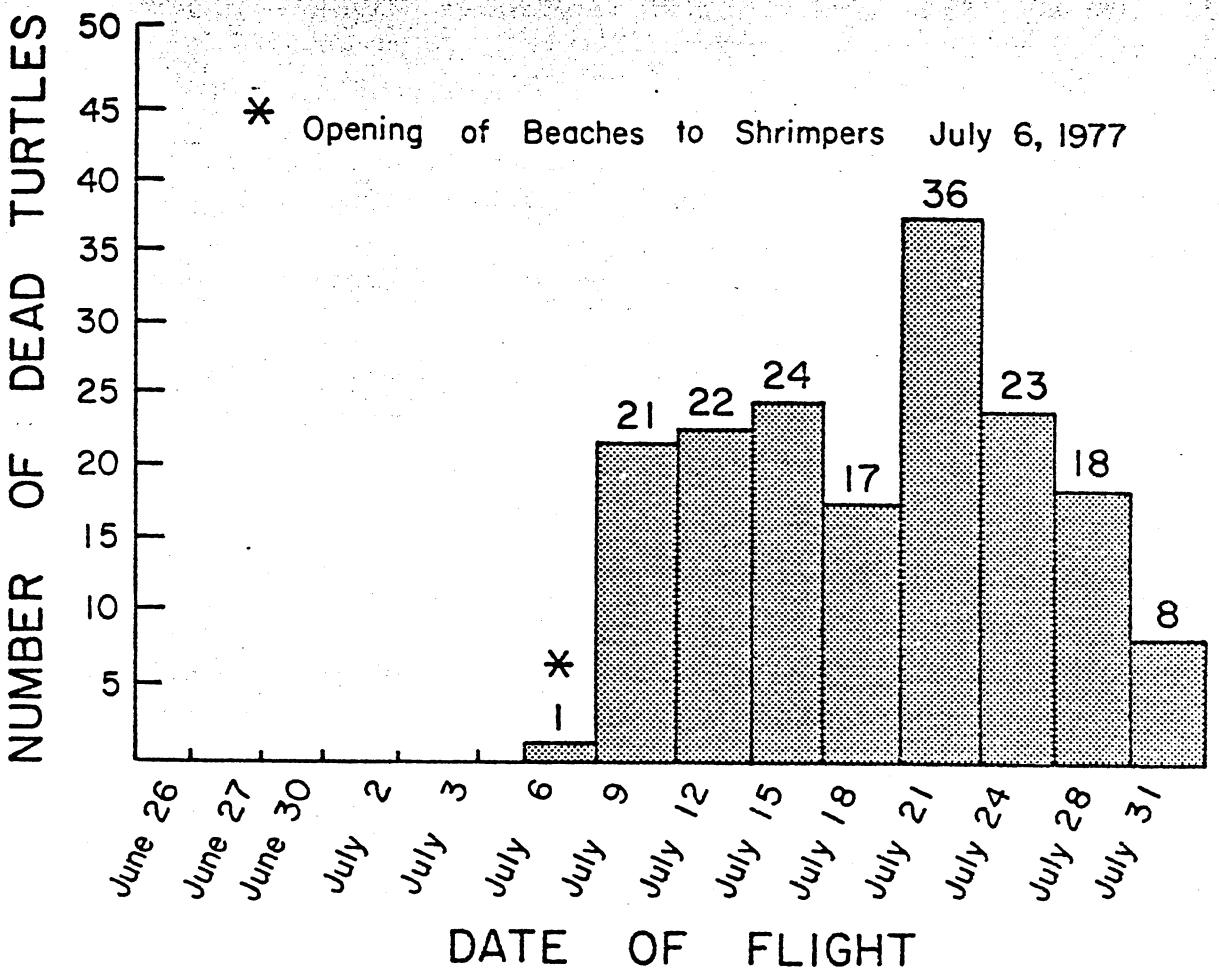

Figure 18. Aerial survey of sea turtles observed dead on Georgia beaches, distributed by flight day, 26 June - 31 July, 1977.

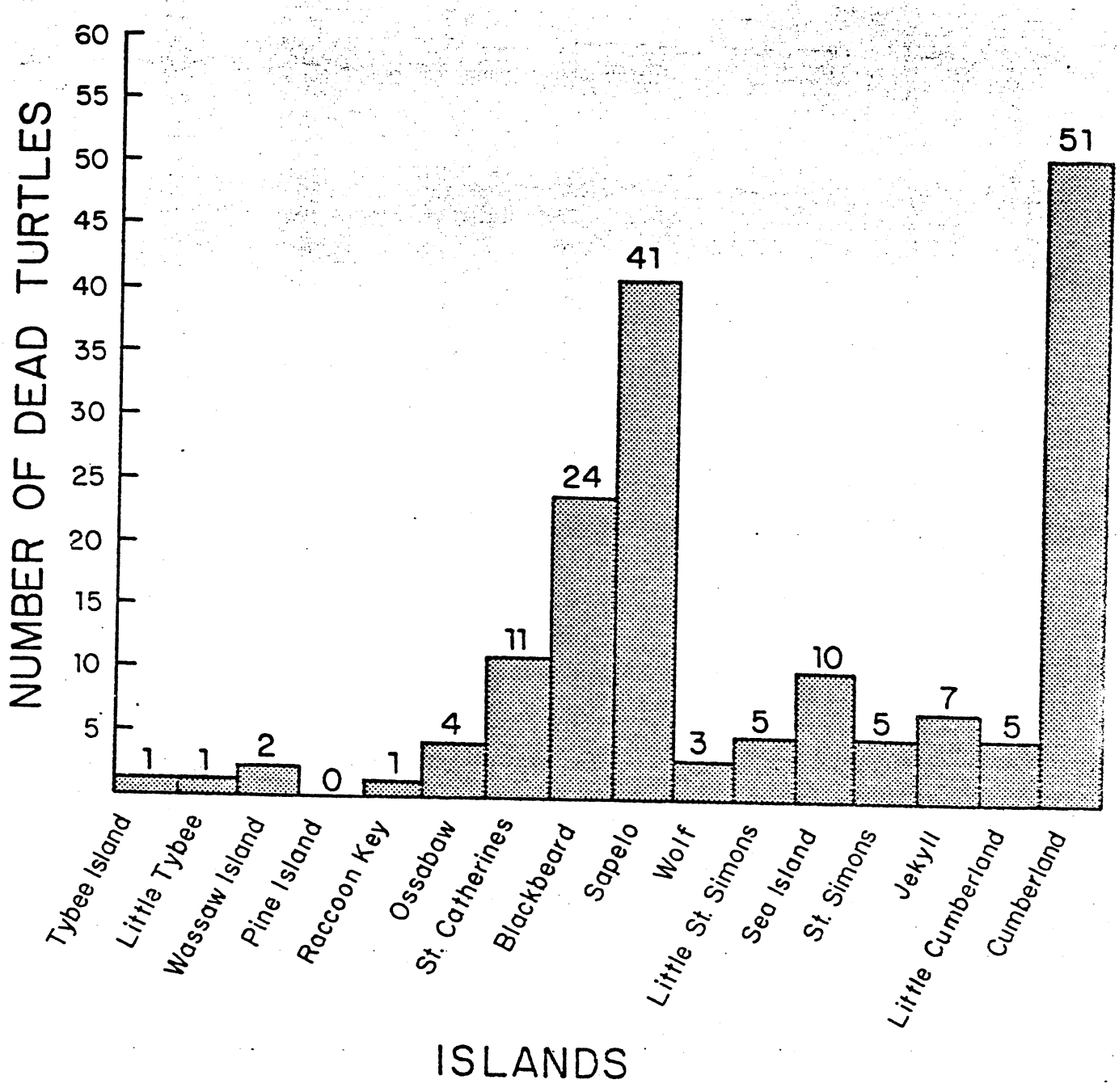

Figure 19. Aerial survey of total sea turtles observed dead on Georgia beaches, distributed by islands, 26 June - 31 July, 1977.

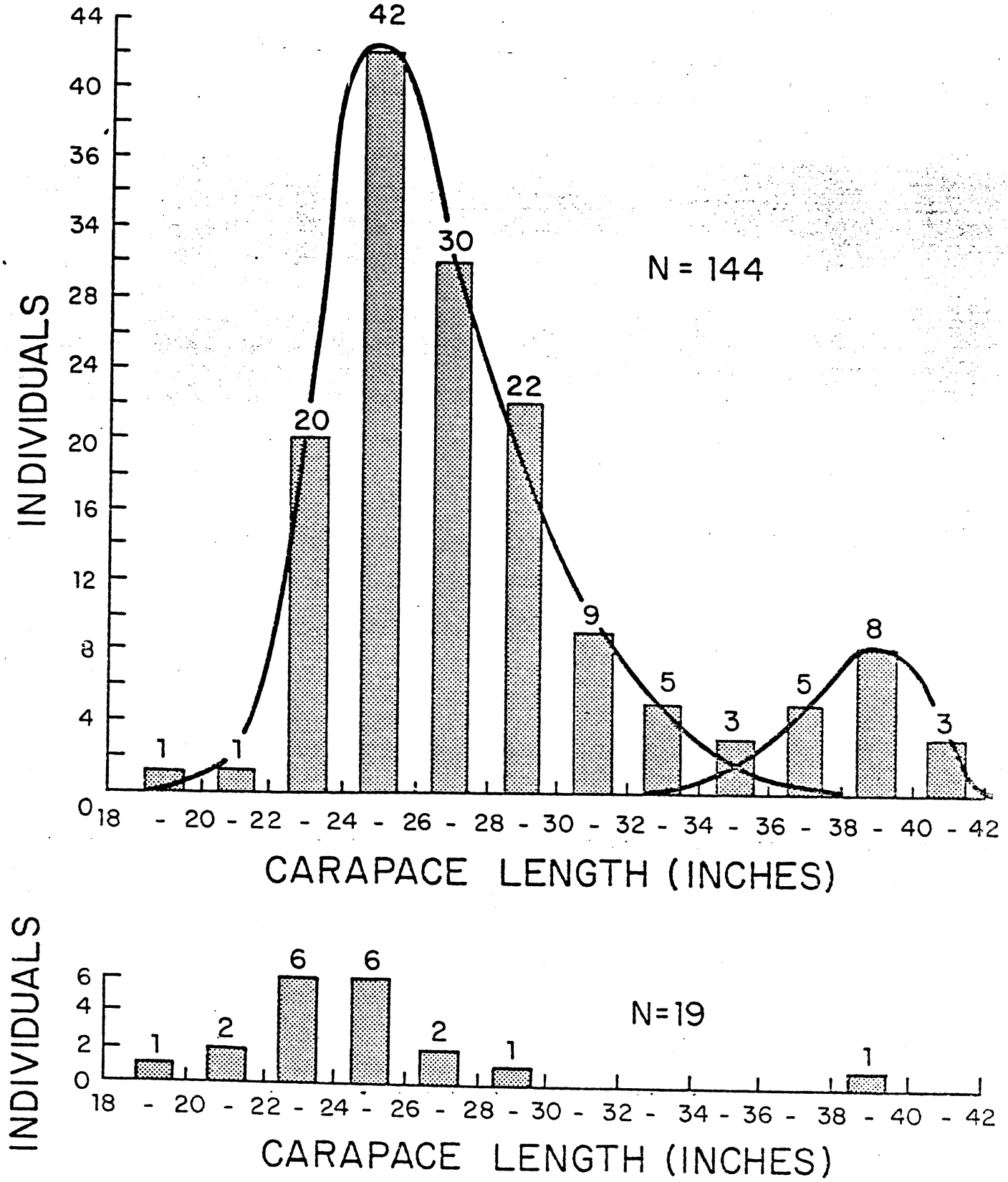

Figure 20. A distribution of the size classes of loggerheads found dead on Georgia beaches (top) compared to a similar distribution of loggerheads caught by shrimp boats (bottom) in Georgia.

as well as other near-shore currents on distributing loggerhead carcasses is not known at this time, we cannot correlate areas of high mortality with beaches where the turtles strand. Our stranding data also reflect the fact that beach cleanup crews on Tybee, Sea, St. Simons, and Jekyll Islands remove carcasses early each day. Thus, our aerial surveys would miss at least two thirds of the carcasses on these three islands. Aerial surveys recorded 28 percent of the carcasses ground survey team detected on these islands and 77 percent on the remaining islands (Ossabaw, Blackbeard, Little Cumberland, and Cumberland Islands). Therefore, the bimodal distribution of carcass strandings shown in Figure 19 is, in part, a product of island development practices.

Figure 20 illustrates the distribution by size class (carapace length) of 144 carcasses measured over a seven year period on several Georgia beaches. Curves which suggest two normally distributed, slightly overlapping populations of turtles (carapace lengths) have been fitted by eye. Approximately 88 percent of all turtle mortality on Georgia beaches may be classified as juvenile or sub-adults with carapace lengths (straight measure or over-the-curve) ranging from 22 inches to 34 inches. The remaining 12 percent are probably adults with an over-the-curve carapace length of 36 inches to 42 inches. The scarcity of individuals in this larger category supports an observation by Georgia tagging programs on nesting beaches that relatively few adult breeding females are being captured by Georgia shrimpers (Bell & Richardson, 1977). A similar distribution of loggerhead turtles captured during on-board observations (Figure 20) suggest a 1:1 relationship between a juvenile class being captured by shrimp boats and a similar class appearing as carcass strandings on the beaches. This observation does not comfortably fit with a previous observation (Figure 14), based on interviews, that turtles in the

20 inch - 30 inch range and greater than 30 inch range are being caught in approximately equal numbers. In the interviews, shrimpers evidently placed many of their captured juveniles in the $\geq$ 30 inch category.

Because sounds were closed in 1977 to all shrimpers, we could not compare the vulnerability of sea turtles occurring within the sounds as opposed to those outside of the sounds but near the ocean beach. We know that only eleven loggerheads were captured in St. Andrews Sound and four in Wassaw Sound during an intensive two day shrimping effort after sounds were opened on 4 October 1976. Most sea turtles had evidently departed Georgia waters by this late in the season. Carcass strandings on beaches obviously were not contributed by shrimping in the sounds during 1976. Based on the distributions in Figure 17, an August or early September date for opening the sounds to shrimping would produce a much greater number of turtle casualties than was experienced in 1976.

Some carcasses showed obvious signs of mutilation. Many of the carcasses were missing flippers and/or heads. Mutilation could be partially attributed to sharks or other predators. Some turtles, however, had obviously been mutilated by man. Out of 138 carcasses carefully measured and inspected on Cumberland Island during the last few years, ten individuals were obviously butchered, several of them for meat, and another three individuals were shot in the head and carapace.

Estimates of Mortality

At any given time, the number of Georgia vessels actually trawling in Georgia waters will be less than the actual number registered to trawl in the state. Also non-resident boats trawl Georgia waters on an infrequent basis and often do not offload their catches in the state. For these and other reasons, estimating the total turtles captured and killed each year in Georgia is difficult. In 1976, 321 commercial vessels were

licensed to trawl in Georgia. We were unable to obtain a county distribution of those trawlers in the state. However, Nix et al.(1975) studied the Georgia fleet of 307 commercial vessels by county. To obtain mortality estimates for Georgia counties, we have used Nix's 1975 figures in Figure 12. Using our mortality estimate of 7.9 percent of turtles captured, approximately 745 turtles may have been drowned by the 307 vessel fleet of 1975. Based on the distribution in Figure 20 (top) 745 dead turtles might be apportioned to 656 juveniles (88 percent) and 89 adults (12 percent). The estimated mortality induced by the 1976 commercial fleet of 321 vessels may approximate 778 sea turtles (Table 13).

Table 12. Minimal estimates of total turtles which die each year in shrimp nets in Georgia. Vessel distribution by county is adapted from Nix et al, 1975. Data pertains only to commercial vessels with Georgia registry.

Area	Turtles[1] Captured Per Boat	Mortality[2] Percent	Boats	Total Dead Turtles
Chatham and Bryan Counties	29.0	7.7	71	159
McIntosh and Liberty Counties	29.3	6.3	129	238
Glynn and Camden Counties	34.7	9.5	107	353
State	30.7	7.9	307	745

1, from Figure 11; 2, from Table 9.

Table 13. A summary of the basic parameters of shrimp trawling and the incidence of sea turtle capture and mortality in Georgia, 1976. Data pertains only to commercial vessels with Georgia registry.

Category	Data Source: On-board Observations	Data Source: Interviews
Total commercial boats registered in Georgia, 1976	-	321
Length of shrimping season in months	-	6.7
Months of shrimping season when turtles are actively caught	-	5
Shrimping days per month	-	22.2
Trawls per day	2.7	4.5
Hours per trawl	2.6	2.1
Trawl hours per day	7.0	9.5
Net width	61.8	56.5
Trawls per turtle captured	4.75	16
Turtles captured per boat per year (1975)	76	30.7
Estimated turtles captured by the 1976 commercial fleet	-	9855
Percent mortality of turtles caught	15	7.9
Estimated total turtle mortality induced by the 1976 commercial fleet	-	778

VII. THE LOGGERHEAD SEA TURTLE POPULATION IN GEORGIA: DATA AND MODEL ESTIMATES

Very few loggerhead populations have been censused or properly estimated. Typically, a census involves the number of breeding females per island during a particular season. Since turtles rarely breed during consecutive seasons, we must estimate total adult females nesting in a particular area based on tagging studies and re-migration estimates. Re-migration is the phenomenon of a sea turtle returning to nest at the same location over a period of several years. The following is a first approximation of total female nesting loggerheads alive at one time and nesting exclusively on the Georgia coast.

Estimating Total Females Nesting in Georgia

Survey Data

Figure 21 shows the cumulative number of nests estimated during our aerial survey, distributed according to island. Figure 22 shows the number of dry runs, also distributed by island. A total of 441 nests were recorded during the 14 flights. By the 12th flight (24 July, 1977), most nesting activity had ceased (Figures 23 and 24). Table 14 compares the aerial survey to ground censuses for six Georgia islands. The Blackbeard Island ground survey of nests and dry run crawls was conducted daily by staff of the Blackbeard Island National Wildlife Refuge. The remaining four islands represent active tagging programs and all-night patrols. A brief description of these tagging programs may be found in Appendix VII.

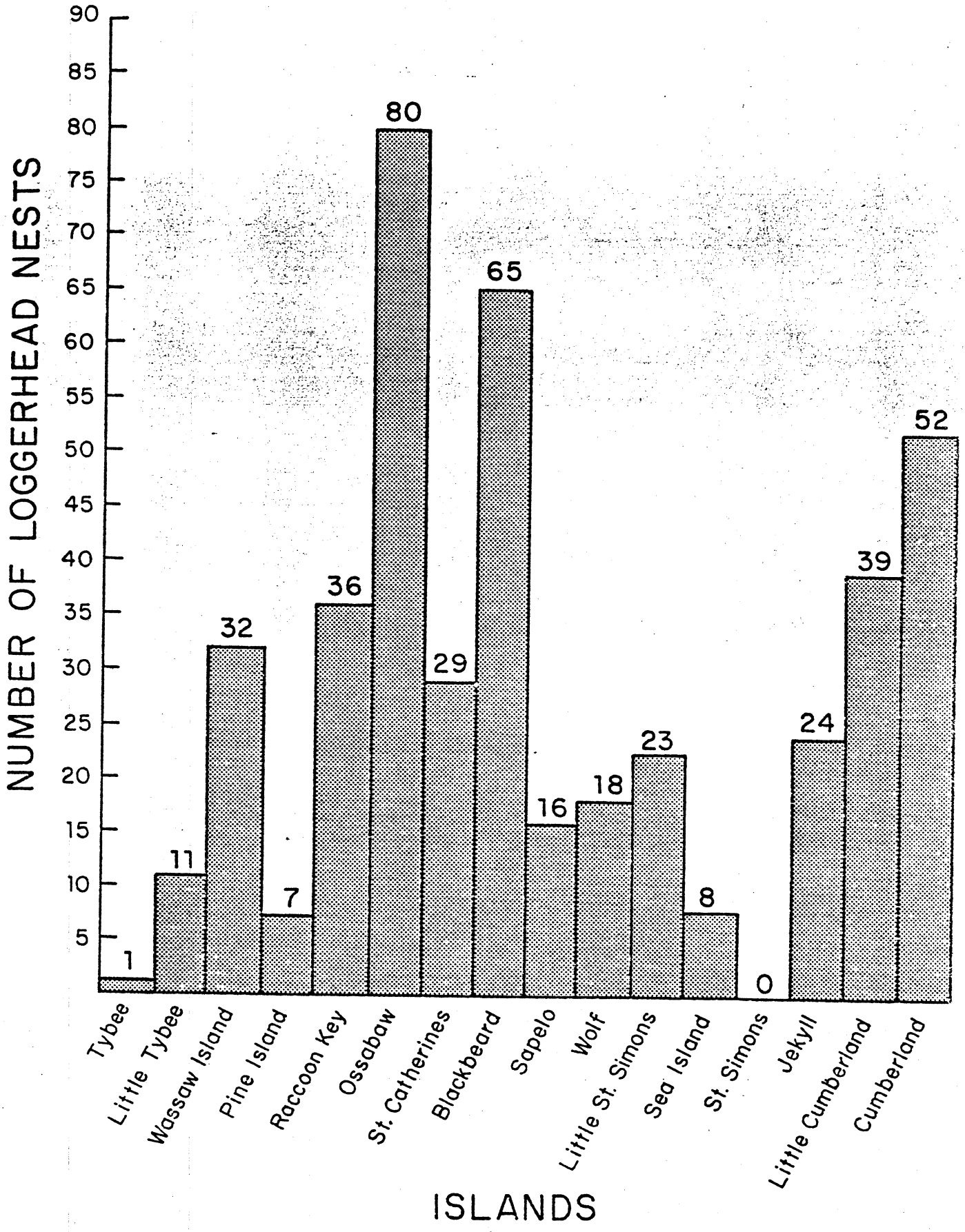

Figure 21. Loggerhead nesting activity by islands, Georgia coast, 26 June - 31 July, 1977, from aerial surveys.

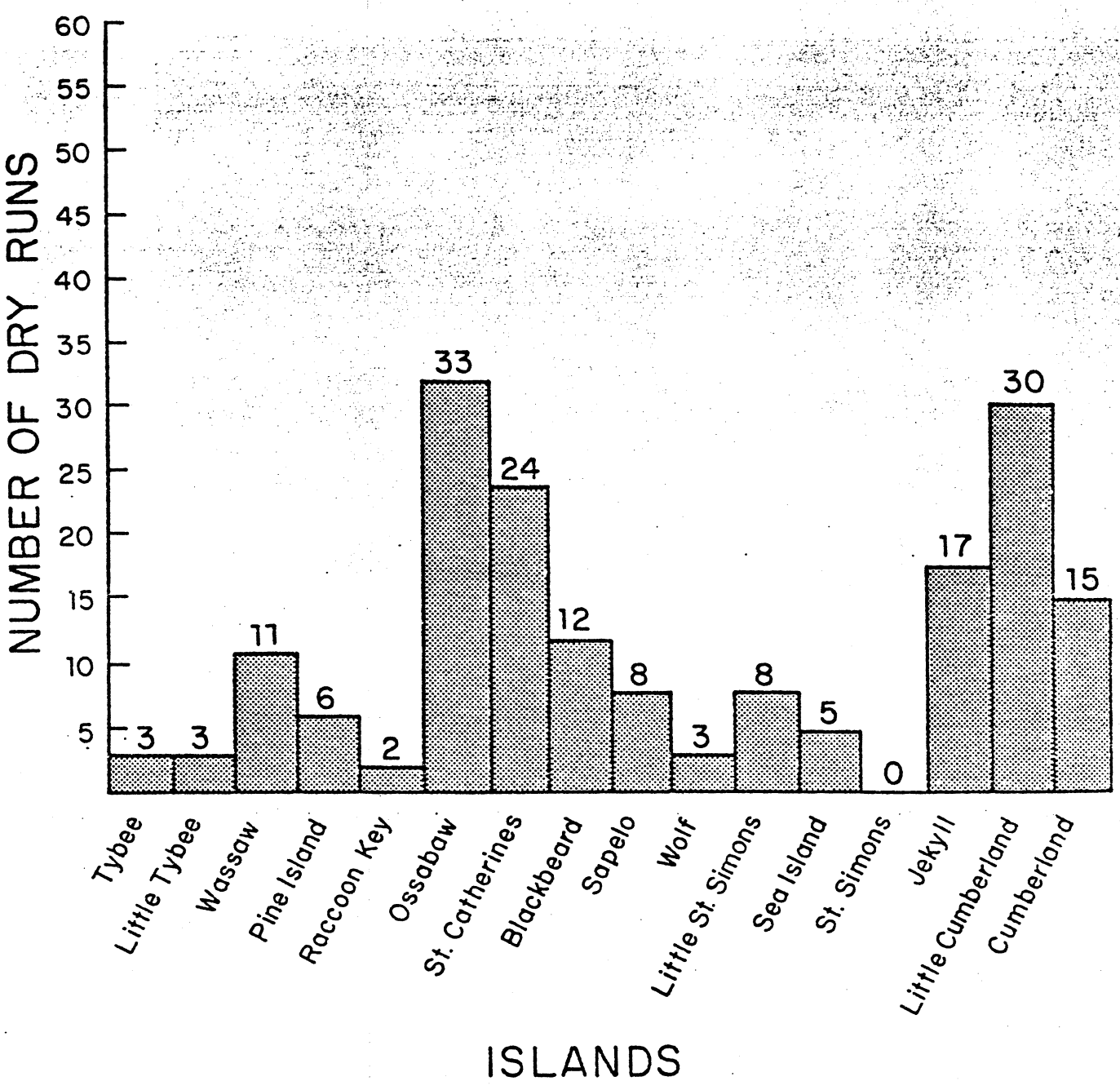

Figure 22. Dry runs of loggerheads by islands, Georgia coast, 26 June - 31 July, 1977, from aerial surveys.

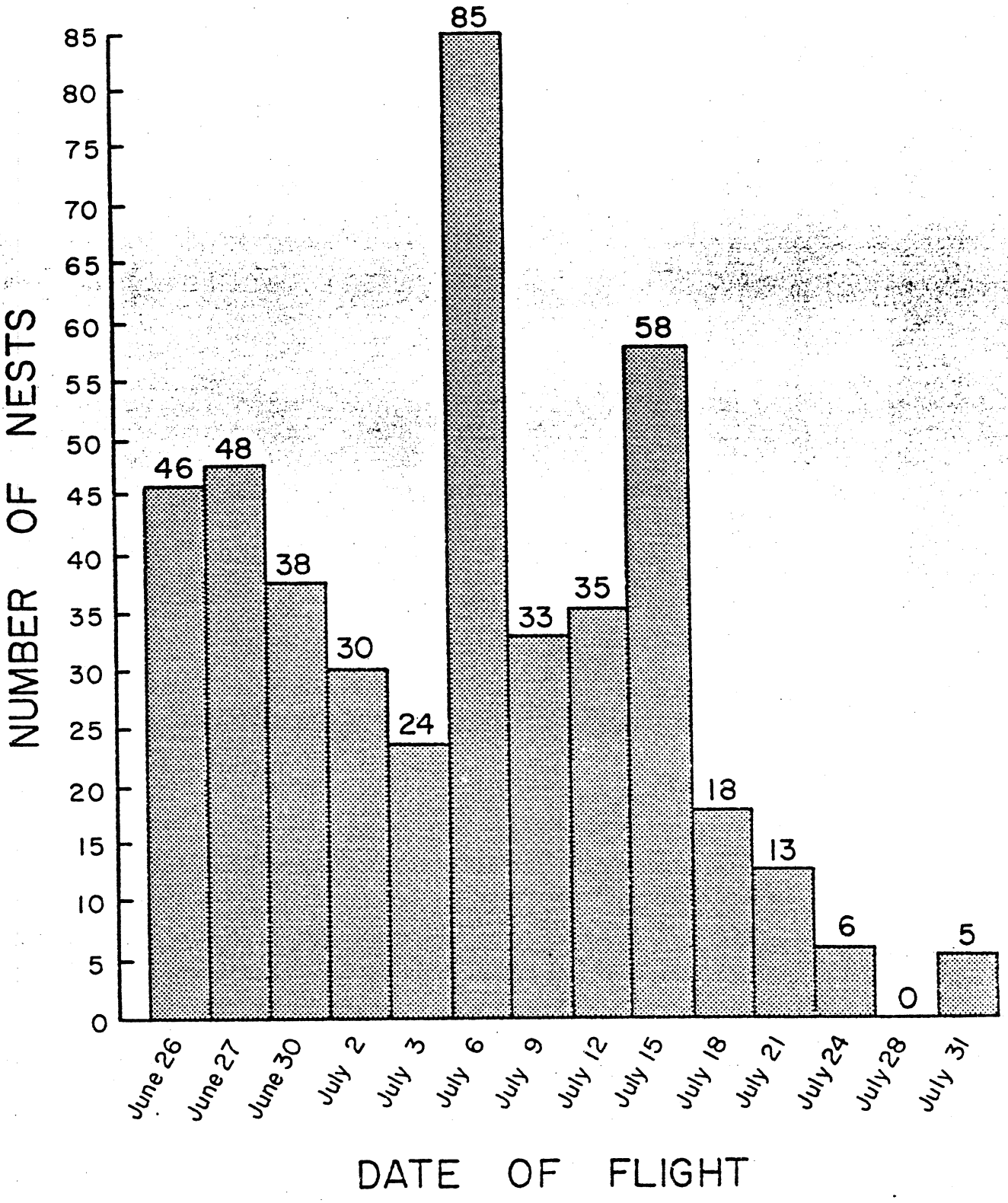

Figure 23. Loggerhead nesting activity by date, Georgia coast, 26 June - 31 July, 1977, from aerial surveys.

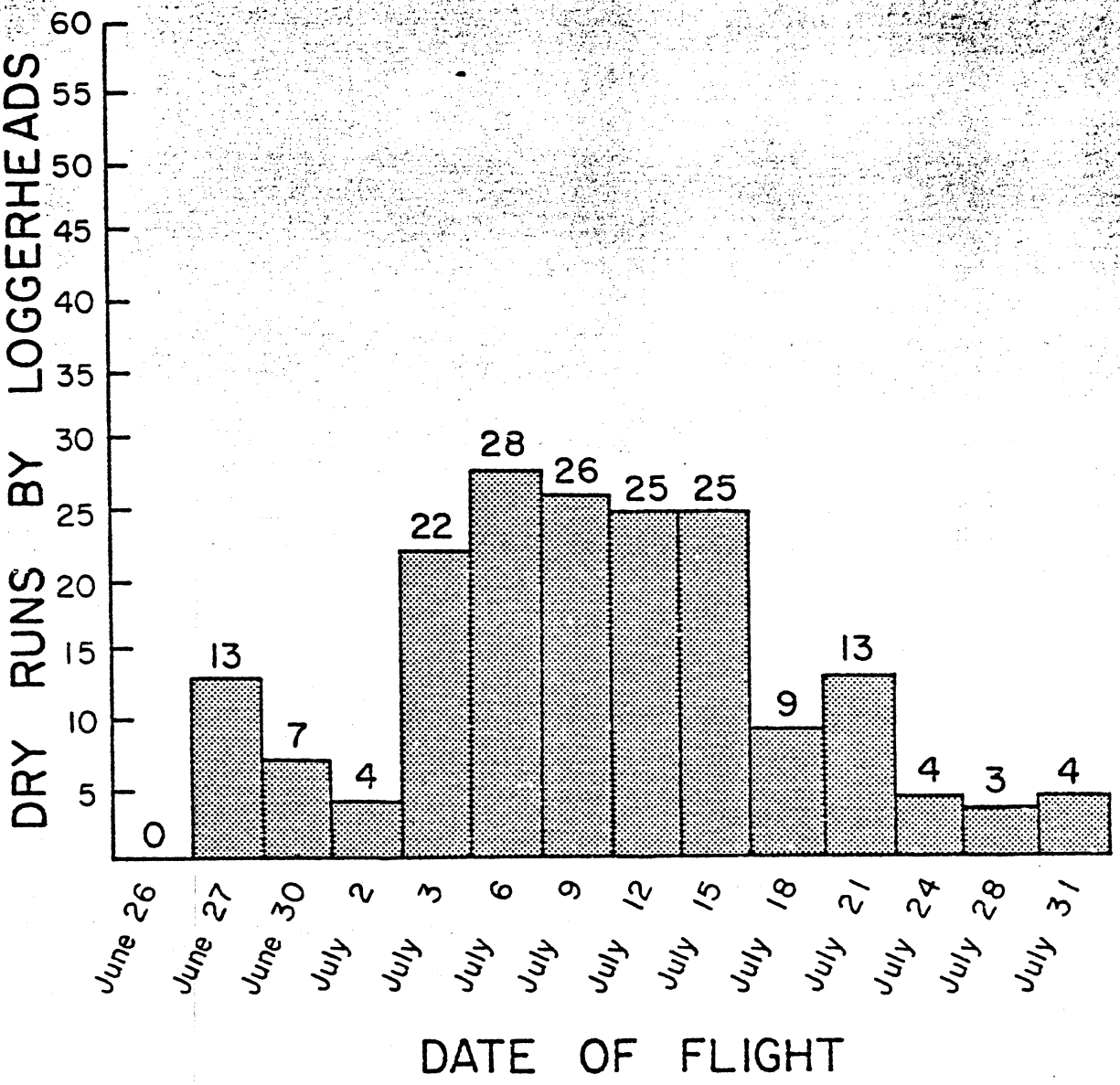

Figure 24. Dry runs of loggerheads by flight, Georgia coast, 26 June - 31 July, 1977, from aerial surveys.

Table 14. A comparison of numbers of nests, crawls, and dry runs by aerial and ground surveys, 26 June - 30 July, 1977.

Islands	Total Turtles	Nests		Dry Runs		Total Crawls	
		Ground Count	Aerial Count	Ground Count	Aerial Count	Ground Count	Aerial Count
Wassaw	44	36	32	89	11	125	43
Ossabaw	46	38	80	32	33	70	113
Blackbeard		93	65	22	12	115	77
Jekyll	29	27	24	38	17	65	41
Little Cumberland	56	52	39	52	30	104	69
Cumberland	50	41	52	14	15	55	67

significant differences?

By inspection of Table 14, the aerial survey method seemed most reliable for consistently estimating nests, as opposed to dry run crawls and total crawls. Nevertheless, aerial surveys and ground surveys differed considerably, ranging from an overestimating of nests on Ossabaw Island by 2:1 to an underestimation of nests on Blackbeard by 0.7:1. A number of factors may be responsible for these discrepancies. If beaches are eroding, a crawl trace will be nearly obscured following a high tide, thereby causing an underestimation in aerial censuses. A very flat, accreting beach will support persistent crawl marks, causing an overestimation in aerial censuses. Furthermore, a portion of the Ossabaw beach was not accessible to the ground patrol, and it is possible that a considerable proportion of dry run crawls were erroneously classified as nesting crawls during daylight surveys on Blackbeard. If the high Ossabaw values and the low Blackbeard values are dropped, we obtain an estimate of 147 nests for the remaining four islands, which corresponds to 1.25 nesting female turtles per nest surveyed by air. The relationship of nesting females per nest ranges from 0.96 to 1.44 for the four islands. The total aerial nest survey (441 nests) times the conversion factor 1.25 suggests that approximately 551 adult female loggerheads were nesting on the Georgia coastal beaches in 1977.

Model Predictions

Translating the estimated 551 annual loggerhead females to total loggerhead females comprising the Georgia population requires some preliminary modeling work currently being performed on the Little Cumberland Island data. A series of observations (MODEL CONSTRAINTS Table 15) drawn from Little Cumberland Island turtle population data have been incorporated into a theoretical model with logical form (MODEL ATTRIBUTES Table 15) and predictive results (MODEL PREDICTIONS Table 15).

Table 15. A predictive model of the population dynamics of adult female loggerheads nesting on the Georgia coast

I. MODEL CONSTRAINTS

a) a remigration schedule must be as follows:

Interval	Percent of Population
annual	3
2-year	56
3-year	31
4-year	7
5-year	3

b) approximately 55 percent of all new arrivals (neophytes nesters) will remigrate.

c) at least 70 percent of returning turtles will remigrate again.

d) the longest recorded nesting history of a loggerhead (on Little Cumberland Island) is 14 years.

e) neophyte nesters make up approximately 30 percent of each season's total turtles.

II. MODEL ATTRIBUTES

a) the remigration schedule is maintained as above.

b) there occurs a 40 percent mortality loss from the breeding population after the first nesting year.

c) 10 percent of the remaining adult population dies each year after the second adult year.

d) any turtles remaining after the 23rd adult year (less than 1 percent of the original population) are considered dead.

e) 51 percent of the neophytes remigrate a second time.

f) 77 percent of the returning turtles remigrate a second time.

III. MODEL PREDICTIONS

If 1000 neophyte nesters enter the model population each year:

a) the total population will remain stationary at 6408 adult nesting females,

b) neophyte nesters constitute 16 percent of the population at any one time,

c) 2997 adult females nest each year, or 47 percent of the total population.

d) neophyte nesters constitute 33 percent of the seasonal breeding group of 2997 individuals.

Assuming an annual figure of 551 nesting females, the model predicts (Table 15) a total population of 1172 nesting females, with an annual recruitment of 165 new turtles (neophytes) into the population each year. If the population is stable, we must assume mortality of an equivalent stationary number (165 adults) removed from a population of older breeding females (1007 individuals) ranging in age span of breeding years from one to twenty-two. We do not know the number of years which elapse between birth and initial breeding age.

The most striking prediction of the model is that 47 percent of the total population breeds each year. Previously, we have assumed that annual nesting turtles represented a much smaller proportion of total adult females (Richardson et al, 1977a). Therefore, there may be fewer adult loggerheads in the Georgia population than we had previously predicted.

If 12 percent of all turtles killed in shrimp nets are breeding adults (Figure 20), then an estimated 78 dead adult turtles per year (12 percent of 650 dead turtles, Table 12) could be equivalent to 14 percent of the annual female breeding population or 7 percent of the total breeding population. We do not know anything about the number of adult male loggerheads associated with the Georgia population except that they appear to be far less numerous than females. By using a biochemical assay for testosterone, a recent study found that a population of juvenile green turtle (Chelonia mydas) exhibited a female dominated sex ratio of 33:1 (Owens, et al, 1976).

A Survivorship Curve for Georgia Loggerheads

A hypothetical survivorship curve (Figure 25) summarizes our knowledge of loggerhead population ecology. Additional assumptions contained in this figure, not listed in Table 16, are as follows:

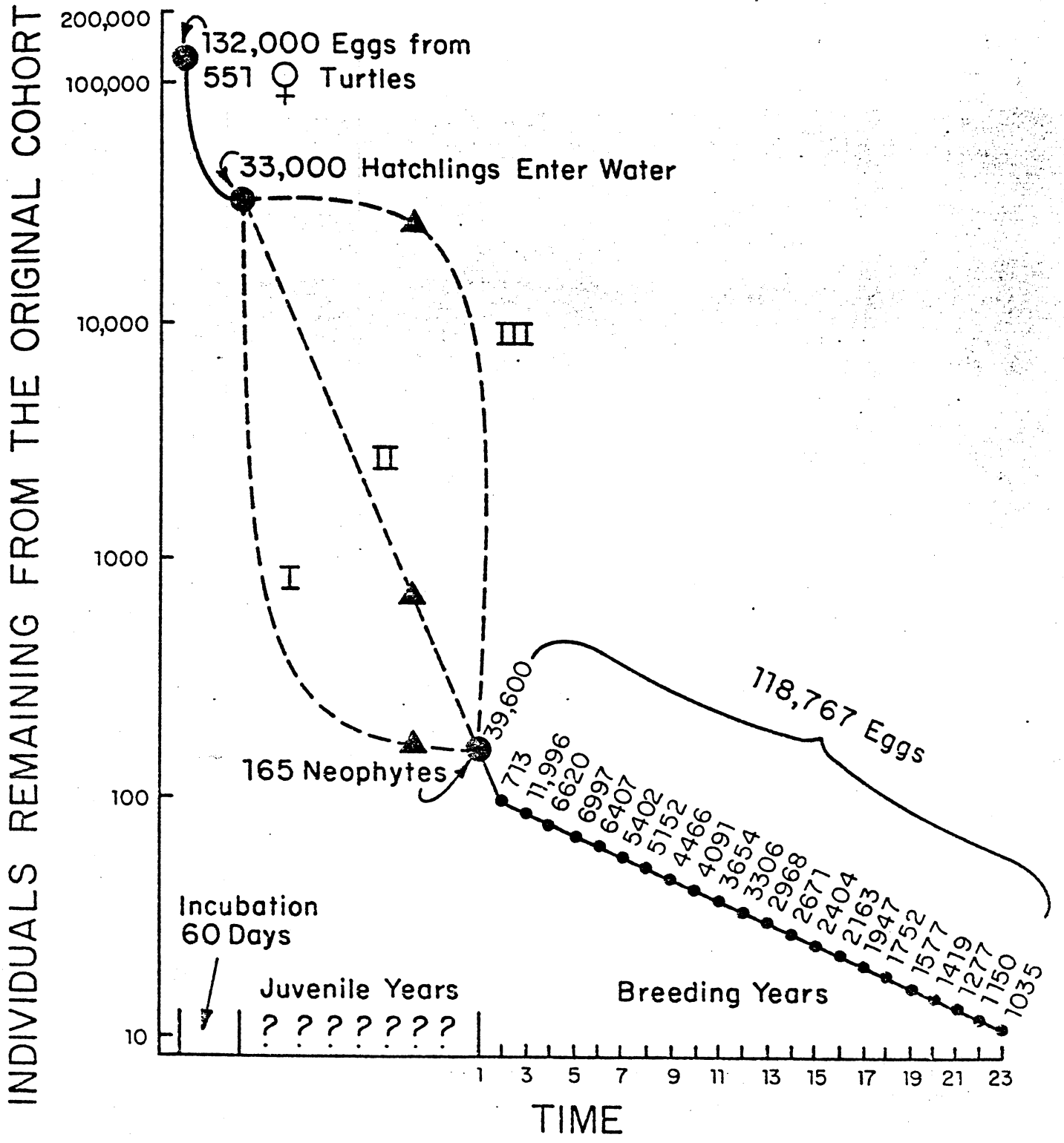

Figure 25. A hypothetical survivorship curve for the eggs deposited by 551 female turtles on Georgia beaches, 1977.

a. the average female will lay two nests (range 0 - 6) in a season (Little Cumberland data).

b. an average clutch size is 120 eggs (range 40 - 180); (Little Cumberland data).

c. Survival of eggs and young on the beach, given conditions of natural predation and mortality, is arbitrarily estimated at 25 percent. (Hatchery production maximum at approximately 80 percent; we do not currently have natural survival estimates since virtually all of the island projects utilize a hatchery or sustain almost total mortality from feral animals).

Several general points may be developed from Figure 25:

a. we are confident of seasonal numbers of adult turtles, clutches per female, and eggs per clutch. Although 75 percent mortality from native and feral animal predation is an estimate, the actual information is currently being collected as part of the 1977 Cumberland Island study.

b. the model from initial sexual maturity to final death is speculative but is probably fairly accurate since it satisfies so many constraints established by the Little Cumberland data. We expect this portion of the model to be continually refined.

c. we can say little about the period from hatchling turtle to young sexually mature adult. Our model offers three alternatives for the fate of a cohort of juvenile loggerheads. A triangle (Figure 25) represents a hypothetical point on each of the alternative paths where the juveniles most commonly killed by shrimp nets might appear. If the facts fit Alternative III (Figure 25), then shrimping mortality occurs at a

period in the turtle's life cycle when juvenile turtles are at a surplus, and the negative impact of the shrimping industry on the population would be less. If Alternative I exemplifies the facts, then turtles are being removed from the population by the shrimping industry at a time when turtle numbers are critical to the continuing stability of the breeding population, at a time when the removal of juveniles would have a near 1:1 relationship to the number of maturing females available to the breeding population. Unaccustomed mortality at this stage of a survivorship curve could be disastrous to the breeding population. Undoubtedly, the real situation lies somewhere in the middle (Alternative II).

It is doubtful that we will soon know what happens to the hatchlings during the first two or three years of their lives. The mystery of these years is often discussed in the sea turtle literature. However, a great many juvenile turtles of moderate size seem to congregate each summer in the vicinity of the sea food processing factories on the Georgia coast. Until a concerted effort is made to tag and analyze the growth and survivorship of these juveniles, the central section of the survivorship curve must remain obscure.

VIII. THE RIDLEY, LEATHERBACK AND GREEN SEA TURTLES ON THE GEORGIA COAST

The Ridley, the leatherback, the green, and the hawksbill are four species of non-breeding sea turtles which are known to occur on the Georgia coast. Due to small sample sizes, frequent uncertainty of proper identification, and the brief nature of this survey, the impact of the Georgia shrimping fleet on these species is unquantified.

Ridley

This species is commonly encountered in Georgia's estuarine waters. It nests exclusively on the Tamaulipas coast of Mexico, but it ranges widely and can be found throughout the Gulf of Mexico and along the Atlantic coast north to New England. The total number of breeding females seen at the nesting beaches has been dropping rapidly in recent years, causing grave concern for its chances of survival (Meylan, 1977).

The impact of the Georgia shrimping industry on this species proved to be difficult to assess. Many people cannot or do not differentiate the Ridley from the loggerhead. Each of our estimates for loggerheads or total turtles undoubtedly include a small proportion of Ridley turtles, but the exact proportion is unknown. Some shrimpers are definitely aware of the Ridley, which they identify as a "small, round turtle" which appears in their nets.

Four out of sixteen turtles captured in St. Andrew Sound during our on-board observations were Ridleys, constituting 25% of this small sample. Measurements of these four,

plus five additional animals found dead on the beach, are provided in Table 16. The carapace length of adult female Ridleys on the Tamaulipas nesting beach ranges from 23.4" to 29.5"; therefore, all but one of the individuals in Table 16 are juveniles. Three of the four animals taken on-board were identified as males.

There is some evidence that the Ridley may be particularly vulnerable to shrimping pressures, appearing among the first to be caught and the first to disappear from St. Andrew Sound after this sound was opened for shrimping in early October, 1976 (Figure 26). The number of Ridley skulls which have been found on the Georgia beaches over the last few years would indicate that Ridleys make up a greater proportion of total turtles found dead on the beach than our beach survey would indicate. From 7 October 1973 to 22 November 1973, six out of 49 carcasses (12 percent) on the Cumberland Island beach were identified as Ridley turtles. From 10 May 1976 to 24 September 1977, 88 carcasses were counted from the same location, and none of these were identified as Ridleys. Ridleys accounted for one out of nine carcasses in 1976 and none of eight in 1977 on Little Cumberland Island.

There is a possibility that the number of Ridley turtles in Georgia waters has declined in recent years; Ridleys may also undergo natural cycles of abundance. Until we obtain more on-board observations and educate people to the identification of turtles, we can say very little about this species. If, indeed, the survival of the Ridley is as dire as some investigators indicate, then any Ridleys captured or killed in Georgia must be considered critical.

Leatherback

The leatherback turtle seems to be a common non-breeding visitor on the Georgia coast. It is a cosmopolitan species, having been described as an animal having a temperate range with tropical nesting habits.

Table 16. The carapace length of Ridley sea turtles captured or found dead in Georgia, 1974-1976.

Date	Source	Location	Sex	Carapace Length (Inches)	How Measured
28 Sept. 1976	Trawler	SAS	Male	10.7	Straight
2 Oct. 1976	"	SAS	Female	28.7	"
4 Oct. 1976	"	SAS	Male	12.6	"
4 Oct. 1976	"	SAS	Male	14.2	"
10 Feb. 1974	Dead-on-beach	CBI	?	19.5	Curvature
9 Oct. 1974	"	CBI	?	17.7	"
25 Oct. 1974	"	CBI	?	21.7	"
23 Nov. 1974	"	CBI	?	20.9	"
30 Oct. 1976	"	LCI	?	16.9	"
Mean				18.1	

SAS - St. Andrew Sound; CBI - Cumberland Island; LCI - Little Cumberland Island

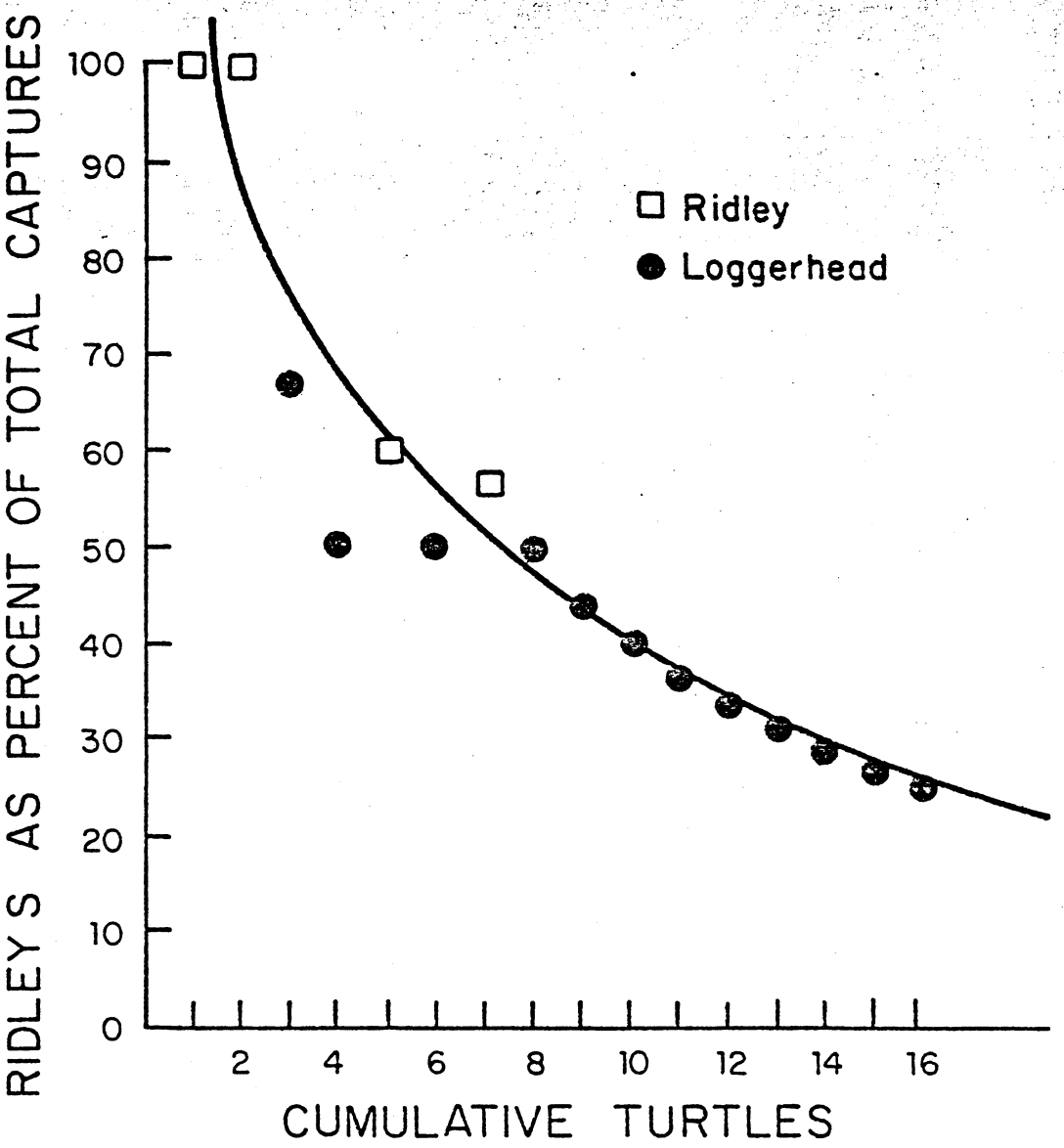

Figure 26. Ridley captures as percent of loggerhead captures over time.

Its principal diet is jellyfish, which probably accounts for its non-breeding distribution in cooler ocean waters.

The leatherback is well known to Georgia shrimpers. Of 59 interviews that responded to the leatherback question, 25 individuals (42 percent) said they had never caught this species, 34 (58 percent) said they had caught it at least once in their lifetime, and no less than 12 (20 percent) said they had caught a leatherback during the 1976 season. One vessel caught four leatherbacks in 1976, while another vessel caught ten leatherbacks in 1976. Interview data indicated 24 leatherbacks were caught in 1976. This figure may be inflated since most of the shrimpers reported capturing no more than one or two animals. The leatherback should be considered a rare but regular victim of shrimp nets.

Nearly every leatherback mentioned in the interviews was captured two or three miles off-shore during the spring. Near-shore waters in Georgia are usually closed to shrimpers until June. One captain reported that he caught three leatherbacks in 1975 offshore in depths of 30 feet during the jellyfish season.

Since leatherbacks are strikingly diagnostic from the other species of sea turtles, we can be fairly confident in saying that they do not occur regularly on Georgia beaches. Two adult individuals were found dead on Ossabaw Island several years ago, one on Wassaw Island in 1974, and another freshly drowned leatherback with carapace length of 53 inches was recorded 20 October 1974 on Cumberland Island. An adult leatherback, killed when struck by a boat propeller, was discovered 1 December 1977 on Little Cumberland Island.

Green Sea Turtle

The green sea turtle, like the leatherback, is well known to a great many Georgia shrimpers. This tropical visitor nests abundantly in Costa Rica, more sparingly on a few of the Caribbean Islands and on Florida's Atlantic Coast.

Twenty-eight of the 104 shrimpers interviewed responded to the questions on green turtles, of which six stated they had never caught one. Most shrimpers spoke of having caught "a couple", "a few", or "some", but no large numbers. Only four of those interviewed clearly stated that they had caught at least one green turtle during the 1976 season. Almost all of the responses agreed that greens were much more common several years ago than they are at present, and several said they used to catch greens regularly but not any longer.

There was complete agreement among those interviewed that green turtles captured in Georgia are small individuals, perhaps 14 inches to 18 inches in carapace length. These turtles are caught close to shore, either near the ocean beach or within the sounds and estuaries. Two vessels stated that greens are more frequently captured in Florida waters than in Georgia waters. One vessel reported that greens drown quicker than loggerheads. However, we have no records of a green sea turtle stranding on the beach of any Georgia Island.

As with the Ridley, we can report little quantitative data regarding greens. More on-board observations and specific studies of the juvenile turtles, including those which congregate in large numbers near the seafood processing factories in Brunswick, are needed to characterize the green turtle population in Georgia.

Hawksbill

There was a single, unconfirmed report that a commercial vessel captured a hawksbill during the fall of 1975. This tropical species is truly a rare visitor to the Georgia coast. and we can conclude that it has no relevance to a management study of sea turtles and the Georgia shrimping industry.

IX. SUMMARY AND CONCLUSIONS

The number of vessels which could potentially shrimp in Georgia waters in 1976, based on license records, was 1388. More than half of these (728 or 52 percent) were less than 20 feet in length, representing a non-commercial group which shrimp primarily on weekends for private consumption.

An unknown number of 127 vessels in the 20 foot to 30 foot class are included in the noncommercial shrimping fleet. The noncommercial fleet was not studied, but general observations of their activities, small gear employed, and limited shrimping suggests that the non-commercial shrimper does not account for a significant portion of sea turtles killed each year in shrimp nets.

There were 533 vessels greater than 30 feet in length that purchased shrimping licenses in 1976. We assume that most were commercial vessels. At least 40 percent (212 vessels) of these were registered in adjacent states. A survey by Nix et al (1975) listed 307 shrimp boats which were off-loading their catch at commercial docks in Georgia in 1975. In 1976 there were 321 vessels greater than 30 feet registered in Georgia.

On 6 July 1977, two days after inshore waters were opened to shrimping, we counted by aerial survey 189 trawlers greater than 30 feet. The average daily number of vessels trawling was 51 prior to 4 July 1977 and averaged 117 after this date.

From interviews with captains and strikers (representing 104 commercial vessels), on-board observations, and commercial dock records, we estimate the following parameters of the Georgia shrimping fleet:

1. the length of the Georgia shrimping season is 6.7 months; since very few turtles are caught off-shore, the near shore season may be a more realistic statistic to use when calculating turtle-shrimper interaction over time.

2. shrimpers, based on interviews, trawled an average of 22.2 days per month.

3. data from on-board observations, including some half day trips, indicate that drags averaged 2.7 per day; interview data estimated 4.5 drags per day.

4. on-board observation data indicated shrimpers averaged 2.6 hours per drag; interview data indicated 2.1 hours per drag.

5. commercial boats pull nets with an average width opening of 56.5 feet. Two nets are pulled at a time, thus having a total drag path width of 113 feet.

6. an average commercial craft may be expected to have its nets deployed 1110 hours per year, dragging a combined area of 57,757 acres per year of 388 acres per day. A 300 vessel fleet could conceivably drag a total area of 27,072 square miles. Since much shrimping is conducted in favorite channels or holes, these areas receive an enormous amount of drag time per unit area.

Incidence of capture appears to be low off-shore and late in the season, but is high in near-shore areas, especially during the first days of the season. When sounds are opened late in the season (as in October, 1976) the capture of turtles is minimal.

Based on average activity patterns for commercial boats, 30.7 turtles per vessel per year were captured at the rate of .06 turtles per drag during a 6.7 month season or .09 turtles per drag during a 5 month near-shore season. During limited inshore on-board studies, we recorded .20 turtles per drag. Since many captains estimated one turtle caught per day during inshore fishing, our estimate of 30.7 turtles per season may be too low.

Our selection of size classes for the interviews (carapace lengths) were: less than 20 inches, 20 - 30 inches, and greater than 30 inches. However, our measurements of turtles found dead on the beach revealed a possible bimodal distribution with approximately 88 percent of the individuals measuring 22 to 34 inches and 12 percent measuring 36 to 42 inches, with some overlap. There were no loggerheads less than 20 inches. Ridley turtles were generally less than 20 inches in carapace length.

The data estimated equal numbers of turtles were captured in the 20 - 30 inch and greater than 30 inch size classes. If the turtles which stranded on the beaches reflect the distribution of shrimper induced mortality, than a proportion (38 percent) of the larger juveniles were included in the greater than 30 inch class. Our earlier observation that most turtles being caught are juveniles and not nesting adults is supported by the fact that only 3 percent of 1,000 female sea turtles tagged on St. Andrew Sound nesting beaches (Jekyll, Little Cumberland, Cumberland) have been captured by shrimpers in the St. Andrew Sound area.

The number of turtles caught per boat per year seems to be directly related to net widths, reaching a maximum for nets with individual openings greater than 60 feet in width.

Fourteen loggerheads and two Ridleys were captured during an intensive shrimping period when sounds were opened in Georgia on 4 October 1976. This low number would indicate that most sea turtles had left Georgia waters in October. For years prior to 1977, October was the second greatest month for total records of turtle strandings on the beaches.

We were unable to define the distribution of turtle captures by habitat. Most captures occur where shrimpers preferentially drag, particularly the sounds, channels leading into the sounds, and the flats on either side of the channels. Channels associated with the Savannah River, Ossabaw Sound,

and St. Andrew Sound were areas heavily shrimped and resulted in the capture of many turtles. Several shrimpers reported catching 50-100 turtles during 1976 in the Brunswick Channel. Such captures may reflect a hatchery program on Little Cumberland Island (100,000 young released since 1965).

Based on interview data, minimal mortality rate is 7.9 percent. The 321 commercial vessel Georgia fleet of 1976 thus could kill 778 turtles annually. During our on-board observations, we recorded 15 percent mortality (after resuscitation) for all captured sea turtles (4/26) and 19 percent for loggerheads (4/21).

We were unable to accumulate sufficient on-board observations to correlate physiological conditions of captured turtles with length of drag time. Since a turtle can enter at any time during a drag, a very large sample will be needed to define this statistic. We observed one loggerhead that was dead after a 2.5 hour trawl. We found that drag time was directly related to size of vessel (length) for small to medium craft and that vessels greater than 40 feet in length averaged 2.2 hours per drag.

Because 1976 and 1977 were highly irregular shrimping seasons, we were not able to adequately describe periodicity and frequency of captures. With the exception of leatherbacks, most sea turtles are caught inshore (within 2 to 3 miles of the islands). The appearance of dead turtles on the beaches in 1977 coincided exactly with the opening of the inshore shrimping season on 6 July.

We have constructed a population model to assemble and interpret the data relating to capture of turtles in Georgia. The model meets several stringent constraints developed from 14 years of nesting and tagging data on loggerheads from Little Cumberland Island. The model predicts a total population of 1170 adult females, of which 47 percent nest per season.

It also predicts that 182 new turtles will enter the breeding population each year. Assuming 650 turtles are drowned in shrimp nets each year, and if 12 percent of these are nesting adults, then the Georgia population could be sustaining an incidental harvest equivalent to 7 percent of the total adult female population, 12 percent of the annual nesting population, and 43 percent of the annual recruitment of new adult female turtles to the population.

Assuming 25 percent survival of the eggs on the beach, the model predicts that only .5 percent of the hatchlings would need to reach maturity to sustain the population (5 adults per thousand hatchlings).

Obviously, the survival strategy of the loggerhead is such that very high juvenile mortality at some stage in the life cycle must occur without endangering the population. However, since the origin of juvenile turtles in Georgia is unknown (they may represent Florida and South Carolina reproduction), the relationship of juvenile mortality in Georgia to the regional loggerhead population is further confounded.

Damage to gear or to commercially important species (shrimp, crabs, and fish) captured with the turtles does not seem to be a significant factor for the Georgia shrimp fisherman. Only five individuals out of 104 interviews commented on damage to gear. Three stated that they had never had to cut a net to release a loggerhead. One individual had to cut a net to release a leatherback; another had to cut a try net to release a sea turtle. None of the shrimpers interviewed mentioned damage to the catch from the crushing weight or uncontrolled thrashing of captured sea turtles.

The possibility exists that the Georgia shrimping industry is inducing serious mortality in the numbers of loggerheads in Georgia. It is also possible that shrimper-induced mortality is well within the limits of sustained yield for the loggerhead species. Both possibilities must be carefully considered in the formulation of any management plan or rules and regulations relating to sea turtles and shrimping in Georgia.

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Appendix I. An example of the questionaire used during the interviews of captains and strikers, 1976.

INTERVIEWS WITH CAPTAINS

Boat_____

Captain's Name_____

Years on this boat_____ Years shrimping_____

Strikers Name_____

Years on this boat_____ Years shrimping_____

Length of boat_____ Date of interview_____

Home dock_____Normal shrimping area_____

Average days of shrimping per month___Months shrimped in Ga. _____

Length of trips_____ Average length of trawls_____

Average depth of trawls_____ Average No. trawls per trip__

Types of gear_____ Size of nets_____

Average number of turtles captured per trip_____

Species captured (#)_____

Size classes of turtles captured: 20"____ 20"-30"____30"___

No. of turtles released alive: 20"____ 20"-30"_____30"_____

No. of tagged turtles captured annually_____

No. of turtles captured 1975_____

Other observations: type of weather, seasons, etc. which may correlate with turtle capture, areas of frequent or infrequent captures, etc.

Appendix II. A complete listing of the shrimping activity patterns by each of 103 individual vessels represented in the interviews.

Vessel	Dock	Vessel Length (Feet)	Net Width (Feet)	Gear Type	Shrimping Patterns: Months Per Year	Days Per Month	Trawls Per Day	Hours Per Trawl	Size Classes of Turtles (%): 20'-30'	30'	Estimated Captures: 1975	1976
CHATHAM COUNTY												
Leslie Lee	27	65	50	Split	7.5	26	4	2	70	30	30	18
Warrior	27	67	55	Flat	8	20	4	2	100	0		12
Shady Lady	26	70	75	Flat	8		3.5	2	100	0		
Green Wave	26	50	46	Flat	8	24		2	100	0		
Georgia Baby	26	62	60	Flat		20		2	100	0		
Francis Ann	30	72	75	Flat	7	24	4	3	75	25	100	50
Miss Inah	31	50	40	Balloon	6	25	6	2	25	75	40	
Natalie B.	26	72	65	Flat	7.5	26	5	1.75	25	75	30	30
Miss Tiffany	26	65	60	Flat	3.5		5	2	25	75	100	50
Josie N. II	28	52	50	Balloon	7	25	4	2.5	25	75	75	20
Georgia II	26	52	45	Flat								
Ann H.	26	50	55	Flat	7	20	4.5	2	80	20	25	10
Mr. Mike	30	78	75	Balloon	7.5		4	2.25	50	50	25	10
Capt. Savie	26	55	50	Flat	6	23	3.5	3	33	67		15
Deborah Ann	27	65	65	Flat	7.5	24	4.5	2.5	0	100		6
Long Reach	26	55	60	Balloon	7.5		4.5	2	0	100		3
Terri Ann	32	81	65	Flat	7.5	24	4	3	25	75	20	10
Wanda	31	50	38	Flat	6		5	2	100	0	2	5
Premuda	26	60	58	Flat	7	24	5	2	25	75	12	6
Popsie	25	62	65	Balloon	7.5	25	3.5	3	25	75	20	20
Miss Sandra Dean	31	55	40	Balloon	7	22	4.5	2	75	25	50	25
Lois Lee	26	60	58	Balloon	7.5	24	4	2.5	50	50	30	10
Jeanne "M"	25	60	57	Flat	7.5	25	4.5	3	25	75	6	10
Miss Brenda	25	60	60	Flat	7	23	4	2.5	25	75	20	10
Duchess	31	50	45	Flat			5	1.75				
Capt. Frampton	31	67	50	Exp.	7.5	23	5	1.75	75	25	50	25
GA0068SH	L	16	40	Flat	7	22	5	1			2	1
GA0102HC	L	16	30	Flat	6	21	5	1	90	10	8	4
Jo Ann	30	41		Flat	6.5	26	5	2	50	50	15	5
GA6024YG	L	24	40	Flat	6	14	4.5	1	80	20	20	10
Roger Boy	27	57	50	Flat	7	21	4	2.25	50	50	20	15
Capt. Cracker	T	62	60	Flat	4		4.5	2.5	50	50		5
Bread Winner	29	65	50	Flat	7.5	24	4.5	2.25	25	75	35	12
Louisa A. IV	32	45	45	Balloon	7.5	22	4	2.75	100	0	4	2
Hen Lee	27		60	Flat	7	20	5	2	100	0	6	2
Lisa Lee	T	50	50	Balloon			5	2				
Carol Ann	26	67	65	Flat	6.5	24	5	2	25	75	25	25
Ebb Tide	26	65	65	Balloon	7	22	5	2	25	75	40	40
Big Mike	27	68	60	Flat	7.5	22	3.5	3	50	50	20	10

Appendix II. Continued. A complete listing of the shrimping activity patterns by each of 103 individual vessels represented in the interviews.

Vessel	Dock	Vessel Length (Feet)	Net Width (Feet)	Gear Type	Shrimping Patterns: Months Per Year	Days Per Month	Trawls Per Day	Hours Per Trawl	Size Classes of Turtles (%): 20'-30'	30'	Estimated Captures: 1975	1976
McINTOSH COUNTY												
Scotch	V	52	53	Balloon	6.5	21	5	2.25				10
Two Girls	11	50	45	Flat		16	5	2	100	0		8
Struggler	V	50	75	Flat	6.5							
Wm. Patrick	MS	62	75	Flat	6	22	5.5	2				25
Flying Tiger	13	28	40	Flat	6	20	6	1.5			9	0
Cabaret	MS	60	70	Flat	6		5	2				20
Clino	13	50	55	Balloon	6.5	19	5	2.5			25	
Cumberland	13	68	64	Flat	6	21	5	2			45	20
Golden Rebel	13	72	75	Flat								
Tommy Jr.	14	48	50	Flat	6.5	24	5	2			25	10
Dawn	15	62	58	Balloon	7	22	5	2	10	90		5
Sea Raven	MS	50	62	Flat	6.5	24	3.5	2	50	50		25
June Gail	19	60	50	Flat	6.5	16	7.5	1.25	100	0		3
Hustler	13	68	75	Flat	6.5	23						
El-Mar	19	68	75	Flat	6.5	24	5	2	0	100		25
Whipporwill	V	40	70	Flat	6.5	13	7.5	1.5				3
Sunset	19	58	60	Flat	6.5	22	5	2.25	0	100	40	
Don	V	66	68	Balloon	5.5	24	3	3	50	50		10
Sea Miss	MS	51	38	Flat	7	22	5	2	100	0		5
Kelly Marie	D	45	45	Flat	2.5	24	4	2.75	75	25		4
Harbor Lights	D	57	69	Flat	6.5	25	5	2.25				10
Traitor	22	58	50	Flat	6.5	23	5	2	100	0		15
Calypso	13	68										
Four Winds	13	68	60	Balloon	6.5	25	6	1.75				6
Brandy	19	65	65	Balloon		22		2.5				5
Showdown	19	58	65	Balloon	6.5	26	3.5	2.5	0	100	40	5
New Hope	19	63	65	Flat	6.5	22	3.5	3			30	30
Nomad	18	62	55	Balloon	7		4	2.25	25	75	20	
Mar Gin	18	50	45	Flat	7.5		3.5	2	25	75		10
LIBERTY COUNTY												
High Noon	23	55	55	Flat	6.5	30	4	2.5	0	100		7
Big Wheel	23	64	65	Flat	6.5	21	5	2	0	100		6
West Wind	23	72	65	Flat	6.5	17	3.5	3				10
Grey Ghost	23	63	45	Flat								6
Miss Dorchester	23	54	45	Flat	7.5	20	5	2	33	67		10

Appendix II. Continued. A complete listing of the shrimping activity patterns by each of 103 individual vessels represented in the interviews.

Vessel	Dock	Vessel Length (Feet)	Net Width (Feet)	Gear Type	Shrimping Patterns: Months Per Year	Days Per Month	Trawls Per Day	Hours Per Trawl	Size Classes of Turtles (%): 20'-30'	30'	Estimated Captures: 1975	1976
GLYNN COUNTY												
Evening Star	7	68	60	Balloon	6				75	25	40	
Southern Crown	7	60	48	Balloon	6	20	3	2	90	10		100
Sea Bright	6	68	60	Flat	7	27	3.5	3.5	75	25		
Kimgale	9	51	52	Balloon	7.5	20	5	2	10	90		100
Two Boys	6											
Capt. Eugene	B	56	50	Flat	7	20		2	5	95		40
Chalricstan	9	28	40	Balloon	6	24	5	2	100			
Sandpiper	6	68	76	Flat	7	24	4	2	50	50	50	
Wave	9	55	52	Balloon	5	24	4	1				
Miss Lucille	7	65	65	Flat	3	22	4	2	25	75	30	
Three Girls	6	73	72	Flat	7.5	22	4	2	50	50	60	50
Daisy H.	7	58	55	Balloon	7		4	2	75	25		40
Altamaha II	C	47	45	Balloon	7.5	21	4	2.5	50	50	30	
Winnie	C	68	58	Flat	7.5	20	4	2.5	25	75	15	10
Ferra Boys	C	60	50	Flat	9	23	3	2.5	25	75	30	
Miss Ester	LCF	75	50	Flat	5	22	4	2	25	75	100	50
Lee Ann	9	40	50	Balloon	6	19	4.5	2	100	0	30	
Antonita R.	9	35	42	Balloon	7	20	3	2	67	33	10	3
Scalper	C	64	65	Balloon	7.5	21	4.5	2.5	100	0	20	3
Sarah Jo	9	33	45	Balloon	3		4	2	100	0	1	0
Starlon	10	40	42	Balloon	5		4	2	75	25	20	1
Tomahawk	LCF	91	100	Balloon								
BRYAN COUNTY												
Myrtle "S"	24	68	60	Flat	7.5	25	4	2	25	75		15
Geechee Bay	24	57	57	Flat	7.5	25		2	100	0		
Stormy Sea	24	72		Flat	7.5	25		2	100	0		
John Patrick	24	73	70	Balloon	7.5	18	4	2	75	25	10	20
CAMDEN COUNTY												
Miss Rilla	3	60	65	Balloon	7	25	4	2			50	
Big Mack	3	48	55	Flat	7	23	4	2	100	0	35	
Lady Louise	3	53	55	Balloon	8.5	24	4	2	25	75		20

Appendix III. On-board observations of shrimp boat activity patterns and turtles captured in Georgia, 1976

Vessel	Date	Trip Start	Trip Finish	Hours of Trip	Gear Type	Net Size Feet	Trawl Start	Trawl Finish	Hours of Trawl	Trawl Depth Feet	Trawl Location	Carapace Length	Condition Turtles Captured
Scotch (52')	13 Aug.	0430	1230	8.0	Balloon	53	0625	1010	3.75	10	Wassaw Channel	-	-
Clino (50')	16 Aug.	0430	1300	8.5	Balloon	55	0710	0820	1.17	-13	Lt.St.Simons Ch.	-	-
							0830	0940	1.17	-13	" "	-	-
Southern Lady (58')	2 July	0400	2000	16.0	Flat	45	0800	1100	3.00	-20	Wassaw Channel	-	-
							1130	1445	3.25	-25	" "	73.6cm	active
							1500	1750	2.83	-25	" "	-	-
Warrior (67')	2 Aug.	0430	1500	10.5	Flat	58	0620	0750	1.50		Ossabaw Channel	63.2cm	active
							0815	1120	3.17		" "	-	-
Leslie Lee (65')	31 July	0430	2100	16.5	Split	50	0645	0910	2.42	-30	Ossabaw Channel	-	-
							0930	1215	2.75	-30	" "	55.2cm	active
							1235	1530	2.92	-15	" "	-	-
							1615	1935	3.33	-30	" "	-	-
Leslie Lee (65')	1 Aug.	0500	2100	16.0	Split	50	0625	0845	2.33	-30	Ossabaw Channel	-	-
							0900	1045	1.75	-25	" "	-	-
							1100	1330	2.50	-25	" "	-	-
							1400	1810	4.17	-25	" "	-	-
							1830	2015	1.75	-25	" "	-	-
Leslie Lee (65')	2 Aug.	0430	1500	10.5	Split	50	0620	0850	2.50	-20	Ossabaw Channel	69.6cm	dead
							0900	1120	2.33	-20	" "	-	-

Appendix IV. On-board observations of turtles captured by shrimp boats in Georgia, 1976.

Vessel	Capture Site*	Date	Species	Sex	Dimensions (Straight-line centimeters) Carapace Length	Carapace Width	Plastron Length	Plastron Width	Condition of Turtle at Time of Capture
Capt. Gene	SAS	28 Sept.	Ridley	M	27.2	26.3	20.0	23.5	active
Miss Angie	SAS	2 Oct.	Ridley	F	73	69	56	61	active
Miss Angie	SAS	2 Oct.	Loggerhead	M	100	70	70	67	active
Lois R.	SAS	4 Oct.	Loggerhead	F	56				active
Miss Wave	SAS	4 Oct.	Ridley	M	32	30	25	24.5	comatose but revived
Miss Sylvia	SAS	4 Oct.	Loggerhead	F	69				active
Morning Star	SAS	4 Oct.	Ridley	M	recapture of #5				active
Julio	SAS	4 Oct.	Ridley	M	36				active
Miss Fernandina	SAS	4 Oct.	Loggerhead	F	50				barely alive but revived
Miss Sylvia	SAS	4 Oct.	Loggerhead	F	58				barely alive
Morning Star	SAS	4 Oct.	Loggerhead	M	61	48	49	39.5	comatose; revived
Toredo	SAS	5 Oct.	Loggerhead	F	64				active
Lady Cyleen	SAS	5 Oct.	Loggerhead	F	61				
Scott-Mike	SAS	5 Oct.	Loggerhead	F	60				dead
Scott-Mike	SAS	5 Oct.	Loggerhead	F	60				dead
Miss Lucille	SAS	5 Oct.	Loggerhead	F	recapture of #11				active
Nandy	SAS	5 Oct.	Loggerhead	F	61				active
Miss Angie	SAS	5 Oct.	Loggerhead	F	61	51	46.7	43.3	active
Leslie Lee	OSS	31 July	Loggerhead	F	55.2	48.1	44.3	42.5	active
Leslie Lee	OSS	2 Aug.	Loggerhead	F	69.6				dead.
Warrior	OSS	2 Aug.	Loggerhead	F	63.2	54.8	49.9	47.2	active
Southern Lady	WAS	12 Sept.	Loggerhead	F	73.6	61.1	59.5	55.0	active
Johnnie Walker	CAL	22 Sept.	Loggerhead	F	57.3	50.5	45.6	44.0	active
Barbara Sue	WAS	4 Oct.	Loggerhead	F	54.3	44.6	38.0	39.8	crushed; mortally wounded
Green Wave	WAS	4 Oct.	Loggerhead	F					
Bread Winner	WAS	4 Oct.	Loggerhead	F	59.0	51.3			active

*Capture site abbreviations: SAS - St. Andrews Sound, Georgia; OSS - Ossabaw Sound, Georgia; WAS - Wassaw Sound, Georgia; CAL - Calibogue Sound, Georgia.

Appendix V. Length and width of the carapace of loggerhead turtles found dead on the beach, listed by island, year, and month.

Island	Year	Individuals by Month of Observation
Wassaw	1976	May (83.8x , 61.0x , 63.6x); June (63.1x , 57.5x , 76.8x , 58.0x , 94.8x)July (61.1x , 60.7x); October (69.6x).
Ossabaw	1977	May (55.9x50.8); June (96.5x69.2 , 64.8x54.6, 58.4x45.7); July (94.0x71.1); August (63.5x50.8, 86.4x76.2); September (61.0x55.9, 63.5x50.8).
Little Cumberland	1976	September (94.0x80.5, 79.0x78.0, 73.5x71.0, 75.0x70.0, 65.0x68.0); October (70.0x69.0, 84.0x76.0).
Little Cumberland	1977	May (102.9x91.4); July (76.0x72.0, 63.0x); September (68.6x67.3, 74.3x64.8, 61.0x61.0, 74.9x68.6).
Cumberland	1973	October (82.6x); November (101.6x92.7).
Cumberland	1974	March (62.2x); April 79.8x); May 98.4x86.4); July (101.5x94.0, 68.0x68.5, 67.7x65.8); August (63.4x63.0); September (75.0x68.5, 67.0x62.2); October (65.0x63.6, 57.8x54.3, 71.7x68.0, 66.3x65.3, 65.0x62.8, 62.5x58.0, 63.7x62.0); November (x63.0, 73.5x70.0).
Cumberland	1975	March (90.8x83.5); April (67.9x62.8); May (61.0x56.5); June (47.5x46.5, 75.0x67.4, 56.8x56.0); July (82.0x74.5, 66.5x65.8, 74.0x70.0, 67.6x64.7); August (69.5x69.0); September (64.0x61.0); October (9916x90.0).
Cumberland	1976	May (67.5x66.5, 58.2x51.8, 68.0x63.4); June (98.5x82.4, 64.5x63.0, 63.3x61.7, 65.0x58.0, 72.0x73.0, 57.5x60.0, 69.7x69.0, 92.0x85.0, 56.0x55.5, 76.5x71.0, 73.0x67.5, 67.0x65.0, 62.0x57.5, 59.5x57.0, 67.7x65.3, 77.0x73.0, 64.0x63.0, 63.0x61.5); August (67.0x70.0, 72.7x67.0, 98.7x89.5); September (100.0x87.5 , 65.3x65.5, 83.0x76.5, 66.0x , 65.0x61.0, 60.0x58.5, 68.0x , 73.0x67.5, 60.0x).
Cumberland	1977	March (56.0x53.0); April (87.0x78.0, 59.0x59.0); July (73.0x74.5, 73.5x73.0, 60.0x62.0, 63.0x61.8, 62.3x57.0, 72.4x71.4, 64.0x61.5, 73.0x , 53.5x50.0, 64.5x63.0, 60.0x55.0, 104.5x98.3 , 77.0x74.3, 65.0x61.5, 64.0x62.6, 65.0x62.5, 64.0x63.3, 71.0x70.0, 63.5x , 68.6x , 62.2x , 62.2x , 66.0x , 71.1x , 72.3x68.7, 63.0x61.0, 97.0x99.0, 67.0x64.5, 57.0x56.0, 68.6x , 73.3x); August (68.6x , 58.4x , 76.2x , 59.0x59.0, 65.5x65.0, 70.0x68.8, 77.0x68.0, 68.5x61.2, 62.0x61.0, 70.0x , 67.5x66.0, 59.5x55.0, 79.0x69.0), Sept. (65.5x64.0, 95.0x90.0, 66.0x).

Appendix VI. The distribution of sea turtle carcasses (all species) found dead on beaches in Georgia, listed by island, year, and month.

Island	Year	Months												Total
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Sapelo	1973					1	15	9	1					26
Cumberland	1973	-*	-	-	-	-	-	-	-	-	4	1	0	5
Cumberland	1974	0	1	1	1	1	1	4	1	2	11	4		27
Cumberland	1975			1	1	2	3	4	1	1	1	6		20
Wassaw	1976					4	6	2	0	0	1			13
Little Cumberland	1976									6	3			9
Cumberland	1976					3	18	0	3	4	3			31
Ossabaw	1977					1	3	1	2	2	-	-	-	9
Blackbeard	1977							22	8	8	-	-	-	38
Sea	1977							20	15	6	-	-	-	41
St. Simons	1977							9	4		-	-	-	13
Jekyll	1977							21	3	1	-	-	-	25
Little Cumberland	1977						1	2	0	4	-	-	-	7
Cumberland	1977			1	2	0	0	31	18	3	-	-	-	55
All Islands	1973					1	15	9	1		4	1		31
All Islands	1974		1	1	1	1	1	4	1	2	11	4		27
All Islands	1975			1	1	2	3	4	1	1	1	6		20
All Islands	1976					7	24	2	3	10	7			53
All Islands	1977			1	2	1	4	104	50	24	-	-	-	186
All Islands	1973 -1977	0	1	3	4	12	47	123	56	37	23	11	0	317
All Islands	1973 - 1976	0	1	2	2	11	43	19	6	13	23	11	0	131

* Beach not patrolled.

Appendix VII. Research on Nesting Populations of Loggerheads in Georgia.

Our research efforts have produced new information on sea turtles, primarily juvenile loggerheads, captured by commercial shrimping vessels in Georgia. We have frequently utilized information from other investigations, particularly current tagging programs on Georgia nesting populations, in order to place our results in the total perspective of sea turtle population biology. In this chapter, we provide a history and summary of the Georgia tagging programs. Since most of the results from these investigations are unpublished, we summarize several of the unpublished manuscripts pertinent to this report.

Tagging Programs on Georgia Islands

The first research dealing with nesting loggerheads in Georgia was initiated on Jekyll Island during the summer of 1959, at which time 72 adult female turtles were tagged on the beach. This effort produced an indepth study of seasonal loggerhead nesting behavior (Caldwell et al, 1959) which documented, among other observations, multiple clutches per season by individual turtles and long range migration, at least by the breeding females. The 1958 Jekyll research was supported by grants fron the National Science Foundation and from the Georgia Game and Fish Division.

A Georgia tagging program was reestablished in 1964 on Little Cumberland, and in 1972 tagging was extended to Cumberland, Jekyll, Ossabaw, Wassaw, Little St. Simons, Tybee, and St. Catherines Island. Out of this effort developed permanent projects on Little Cumberland, Cumberland, Jekyll, Ossabaw, and Wassaw Islands. Table 17 summarizes the number of nesting female loggerheads observed each summer on the principal islands involved.

Table 17. Total adult female turtles observed per year on the nesting beaches by the principal tagging programs currently active on the Georgia coast.

Year	Island					
	Cumberland	Little Cumberland	Jekyll	Ossabaw	Wassaw	Statewide
1964	-	120	-	-	-	-
1965	-	56	-	-	-	-
1966	-	100	-	-	-	-
1967	-	114	-	-	-	-
1968	-	78	-	-	-	-
1969	-	122	-	-	-	-
1970	-	76	-	-	-	-
1971	-	101	-	-	-	-
1972	*	125	64	-	*	189
1973	*	59	32	14	25	130
1974	63	51	54	45	48	261
1975	65	55	36	16	38	210
1976	50	44	31	-	47	172
1977	44	50	29	45	43	211

* Incomplete coverage.

Turtles which nest on more than one island, particularly those utilizying the combined beaches of Cumberland and Little Cumberland, have been equally apportioned in Table 17 to one or another of the islands but not to more than one island. This permits the figures to be combined to represent total nesting females observed on the Georgia coast. Islands with some tagging but less than a representative beach patrol for a particular season are marked with an asterisk and not included in the figures.

Little Cumberland Island

Tagging on Georgia nesting beaches was resumed in 1964 on Little Cumberland Island and continues on that island today. The Little Cumberland turtle project is funded by the island owners in cooperation with the National Audubon Society and receives additional financial and technical support for its tagging operation from Dr. Archie Carr of the University of Florida. In addition to tagging, an active hatchery program accounts for the release of 6,000 to 10,000 hatchling turtles per year for a combined yield of approximately 100,000 turtles since the inception of the hatchery program in 1965.

Cumberland Island

A small amount of tagging was initiated on Cumberland Island in 1972 for the purpose of testing the amount of nesting overlap between the Little Cumberland and Cumberland populations. This practice was continued in 1973 and, finally, in 1974 a full scale beach patrol was achieved which has continued each summer until the present. Since the actual overlap between the two islands proved to be 20 percent of the combined nesting population, the Cumberland project has been invaluable for extrapolating total population numbers from the Little Cumberland data. The Cumberland turtle project has been sponsored financially and logistically by the National Park Service and by owners of the Candler estate on the north end of the island.

Jekyll Island

The Jekyll Island turtle project, reinitiated in 1972, completed the coverage necessary for a definitive analysis of the St. Andrew Sound turtle nesting area. The three islands of Jekyll, Little Cumberland, and Cumberland bracket the entrance to St. Andrew Sound and collectively account for one of the most concentrated loggerhead nesting areas in the Southeast.

By combining data from the three islands, new theories are developing which deal with the integrity of a population unit, the concept of an island as a boundary for the population, interisland shifting and nesting overlap, navigational movements to and from the nesting beach, and more accurate estimates of total breeding females so essential for proper management guidelines. The Jekyll Island turtle project represents a combined supportive effort involving the Georgia Game and Fish Division (through the Georgia Governor's Intern Program), the Jekyll Island Authority, the Brunswick Junior College, the Coastal Georgia Audubon Society, the Governor's Emergency Fund, the University of Georgia, and numerous volunteers.

Ossabaw Island

The Ossabaw Island turtle project was initiated in 1972 and has continued to be active during all nesting seasons except for 1976. Adult female turtles are tagged on the nesting beach, and eggs are transplanted to a protected hatchery. The Ossabaw turtle project has been privately funded during the first three years of its existence by the Ossabaw Island Project Foundation, a nonprofit private foundation created and funded by owners of the Island. In 1975, alternative funding was obtained from the Georgia Governor's Intern Program, from the New York Zoological Society, and from a private donation by one of the island owners.

Wassaw Island

Preliminary tagging of nesting adult turtles on Wassaw Island began in 1972. A full beach patrol has been active since 1973. As with other Georgia turtle projects, there is a scientific goal to record field data and tag the adult turtles and a conservation goal to protect eggs and produce hatchlings from a controlled hatchery. The Wassaw turtle project is a cooperative venture of the Savannah Science Museum and the U.S. Fish and Wildlife Service. Funding and additional personnel are obtained through public participation. Participants in the project come to Wassaw Island for one week periods, assist in the all-night patrols, and receive room and board for which they pay a fee.

Basic tagging information, such as location and time of emergence, location of beach, and clutch size, are pooled by all of the Georgia projects in a shared data processing system at the University of Georgia. In this manner, thousands of tag numbers and turtle observations are compiled and coordinated. Turtles appearing on more than one island are quickly recognized with a computerized information retrieval system. Ultimately, the sharing of data through a cooperative system will provide the best possible estimates of total population numbers in Georgia. The dividends of cooperative sharing are already becoming a reality, as evidenced by research papers on the Georgia nesting loggerheads.

Unpublished Results from the Georgia Tagging Programs

The following summary of recent papers dealing with Georgia's nesting loggerhead turtles originates primarily with data from the Little Cumberland Island turtle project. This project has maintained a consistently replicated patrol on its beach for fourteen consecutive laying seasons. The resulting

accumulation of life histories on individual turtles, of population estimates where each year is but a single sample point, and of significantly large sample sizes has brought to light a whole new series of observations on sea turtle ecology. Four additional turtle projects on Georgia islands have now been in operation since 1972 and are approaching that point where accumulated data will begin to answer new questions. Perhaps with sea turtles more than any other organism, population studies must be supported for many years before the effort is repaid.

Surprisingly few tags have been returned from Little Cumberland nesting loggerheads (Bell & Richardson, 1977). By 1976, 44 tags out of 647 tagged females had been recovered for a 7 percent recovery rate. Thirteen of these recoveries were from nesting turtles on adjacent beaches prior to the development of turtle projects on those islands and are therefore not considered here. An additional five recoveries were from turtles found dead on the beach, and four of these were from local beaches. The remaining 23 recoveries were trawler recoveries representing 4 percent of the total tagged population. Only six of these (1 percent of the tagged population) have been captured in waters within ten miles of Little Cumberland Island.

Unless shrimpers are failing to return considerable numbers of turtle tags, the impact of shrimp boats on tagged nesting female turtles in the immediate vicinity of the nesting beach must be considered minimal. The remaining trawler recoveries (Figure 27) are distributed along the coast north of Little Cumberland and seem to represent a fall or late summer migration of nesting females away from the nesting beach. A possible migratory path is postulated from Georgia to Cape Hatteras, then to the Chesapeake Area, and ultimately to a warm water area in the mid-Atlantic, perhaps the Sargasso Sea. Because spring and early summer recoveries are largely absent, returning turtles appear to be approaching the nesting beach from the sea, not inshore or parallel to the coasts of Florida or the Carolinas.

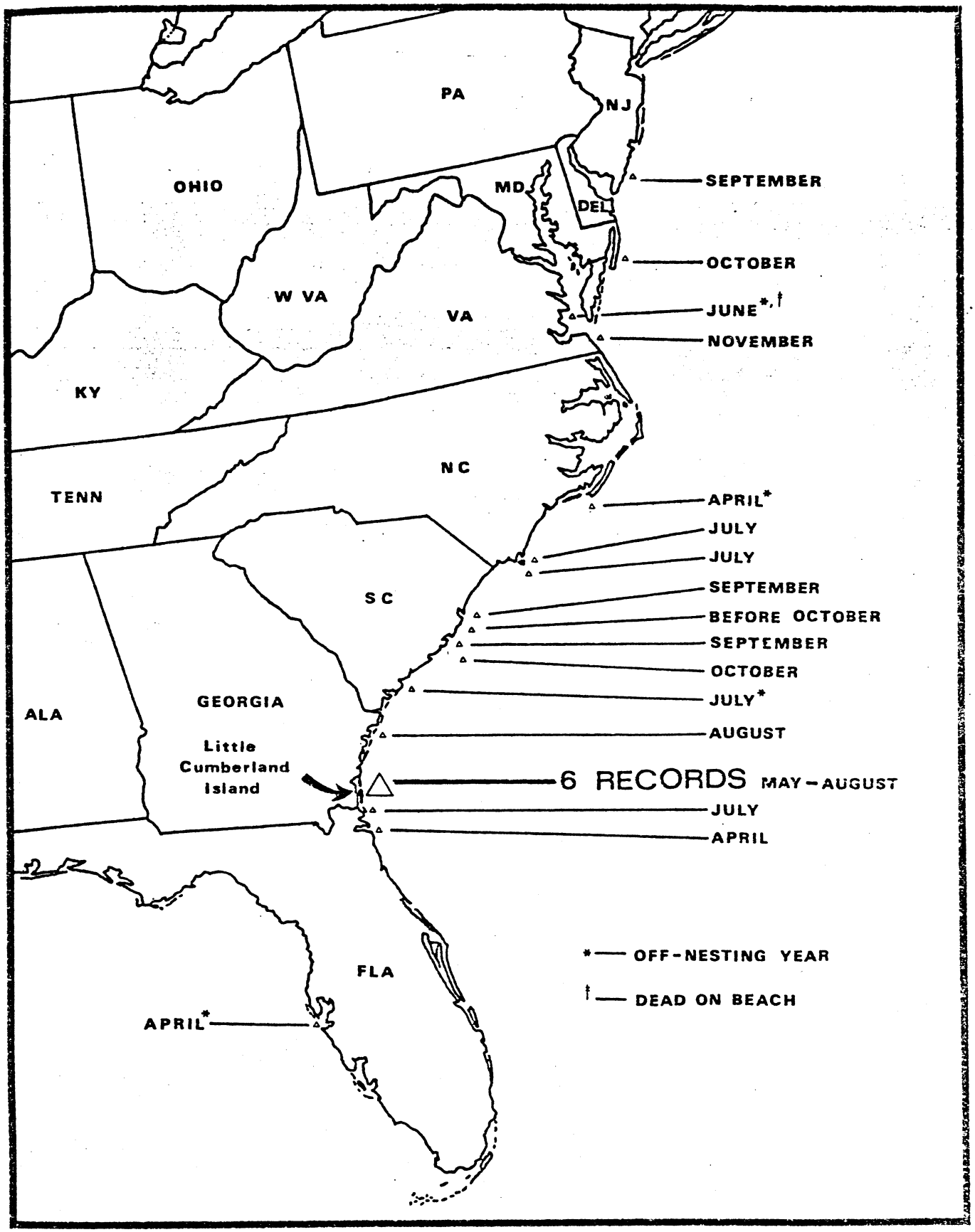

Figure 27. The distribution by area and month of Little Cumberland Island loggerhead turtles captured by trawlers. (From Bell & Richardson, 1976).

Within the St. Andrew Sound area of Georgia, there occurs a seasonal overlap of the nesting populations of loggerheads between Little Cumberland and Cumberland Island (20 percent), Little Cumberland and Jekyll Island (4 percent), and Cumberland and Jekyll Island (2 percent) (J.I. Richardson et al, 1977b). Turtles which shift between islands seem to return to the original island more frequently than can be expected by chance alone. Figure 28 describes the amount of nesting overlap between Little Cumberland and a series of other islands as a function of distance from Little Cumberland.

If a turtle fails to nest successfully (dry run) on the first attempt, she may return within six days for another attempt to lay the same clutch of eggs (Figure 2). Turtles which shift between islands under these conditions will do so only between adjacent islands and at a rate and direction which seems to correlate directly with the relative nesting conditions on the respective islands. If a turtle reappears after nine or more days, regardless of the nesting success of her first visit, she has returned to lay a second clutch of eggs (Bennett and Richardson, 1977). Any tendency to shift to another island at this time is directly related to the absolute distance between the two islands and occurs in either direction with equal frequency.

Based on this analysis of the direction and frequency with which turtles tend to shift their nesting effort from island to island, it is postulated that the adult females move well offshore during the two week interval between consecutive clutches of eggs, returning to the nesting beach for each consecutive clutch by a process of navigational cues. (Our observation in Chapter V that very few tagged adult females are captured near the nesting beaches by commercial shrimp vessels would support this theory.) If a nesting attempt is aborted, the turtle appears to remain close to the nesting beach for a period of up to six days while waiting for a second attempt to deposit the same clutch of eggs.

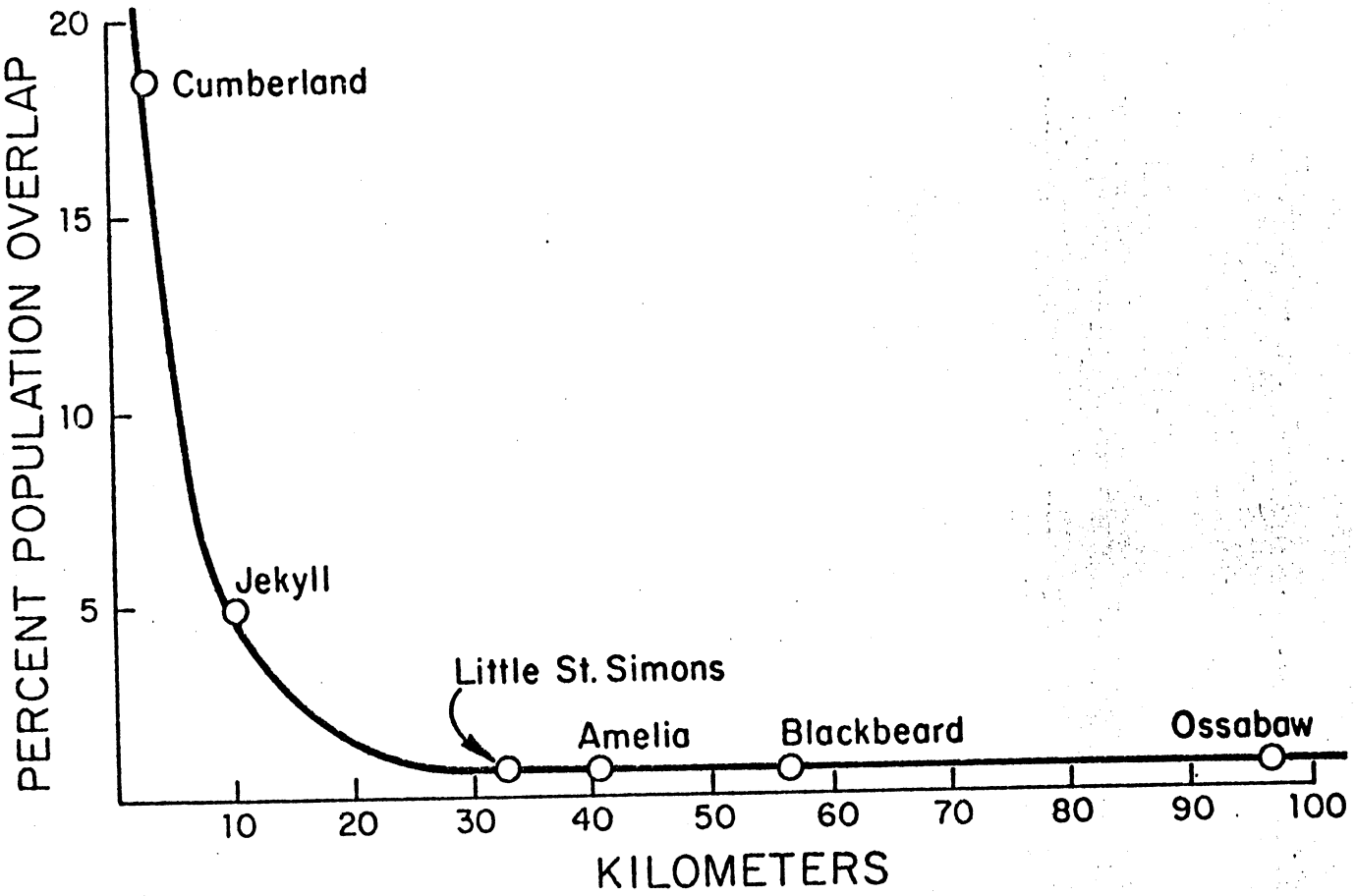

Figure 28. The percent of population overlap of nesting female loggerheads between Little Cumberland Island and adjacent islands as a function of distance from Little Cumberland. (Adapted from Bell & Richardson, 1976).

A conceptual model (Figure 29) considers the return navigational movements of turtles between consecutive nesting visits ("between" nesters) and the local movements of unsuccessful nesting turtles ("within" nesters), including a possible explanation for the frequency with which turtles appear on more than one island. Trawler recoveries in the vicinity of St. Andrew Sound appear to have occurred while the turtles were either approaching the beach on the first attempt to lay or departing the beach after successfully laying ("between" nesters). No turtle has ever been captured or reported by a trawler within six days of an unsuccessful nesting attempt on Little Cumberland Island ("within" nesters).

A closely related problem deals with the ability of a sea turtle to permanently shift its nesting attempts to a new location because of adverse conditions on the original nesting beach. Based primarily on rumor and the opinion of local residents, Caldwell et al (1959) speculated that human development and deteriorating beach conditions probably caused the St. Simons and Jekyll Island turtles to shift their preferred nesting beaches permanently to Little Cumberland and Cumberland Islands. This would imply that an adult sea turtle can switch its navigational preferences to a new nesting beach. The concept is a popular one, having become widely accepted as fact in a number of reports and articles since the original 1959 publication. Actually, not a single example of a permanent nesting shift has been documented by any of the thousand female loggerhead turtles that have been tagged in Georgia. Furthermore, strong site tenacity remains in effect for Georgia sea turtles in spite of the unavoidable but very real harassment of nesting loggerheads associated with the intensive tagging programs currently in operation on Georgia nesting beaches.

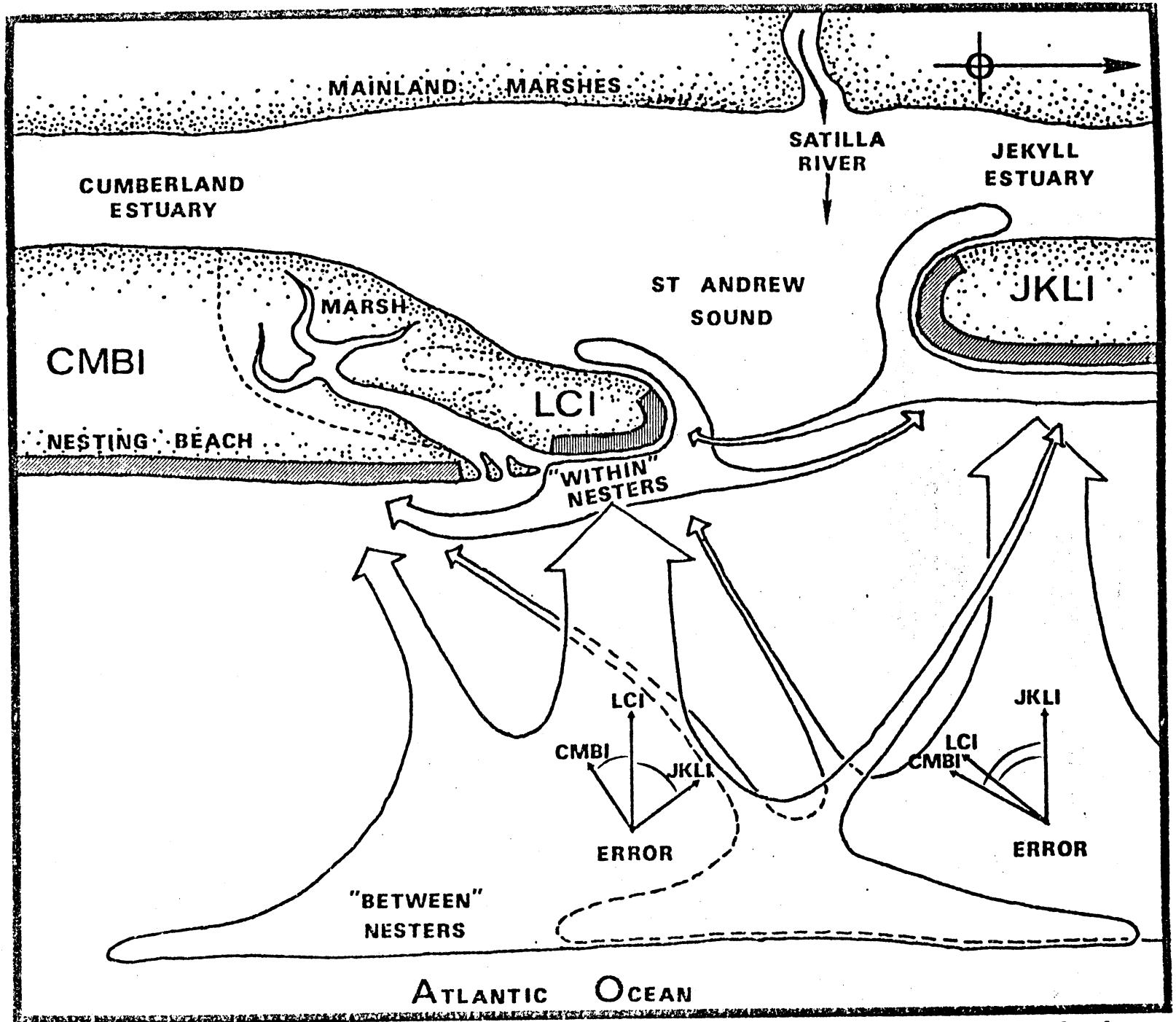

Figure 29. A hypothetical model of the movement and behavior of adult female loggerheads during the nesting season in the St. Andrew Sound area of Georgia (from J. I.

A remigration interval represents the number of years which elapse before a sea turtle returns to her preferred nesting beach. Most remigration intervals (Figure 30) are two or three years in length, but Little Cumberland has also recorded one-year intervals in 3 percent of its returns (T.H. Richardson et al, 1977). Remigration intervals of six to ten years probably occur for a small number of turtles, but tags do not remain on the turtles long enough to document longer intervals.

After population figures have been adjusted for tag loss, incomplete beach coverage, and nesting shifts to adjacent islands, there still remains the undeniable fact that approximately 50 percent of all the turtles which have appeared on the Cumberland beaches for the first time have never returned to those or any other beaches to nest in subsequent seasons. Out of 592 turtles tagged by 1975, at least 290 of them (49 percent) have never been recorded in a subsequent season. Since only 23 of these turtles have been recovered by trawlers, the fate of most of those 290 individuals cannot be linked to death by trawl net. Furthermore, once a turtle has remigrated at least once, its chances of doing so again are at least 70 percent. This is not due to random chance but is a measurable difference which occurs within the nesting population. Some turtles remigrate regularly, but most will never be seen again at the end of their first nesting season. It is both ecologically and biologically illogical that large, long lived animals such as loggerheads should breed but one season in their lives; the fate of the single-time nesters remains an enigma.

Two methods for measuring the size of a population are trap-removal and catch-per-unit-effort (J.I. Richardson et al, 1977a). Statisticians suggest twenty sample points as a minimal sample size. With each nesting season representing one sample, the Little Cumberland project and a similar project in South

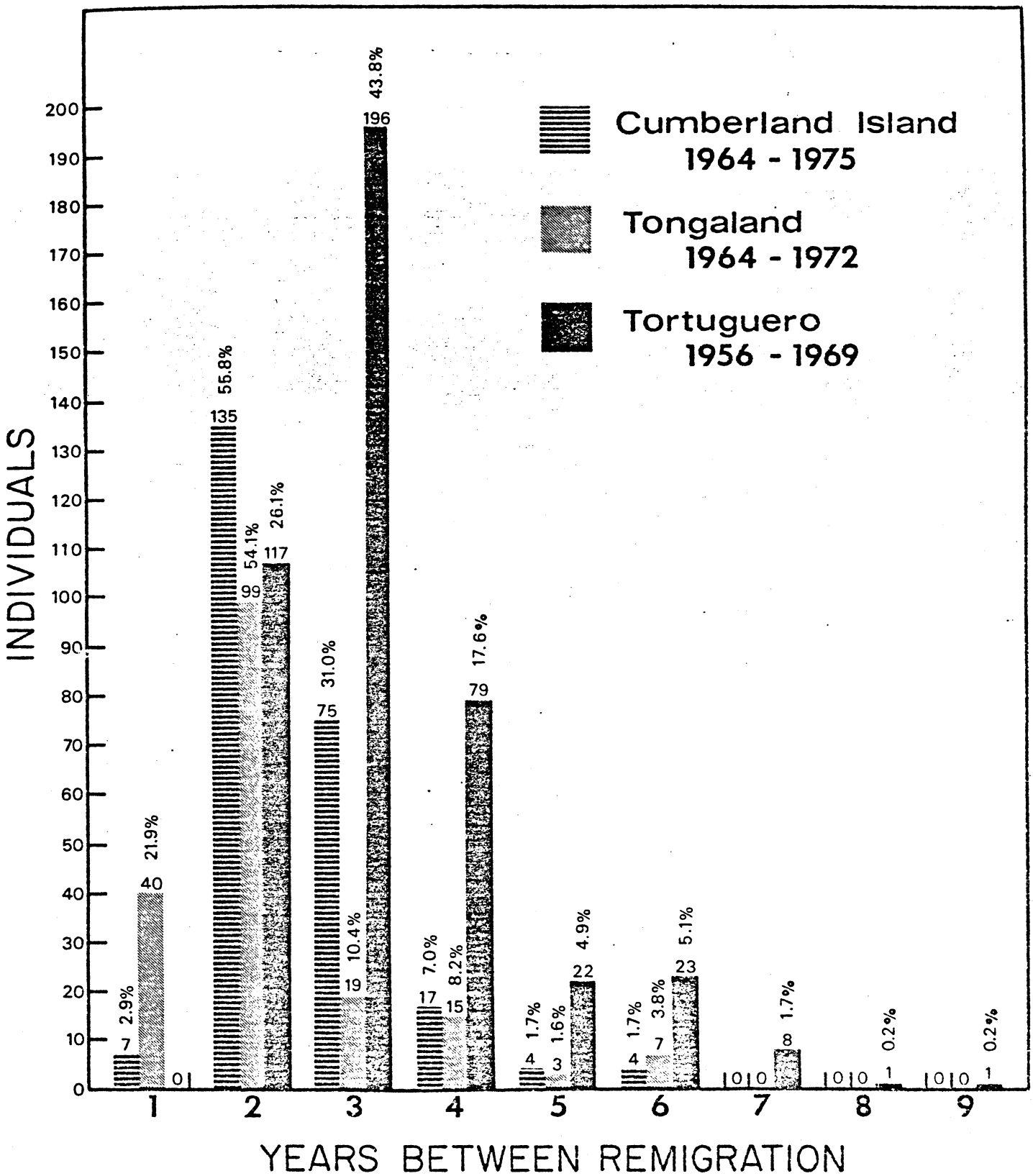

Figure 30. The distribution of remigration intervals observed for loggerheads (Caretta caretta) at Little Cumberland and Cumberland Islands, Georgia, for loggerheads at Tongaland, South Africa (Hughes, 1974), and for greens (Chelonia mydas) at Tortuguero, Costa Rica (Carr & Carr, 1970). (Adapted from T. H. Richardson et al, 1976).

Africa are approaching this number with fourteen such sample points (Figure 31, using eleven seasons). If recruitment and mortality are assumed to be constant and balanced, total population estimates for both projects are predicted to be eight to ten times the average number of laying females in a single season. Actually, these total population estimates are now believed to be too high. More recent estimates, already covered in this report (Chapter 7), suggest that the total population size of adult females may be only slightly more than twice the average number of nesting females observed each season.

A seasonal estimate is in itself difficult to assess since regular fluctuations in seasonal numbers are a regular occurrence (Figure 32). The fact that seasonal fluctuations, beginning in 1973, have suddenly stabilized at a very low level, indicates that perhaps recruitment is no longer keeping pace with mortality. It is also very evident that the release of 6,000 to 10,000 hatchlings per year from Little Cumberland Island has yet to produce a detectable increase in recruitment to the Little Cumberland Island population of breeding females.

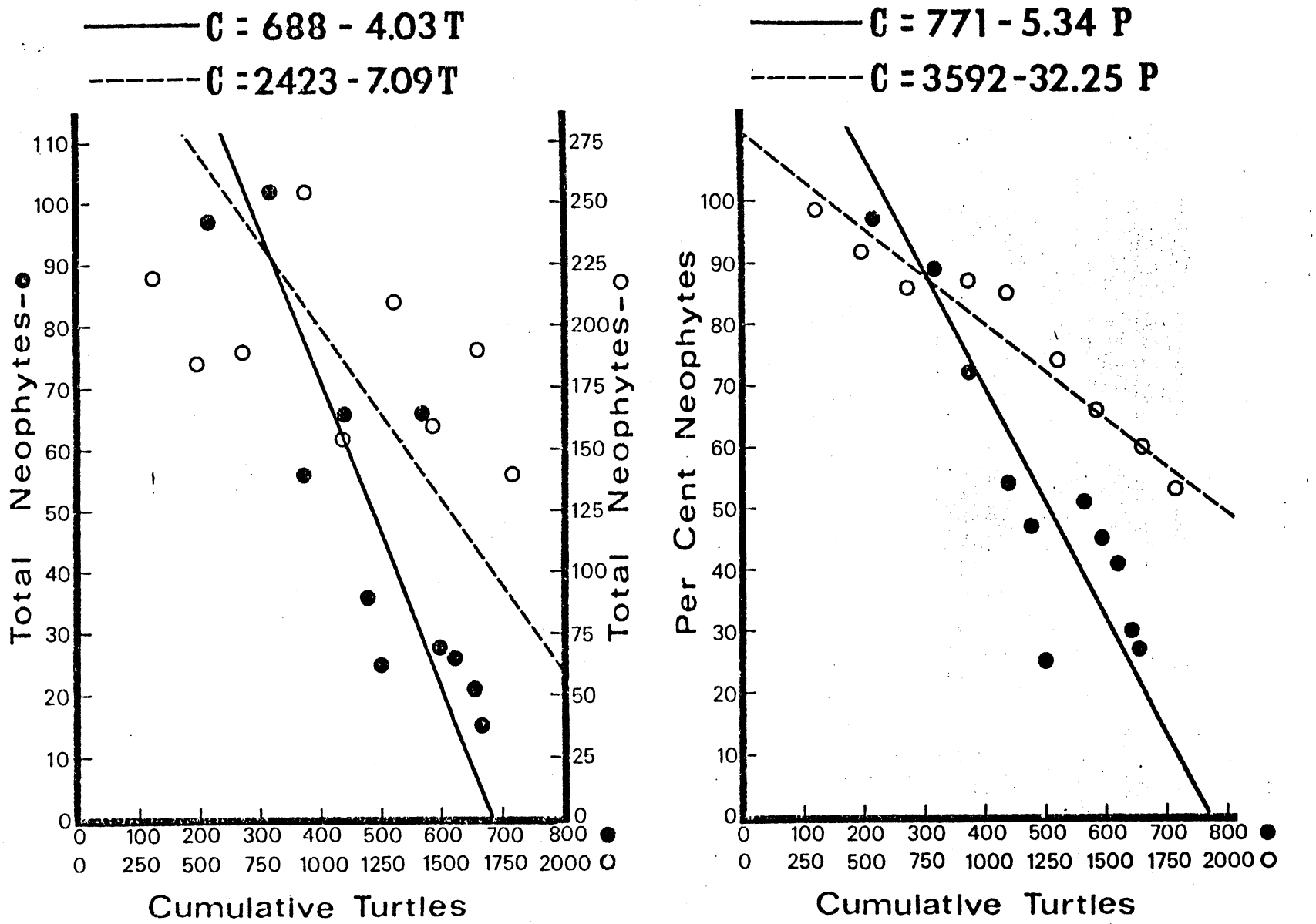

Figure 31. A linear regression comparison of neophyte loggerhead turtles (Caretta caretta) recorded per year to the cumulative number of marked loggerhead turtles up to and including that year. Data are from Little Cumberland Island, Georgia (solid dots and solid lines) from Tongaland (Hughes 1974), South Africa (open circles and dashed lines). (From J. I. Richardson et al, 1976).

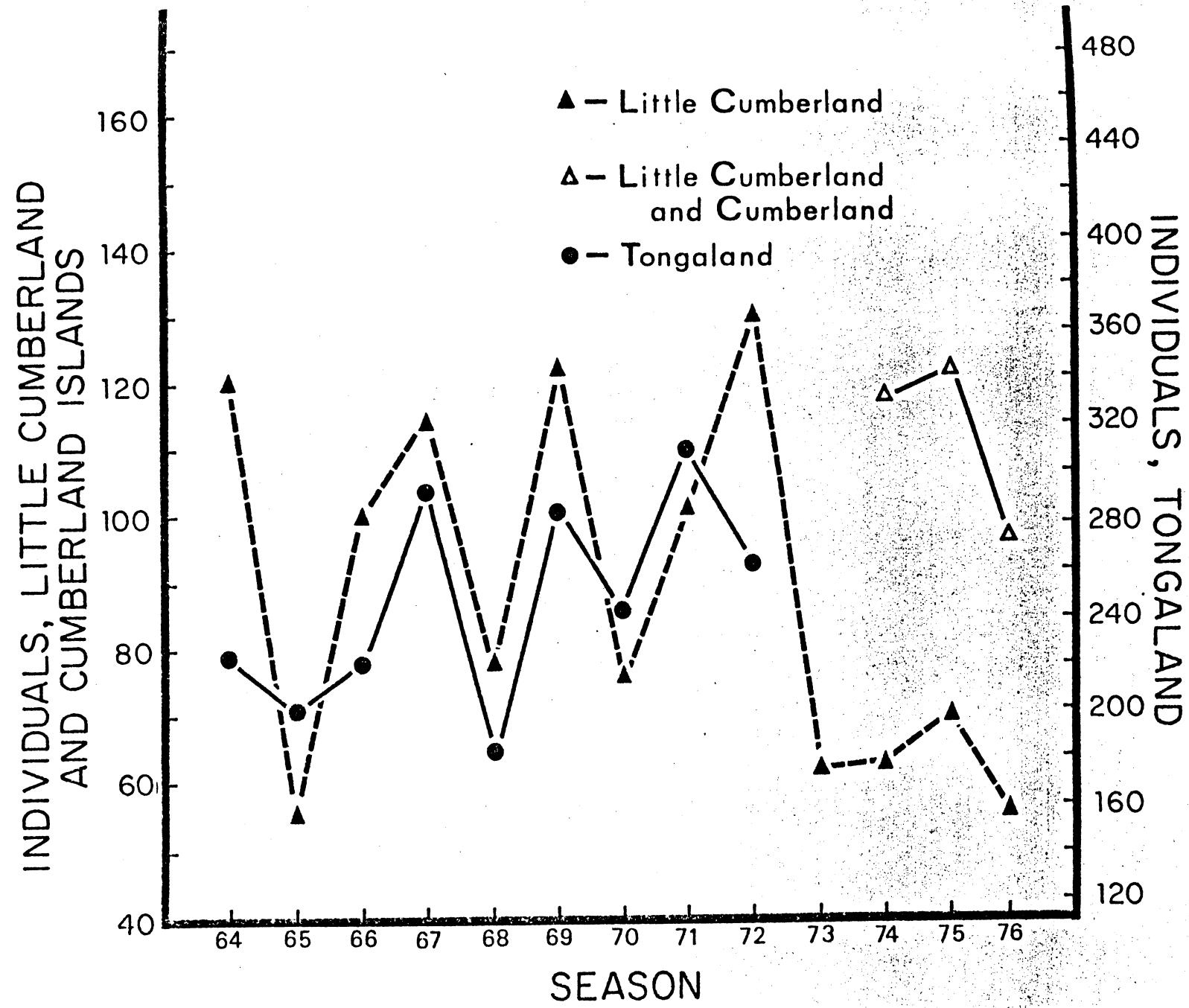

Figure 32. Fluctuations in the annual number of nesting female loggerheads at Little Cumberland Island, Georgia and Tongaland, South Africa (Hughes 1974). A Tongaland season laps a Little Cumberland season by approximately six months. (Adapted from