1981

The status of marine turtles in Chesapeake Bay and Virginia coastal waters

Maryellen Lutcavage
College of William and Mary - Virginia Institute of Marine Science

THE STATUS OF MARINE TURTLES IN CHESAPEAKE BAY AND VIRGINIA COASTAL WATERS

A Thesis

Presented to

The Faculty of the School of Marine Science

The College of William and Mary in Virginia

In Partial Fulfillment

Of the Requirements for the Degree of

Master of Arts

---

by

Maryellen Lutcavage

1981

APPROVAL SHEET

This thesis is submitted in partial fulfillment of

the requirements for the degree of

MASTER OF ARTS

Maryellen Lutcavage

Approved, August, 1981

John A. Musick
Department of Ichthyology

Gerald R. Brooks
Department of Biology
College of William and Mary

N. Bartlett Theberge
Division of Marine Affairs

Marvin T. Wass
Department of Invertebrate Ecology

Christopher S. Welch
Division of Physical Sciences

DEDICATION

This work is dedicated with thanks to Virginia watermen Willy Ashburn, Ed Boyd, Otis Carney, Richard Erdt, Talmadge and Fred Jetts, Willy Jenkins, Carey Heath, Steve Kellum, and Frank of Lynnhaven, for tagging turtles and sharing turtle lore with the author.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

Many thanks to my committee members Jack Brooks, Bart Theberge, Marvin Wass and Chris Welch for their guidance. Barbara Crewe, Claudia Walthall, Nancy Peters, Annette Stubbs, Ann Rooney Char, Ron Ayres, Barry Truitt, Bill English, Bill Walls and Jim Owens deserve recognition for logistic and moral support.

For their special contributions to this effort I wish to thank my major professor Jack Musick for direction and encouragement, and Mo Lynch, who provided initial support for studying sea turtles in Virginia. Vic Zullo (University of North Carolina) and John Killingley (Scripps) graciously donated their time for barnacle analysis. I am especially grateful to friends who have shared the indescribable delights of turtle patrols, and to Joe Sypek, Gene Burreson, Dave Zwerner, Don Hayward, Butch Jones, and Gary Gaston for solving mysteries.

This work was supported by a grant-in-aid from Sigma Xi, the Scientific Research Society, New Haven, Connecticut and by a fellowship stipend from the National Marine Fisheries Service.

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

The Chesapeake Bay serves as a seasonal foraging ground for subadult loggerhead (*Caretta caretta*) and Atlantic ridley (*Lepidochelys kempii*) sea turtles. The abundance, distribution, activities, and mortality of loggerhead, ridley, and leatherback (*Dermochelys coriacea*) turtles were examined. Sea turtles occur in the study region from May through November, with peak abundance in June. Based on commensal organisms and isotope analysis of barnacles, Virginia loggerheads may be derived from nesting beaches in the southeastern U.S.

Substantial sea turtle mortality occurs in Virginia. In 1980, of a total of 828 turtles counted, 288 were carcasses. Major identified mortality sources were accidental capture in poundnet hedging, boat damage, human-induced injury, and predation by the tiger shark (*Galeocerdo cuvieri*).

Seventy-seven sea turtles were tagged and released, with six recaptures in the Chesapeake area. Two forms of incidental catch in poundnets create management problems for Virginia sea turtles.

THE STATUS OF MARINE TURTLES IN CHESAPEAKE BAY AND VIRGINIA COASTAL WATERS

INTRODUCTION

Most information concerning sea turtles found in Virginia and the Chesapeake Bay consists of stranding locations and incidental observations. Several authors as summarized by Musick (1972) have provided records of their occurrence. Hardy (1962) suggested that the Bay may be a summer feeding ground for the Atlantic Ridley turtle (*Lepidochelys kempii* Garman) that move in along with the influx of prey species. Studies are lacking documenting sea turtle distribution, seasonality, abundance, and activity in this estuarine area. The biology and natural history of the loggerhead sea turtle (*Caretta caretta* L.) have been studied by many authors for the southeastern U.S. (Carr and Caldwell, 1956; Caldwell *et al*., 1959; Caldwell, 1962; LeBuff and Beatty, 1971). Recent studies have focused on nesting populations (Talbert *et al*., 1980; Stancyk *et al*., 1980; Richardson *et al*., 1978) and hatchling development (Blanck and Sawyer, 1981). These studies have not addressed the abundance, activity, or human impacts on sea turtles in the northern parts of their ranges.

Shoop et al. (1981), using aerial surveys, studied sea turtle abundance and seasonal distribution in the northeastern coastal waters of the U.S. His work represents the most comprehensive study to date on sea turtle abundance in non-nesting areas of the eastern U.S.

Individuals and small groups of loggerheads are seen predictably throughout Virginia's Eastern Shore and in the Bay as far north as Calvert County, Maryland (Musick, 1972). Sea turtles were reported in

Virginian waters in colonial times by Harriot (1590) in his account of fishing methods in Virginia. A loggerhead sea turtle is accurately depicted in an accompanying drawing by J. White. William Byrd (1737) suggested that at least three species of sea turtles were plentiful in Virginia and were highly prized as seafood.

The Ridley sea turtle, identified by watermen as the "greenfin" is found in the study region, but much less commonly than the loggerhead. Leatherbacks (*Dermochelys coriacea* L.) strand on occasion and have been taken in poundnets by watermen. Locations of recent historic records of area sea turtles are given in Fig. 1. The Atlantic Green turtle (*Chelonia mydas* L.) has been found occasionally in the Bay (Hardy and Mansueti, 1962; Schwartz, 1967) but there are no confirmed records for the Hawksbill turtle (*Eretmochelys imbricata* L.) (Musick, 1979).

Virginia watermen have known that at least two species of sea turtles are common migratory residents of the Chesapeake Bay. Their knowledge remained unexploited until recently. Poundnet fishermen informed VIMS personnel that sea turtles enter their poundnets and become captive in the head end until released when the net is emptied. Lazell (1976) reported that juvenile green turtles are found in poundnets and weirs in New England. Massman (1957) commented on seasonal "Green turtle" mortalities for Virginia, but cause of death was not provided. In 1979, noting the abundance of poundnets in areas of frequent strandings, it was suspected that some mortalities were associated with poundnet incidental catch (Musick, personal

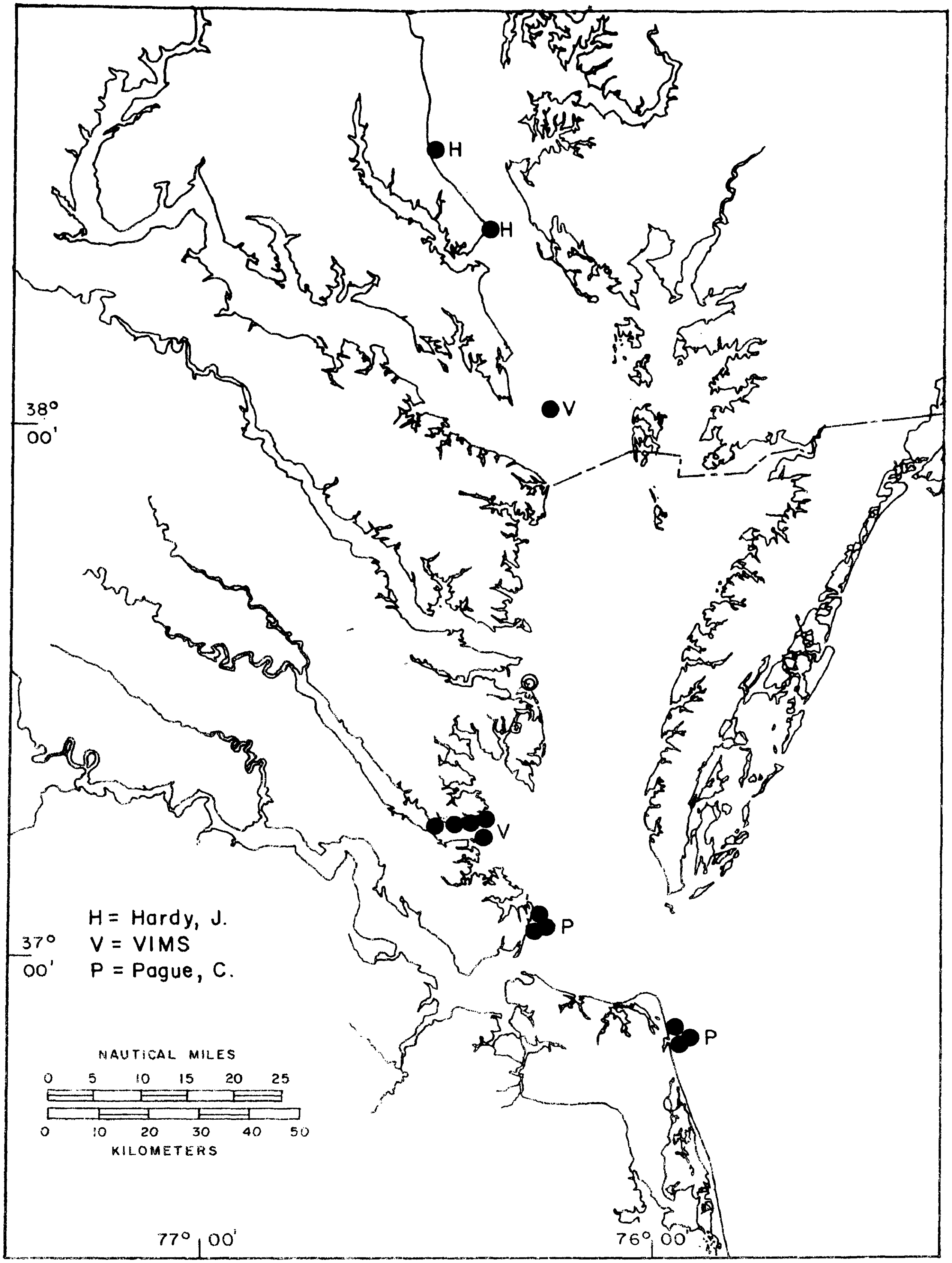
Figure 1. Recent historic records for Chesapeake Bay area sea turtles.

A. *Caretta caretta*

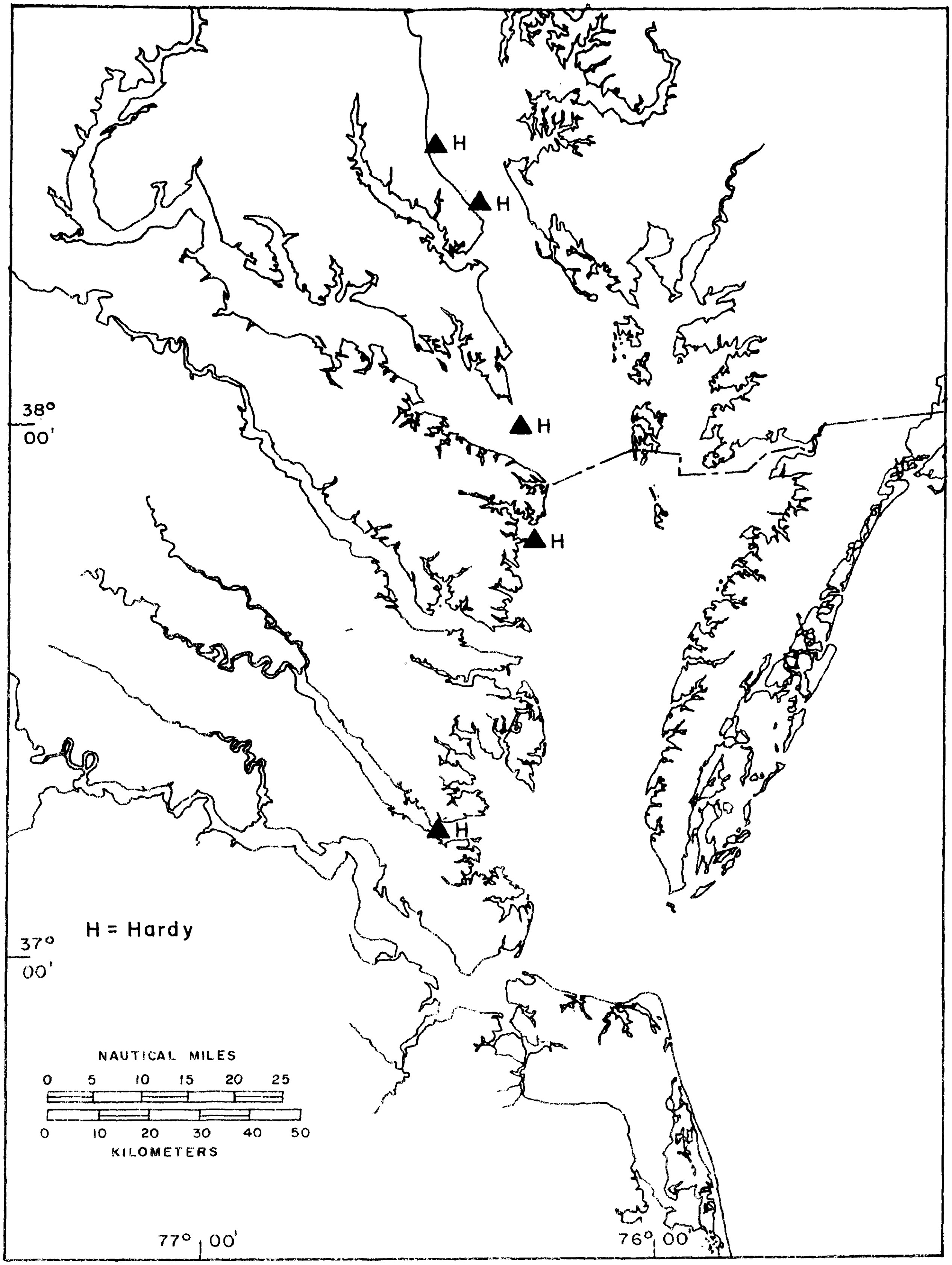
B. *Lepidochelys kempii*

C. *Dermochelys coriacea*.

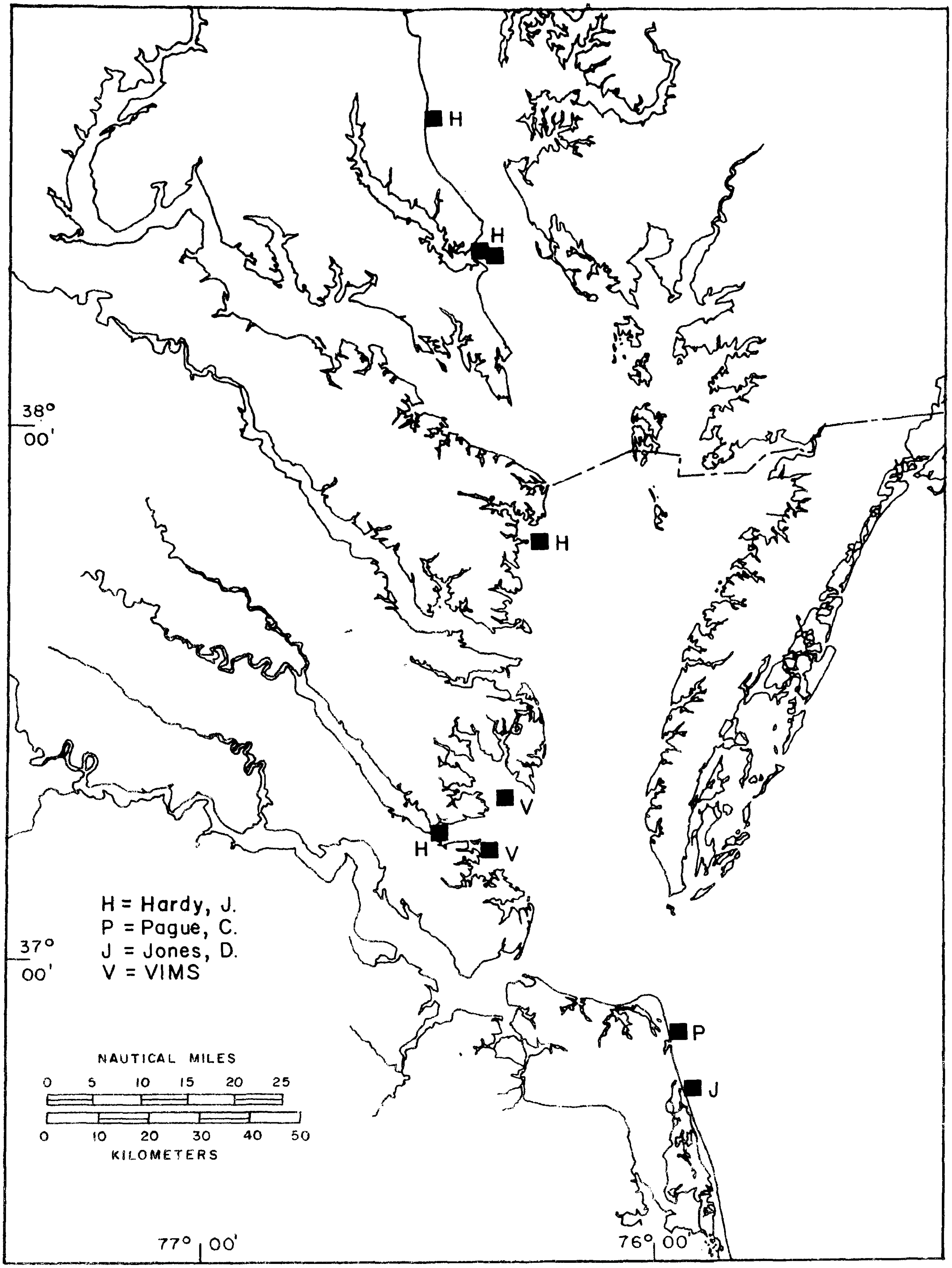
A


H
H
V
38°
00'
V
P
P
H = Hardy, J.
V = VIMS
P = Pague, C.
37°
00'
NAUTICAL MILES
0 5 10 15 20 25
0 10 20 30 40 50
KILOMETERS
77° 00'
76° 00'

B


H
H
H
H
H
38°
00'
37°
00'
H = Hardy
NAUTICAL MILES
0 5 10 15 20 25
0 10 20 30 40 50
KILOMETERS
77° 00'
76° 00'

C


H
H
H
H
V
V
P
J
38°
00'
37°
00'
77° 00'
76° 00'
H = Hardy, J.
P = Pague, C.
J = Jones, D.
V = VIMS
NAUTICAL MILES
0 5 10 15 20 25
0 10 20 30 40 50
KILOMETERS

communication). Poundnets have been used since the late 1800's in Virginia to capture food fishes (Reid, 1955). However, there are no records of sea turtles being taken by a fishery in this area.

The purposes of this present study were: (1) document the distribution, relative abundance, and activities of sea turtles in the Chesapeake Bay and Virginia coastal waters; (2) to identify principal causes of mortality by examining strandings; (3) and to describe and evaluate poundnet incidental catch.

Frazier (1980) outlined the need for identifying sea turtle populations in the coastal zone so that steps can be taken to protect their survival. The movements of subadult sea turtle populations to and within their foraging areas is poorly known (Carr, 1980). Possible origins and migration routes of sea turtles in the study area were addressed by examining their commensal barnacles and other epizootic organisms. Some commensals found on sea turtles may be limited to specific geographic areas and thus may serve as an indicator as to where the host turtle has been (Zullo and Bleakney, 1966).

In 1980, I initiated a tagging project in cooperation with local watermen to follow sea turtle movements with the area. Sea turtles captured in poundnets were tagged with minimum harm done to the turtles. This project also increased watermen's understanding and interest in the status of sea turtles in our region.

Loggerhead turtles have been designated threatened by the U.S. Endangered Species Act of 1973 (Public Law 93-205 87 Statute 884). Both leatherbacks and ridleys are classified as endangered species in the U.S. Recent studies have identified the alarming decrease in nesting loggerhead populations in the southeastern U.S. (Richardson _et al._, 1978). Unlike southern nesting populations, Virginia sea turtles are primarily waterborne. This may account for the previous lack of attention focused on their activities in the northern parts of their ranges.

MATERIALS AND METHODS

Strandings

Several methods were used to determine the status and abundance of sea turtles in the study region, including a stranding report network, interviews with watermen, and examination of live and dead sea turtles. In May of 1979, reports of stranded and live sea turtles were requested through the news media. Public awareness was expanded in 1980, increasing the number of reporting sources and experienced observers. A stranding form (Appendix) designed to collect information on sea turtles was distributed to the following people and facilities:

- military base naturalists
- U.S. Fish and Wildlife Service areas on shorelines
- federal and state recreation areas
- Virginia Marine Resource Commission officers
- the Virginia Coastal Reserve of The Nature Conservancy
- Virginia State Water Control Board
- city beach and landscape crews
- city lifeguards
- inshore charter boat operators and sportfishing groups
- VIMS field workers
- the U.S. Coast Guard local officers-in-charge
- cooperating beach area residents

Observers were instructed as to the proper identification and standard measurement of stranded sea turtles. A sea turtle species identification form is printed on the stranding form (Appendix).

Stranded and live sea turtles were examined for the following information:

<u>CLC</u> carapace length over curvature, measured along the body midline from the anterior-most nuchal point to the tip of the posterior-most marginal scute.

<u>CWC</u> carapace width over curvature, measured across the carapace at widest point of carapace.

<u>CLS</u> carapace length straightline, measured along the body mid-line from the anterior-most nuchal point to the tip of the posterior-most marginal scute.

<u>CWC</u> carapace width straightline, measured across carapace at the widest point of the carapace.

<u>HW</u> head width, measured across curvature at widest point of head.

<u>HL</u> head length, measured along midline from anterior-most prefrontal to posterior-most parietal scale.

<u>PW</u> plastron width, measured along plastron from inner margin of inframarginals to opposite inner inframarginal border.

<u>PL</u> plastron length, measured along midline of plastron from anterior epiplastron to posterior xiphiplastron.

Weights were taken with commercial fish scales when available. Stranding form and watermen survey card measurements were reported in inches and converted to metric measurements. Photos were taken of 38 sea turtles in 1979 and 35 turtles in 1980 to document carcass damages, number of vertebral and coastal scutes, and barnacle encrustation patterns. Most carcasses in municipal areas were buried or removed to a dump site shortly after being measured.

<u>Sex</u>

Researchers have been unable to identify the sex of immature sea turtles based on external morphology (Hughes, 1974a; Owens *et al.*, 1978). Owens has identified the sex of juvenile turtles by microscopic examination of their gonads. Based on the minimum nesting sizes provided in Table 1, the following criteria were used to determine the sex of turtles:

a. loggerheads with CLC of 85 cm or greater were designated male if the tail extended several inches beyond the rear tip of the carapace.

b. loggerheads with CLC of 85 cm or greater were designated female if an elongate tail was not present.

c. loggerheads with CLC less than 85 cm were designated as immature unless sex was determined by dissection. Sex of dissected turtles was determined by visual inspection under 10X magnification according to Owens (personal communication, 1980) and verified by histopathological examination at the University of Rhode Island.

d. *L. kempii* and *D. coriacea* were identified as above, based on their minimum nesting sizes.

Stomach Contents

Stomach remains were taken from fresh strandings when available. Stomachs were tied off at the lower esophagus and at the pylorus and removed. A longitudinal cut was made through the inferior stomach curvature and contents were removed, fixed, and identified to lowest taxon. The intestines were excised and sectioned into segments. These contents were recorded and identified to lowest taxon. Due to the small number of stomachs examined, wet weights of stomach contents were recorded but not used to quantify food habits.

Commensals

Some commensal invertebrates found on marine reptiles have specific distribution that may serve as a clue to where the host animals have been (Zullo and Bleakney, 1966; Jeffries and Voris, 1979). A general survey of the kind and number of commensal organisms

TABLE 1

MINIMUM NESTING SIZES OF ATLANTIC SEA TURTLES

SPECIES	LOCALITY	MINIMUM NESTING SIZE (cm)	SOURCE
C. caretta	Cape Romain, SC	84.5	Caldwell, 1959
L. kempii	Tamaulipas, Mexico	59.5	Pritchard and Marquez, 1973
D. coriacea	Trinidad	152.0	Pritchard, 1971

was conducted on stranded and live turtles. Type and severity of barnacle encrustation was noted in 1979 and on a regular basis in 1980. Samples were removed with forceps, fixed in formalin (10% buffered) and preserved in 40% ETOH for later identification, according to Gosner (1971). Barnacles were both fixed and preserved in 70% ETOH as recommended by Zullo (1979).

Selected live barnacles of the species Chelonibia testudinaria (L.) were removed and submitted to J. S. Killingley, Scripps Institute of Oceanography, for determination of oxygen and carbon isotope composition. Isotope analysis of their carbonate shells may allow extrapolation of the temperature and salinity regimes in which the barnacles developed (Lloyd, 1964). This method was used by Killingley (1980) to track whale migration in the Pacific. He suggested its possible usefulness in tracking sea turtles. Results of isotope analysis were used in an attempt to reconstruct the movements of two Virginia sea turtles before they stranded (MT-2-80 and MT-16-79).

Necropsy

Post mortem examinations were performed on fresh strandings when available, according to the procedure of Wolke and George (in press). Morphometric data were taken, and the general condition of the carcass noted. Physical damage was recorded and sometimes photographed. The carcass head was examined in detail for signs of trauma or hemorrhage. Special attention was paid to evidence of drowning.

An incision was made along the ramis of each mandible to expose the mouth cavity, trachea, larynx, and esophagus for signs of asphyxiation or obstruction. Dissection proceeded so that all major organs were examined. Tissue samples or organs and lesions were fixed in formalin (10% buffered) for identification. When feasible, skulls and humeri were removed for deposit with the U.S. National Museum for use in an age and growth study (J. Frazier, personal communication).

Incidental Catch

In 1980, ten watermen from selected areas where turtles were abundant agreed to monitor poundnet sea turtles and to tag any found alive in their nets. Tags, applicators, and record cards were distributed among cooperating fishermen. Date of capture, species, carapace length, apparent sex, and tag number were requested on self-return, stamped postcards. Watermen were asked to place a Monel self-clinching ear tag on the trailing edge of the right front flipper before releasing the turtle (Appendix). Dr. Archie Carr provided Hasco tags series K and G (National Band and Tag Co., Newport KY, sizes 681K and 49). Most turtles were released after tagging by watermen from boat decks as the boat moved from one poundnet to another location. In this manner turtles would be less likely to re-enter the same net.

Watermen were also asked to note turtles re-entering nets, as well as the numbers on any previously tagged turtles. Thus, I was able to follow the movements of several turtles as they were recaptured alive in poundnets throughout the summer and fall of 1980.

A final survey submitted to poundnet taggers in late 1980 requested information concerning totals of sea turtle catch, species, and number of dead turtles in poundnet hedging. Watermen also provided net locations, orientation, mesh size, as well as times of initial and final captures.

RESULTS

In 1979, over 246 sea turtles were counted alive or stranded in Virginia and the Chesapeake Bay. The 1980 count was 828 sea turtles, including turtles found alive in poundnets. Species, status of turtles, and observation sources for records are summarized in Table 2.

Totals for 1979 are underestimated for several reasons. The study was begun in late May and therefore turtles arriving in early and mid-May were not counted. Secondly, both sighting and stranding reports, coverage area and quality of observer reports were enhanced in 1980 through increased media coverage, public awareness, and greater familiarity with turtles by observers such as city crews. Further, watermen were not interviewed in 1979; their total sea turtle incidental catch and poundnet mortalities have not been estimated for that season. In 1980, poundnet catch contributed almost 25% of the season's total turtle observations. Unfortunately, the late start of the 1979 study and the failure to sample poundnet catch significantly lowers turtle totals for that season.

Coverage was probably minimal for both years in remote marsh areas and shorelines such as the Eastern Shore, Rappahannock and Piankatank river shorelines, Mathews County shoreline, and lower Maryland shorelines.

Because information was provided by the public, the reliability of some reporting sources vary in identification and accuracy of

TABLE 2

SEA TURTLE SPECIES COMPOSITION BASED ON DATA RECORDS

1980 Live and Stranded		1980 Strandings only	
Species	number	Species	number
C. caretta	341	*C. caretta*	260
L. kempii	14	*L. kempii*	9
D. coriacea	3	*D. coriacea*	3
unknown	25	unknown	16
Total	383		

1979 Live and Stranded		1979 Strandings only	
C. caretta	166	*C. caretta*	159
L. kempii	9	*L. kempii*	9
D. coriacea	2	*D. coriacea*	2
unknown	14	unknown	10
Total	191		

TABLE 2

REPORTING SOURCES FOR SEA TURTLES

1980

78	turtles examined by M.L. (MT series)*
136	turtles reported by stranding form (SF series)*
85	carcasses reported by telephone but not examined*
76	turtles reported alive by telephone or other source*
73	live turtles tagged and released by watermen (TAG series)*
46	turtles reported dead in poundnets by watermen (survey)
211	live turtles reported in poundnets but not tagged (survey)
118	live turtles reported by the Virginia Coastal Reserve
5	turtles reported killed (NMFS enforcement division)
828	TOTAL

1979

74	turtles examined by M.L. (MT series)*
71	turtles reported by stranding form (SF series)*
60	turtles reported by telephone but not examined*
41	turtles reported by the Virginia Coastal Reserve (39 live, 2 dead)
246	TOTAL

*sex records available include species, location, condition and apparent SEX measurements. To reduce errors, I sought to verify reports with call-back interviews, and to eliminate duplicate reports. Carapace measurements were arranged by reporting sources so that biometric analysis may be most representative of actual dimensions of Virginia sea turtles.

Distribution and Abundance

In 1980, initial sightings occurred in early May. Sea turtles were sighted regularly from May through November. Initial sightings and monthly sea turtle abundance are depicted in Figures 2 and 3, respectively. The last stranding occurred on 3 December. Figure 4 provides late season locations based on strandings and watermen survey. Water temperatures may affect the distribution of sea turtles (Hughes, 1974b; Mrosovsky, 1980) and are provided for areas in which sea turtles were abundant (Figure 5).

In 1979, the earliest sea turtles in the Bay had already arrived before this study began. Live turtles were found through November; and the last recorded stranding ocurred on Back Bay NWR on January 13 (1980). That stranding was decomposed and may have washed in from offshore.

Loggerhead aggregations reported to VIMS were concentrated in channels and inlets of the Eastern Shore's barrier islands, as shown in Figure 6. Turtles were observed most often as individuals or pairs. Up to seven turtles were reported on the surface simultaneously in New Inlet (south of Wreck Island) and in groups of

Figure 2. Initial 1980 sea turtle sightings. Points represent stranded turtles unless indicated by (L) live.

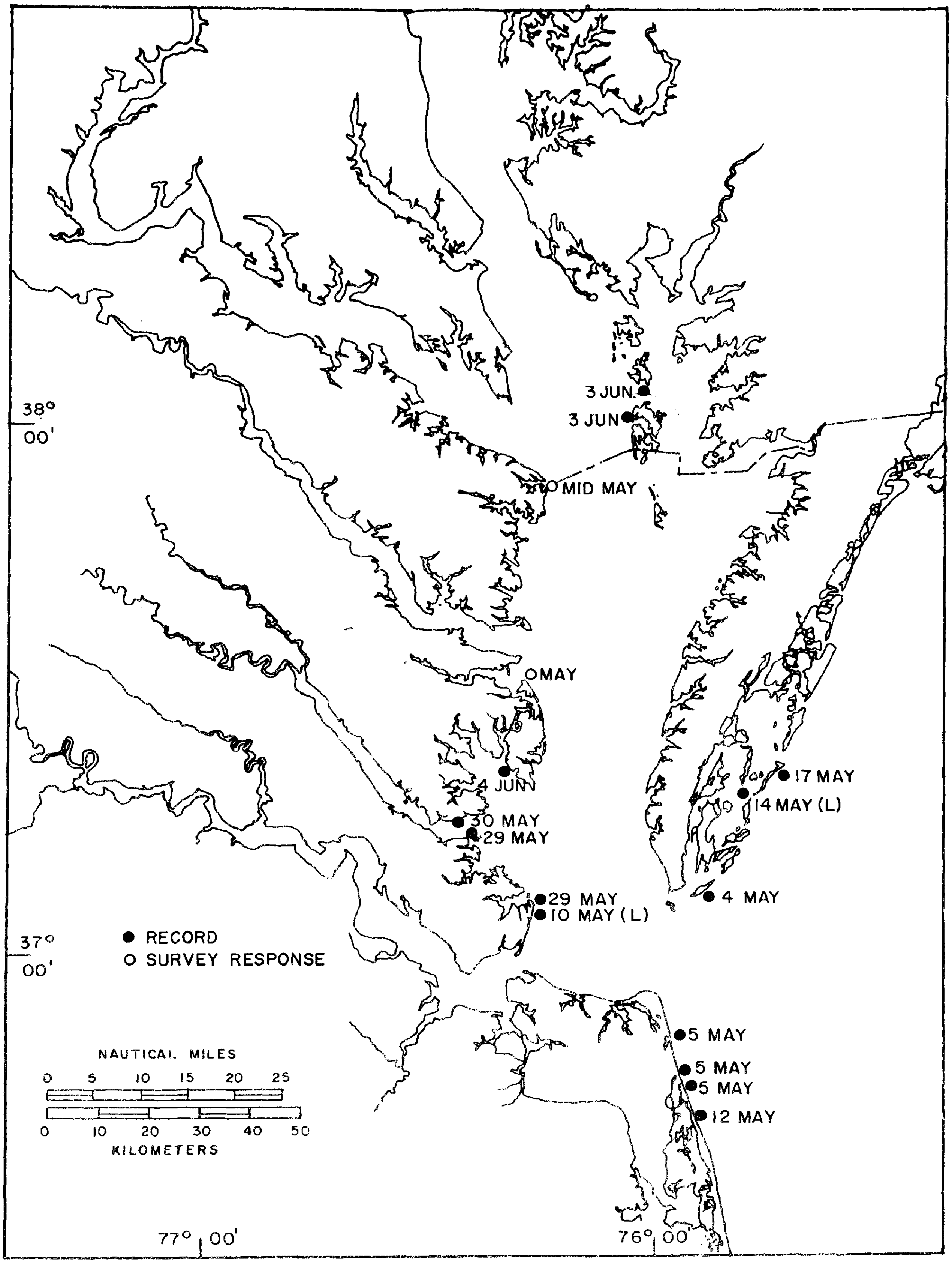
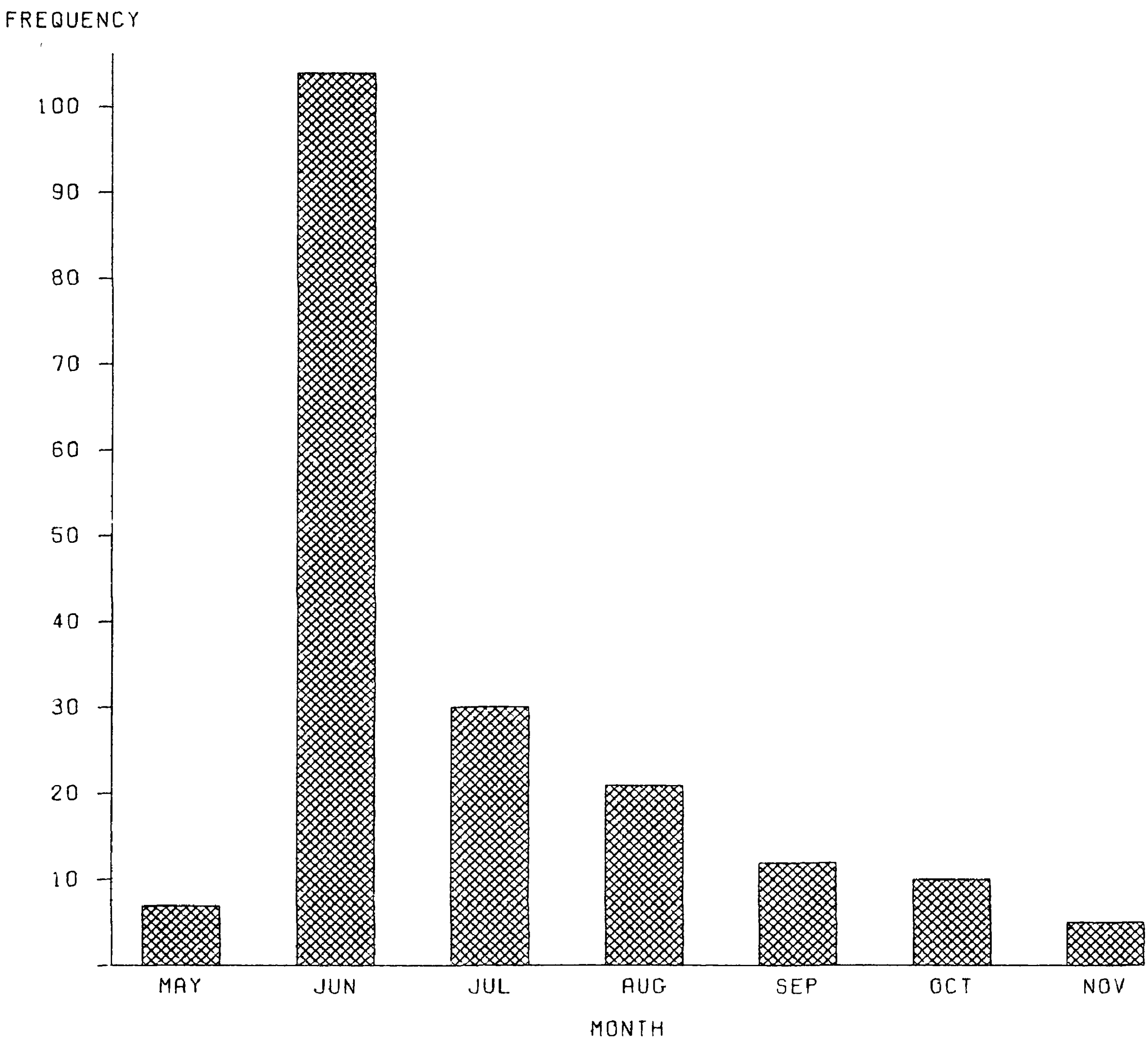

3 JUN.
3 JUN
38°
00'
MID MAY
OMAY
4 JUN
30 MAY
29 MAY
17 MAY
14 MAY (L)
29 MAY
10 MAY (L)
4 MAY
37°
00'
RECORD
SURVEY RESPONSE
5 MAY
5 MAY
5 MAY
12 MAY
NAUTICAL MILES
0 5 10 15 20 25
0 10 20 30 40 50
KILOMETERS
77° 00'
76° 00'

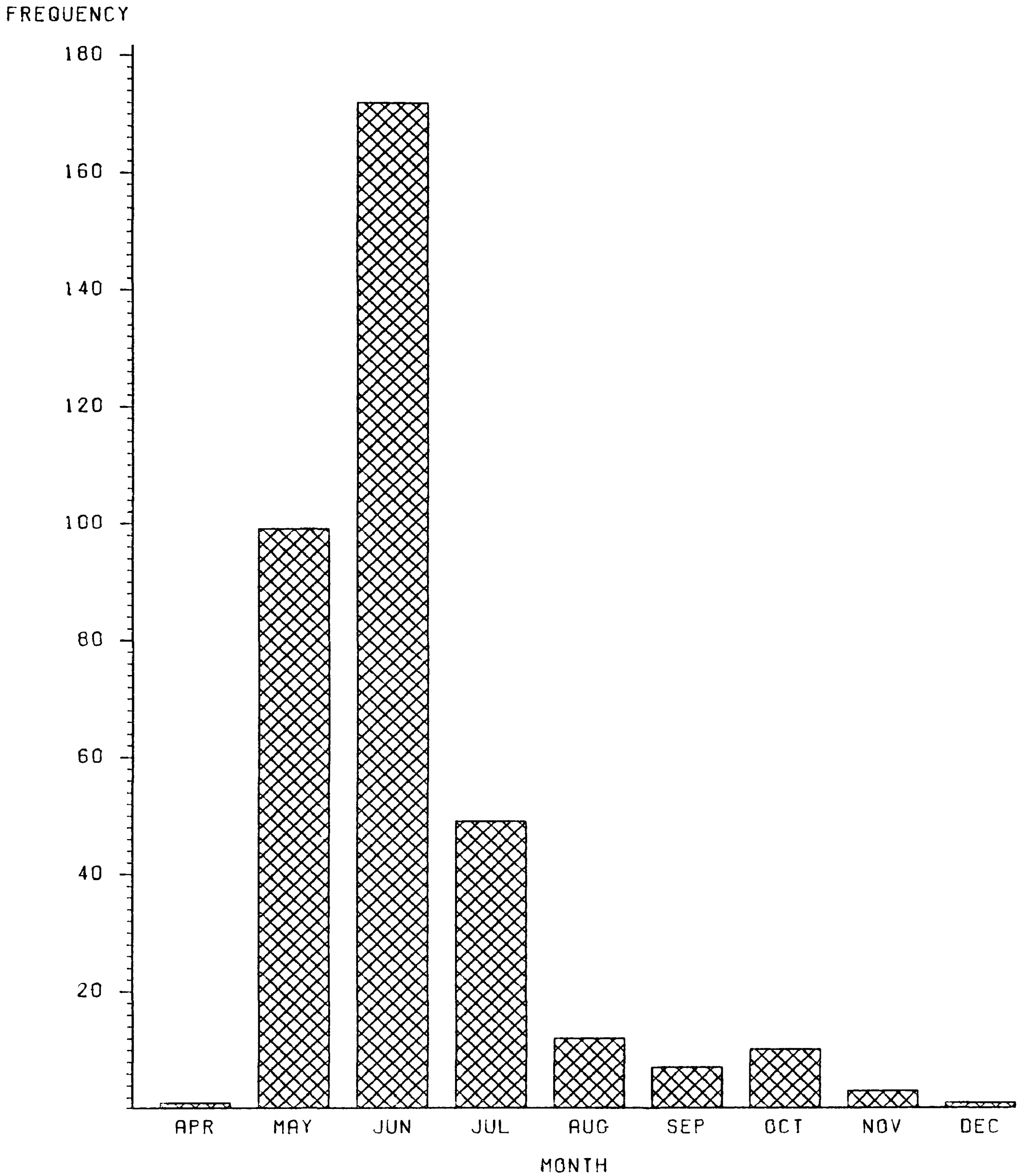
Figure 3. Monthly sea turtle count, including live and stranded sea turtles.
A. 1979
B. 1980.

1979 SEA TURTLES
MONTHLY COUNTS



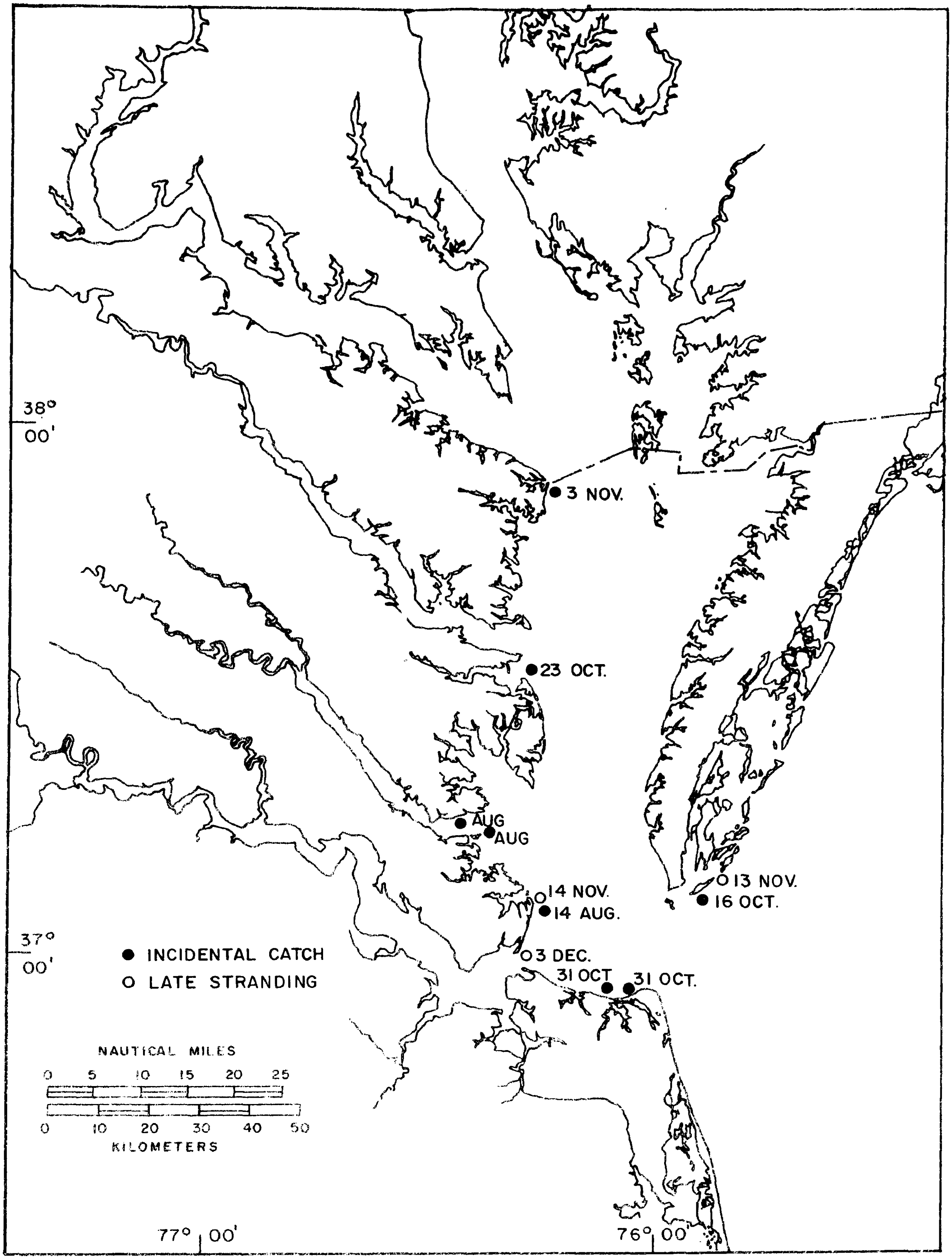
LIVE SEA TURTLES AND STRANDINGS COUNTED PER MONTH

SEA TURTLES 1980
TOTAL NUMBER COUNTED PER MONTH



INCLUDES LIVE AND STRANDED SEA TURTLES

Figure 4. Final sea turtle sightings in 1980.



38°
00'
3 NOV.
23 OCT.
AUG
AUG
14 NOV.
14 AUG.
13 NOV.
16 OCT.
37°
00'
INCIDENTAL CATCH
LATE STRANDING
3 DEC.
31 OCT
31 OCT.
NAUTICAL MILES
0 5 10 15 20 25
0 10 20 30 40 50
KILOMETERS
77° 00'
76° 00'

Figure 5. Seasonal water temperatures for the Chesapeake Bay area in 1979 and 1980. (CBI *J. TAFT* cruises, supplied by Bill Cronin; VIMS unpublished data).

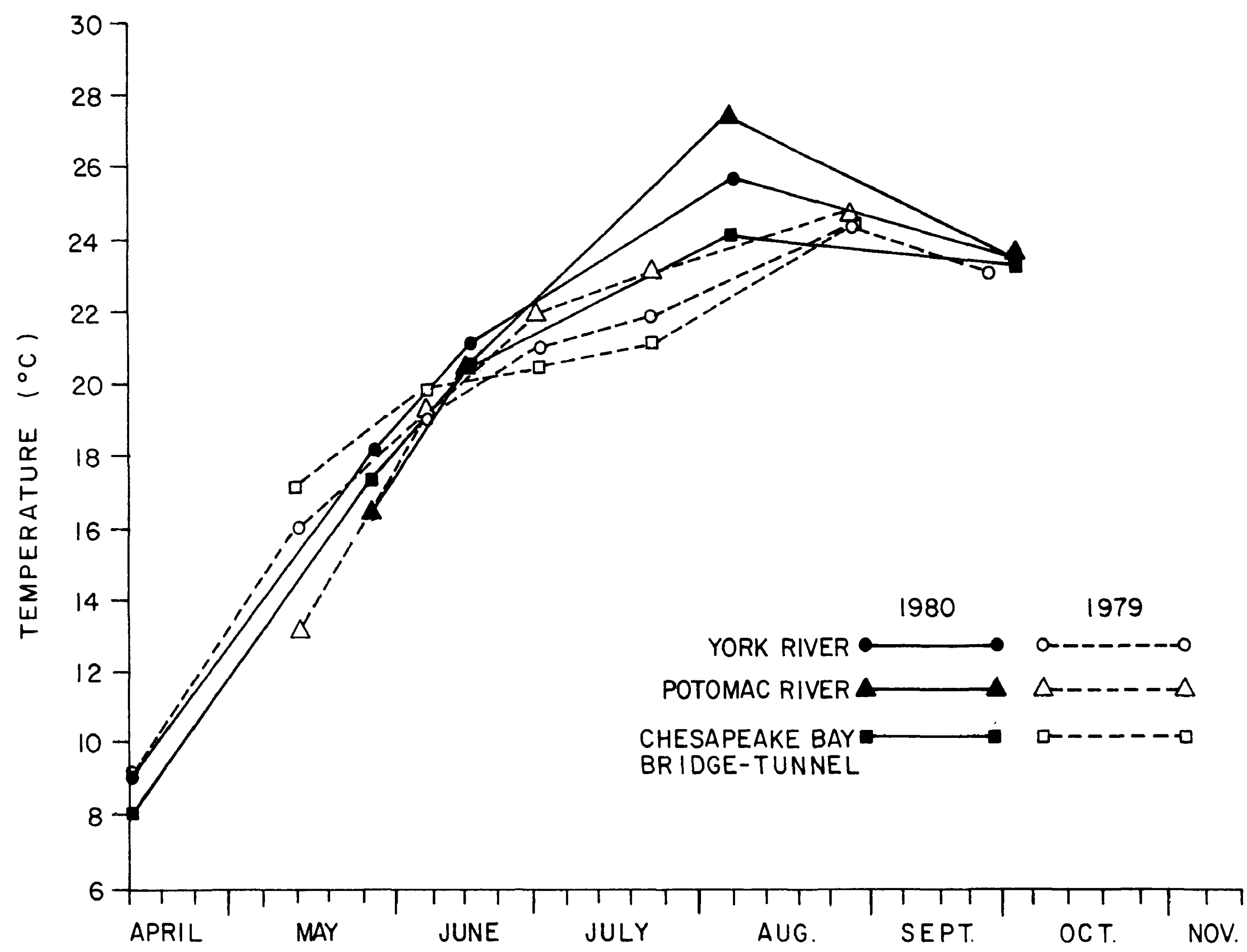
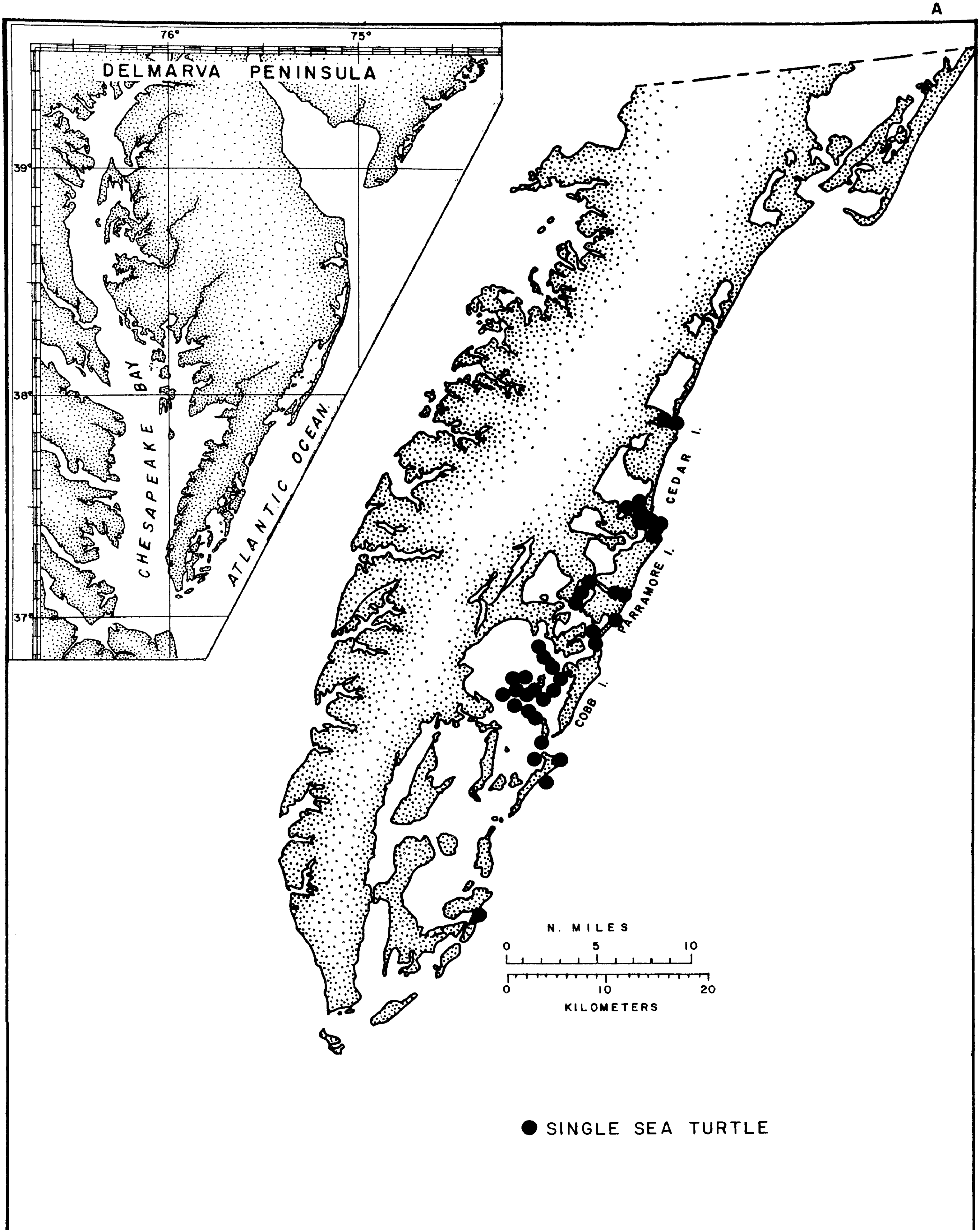
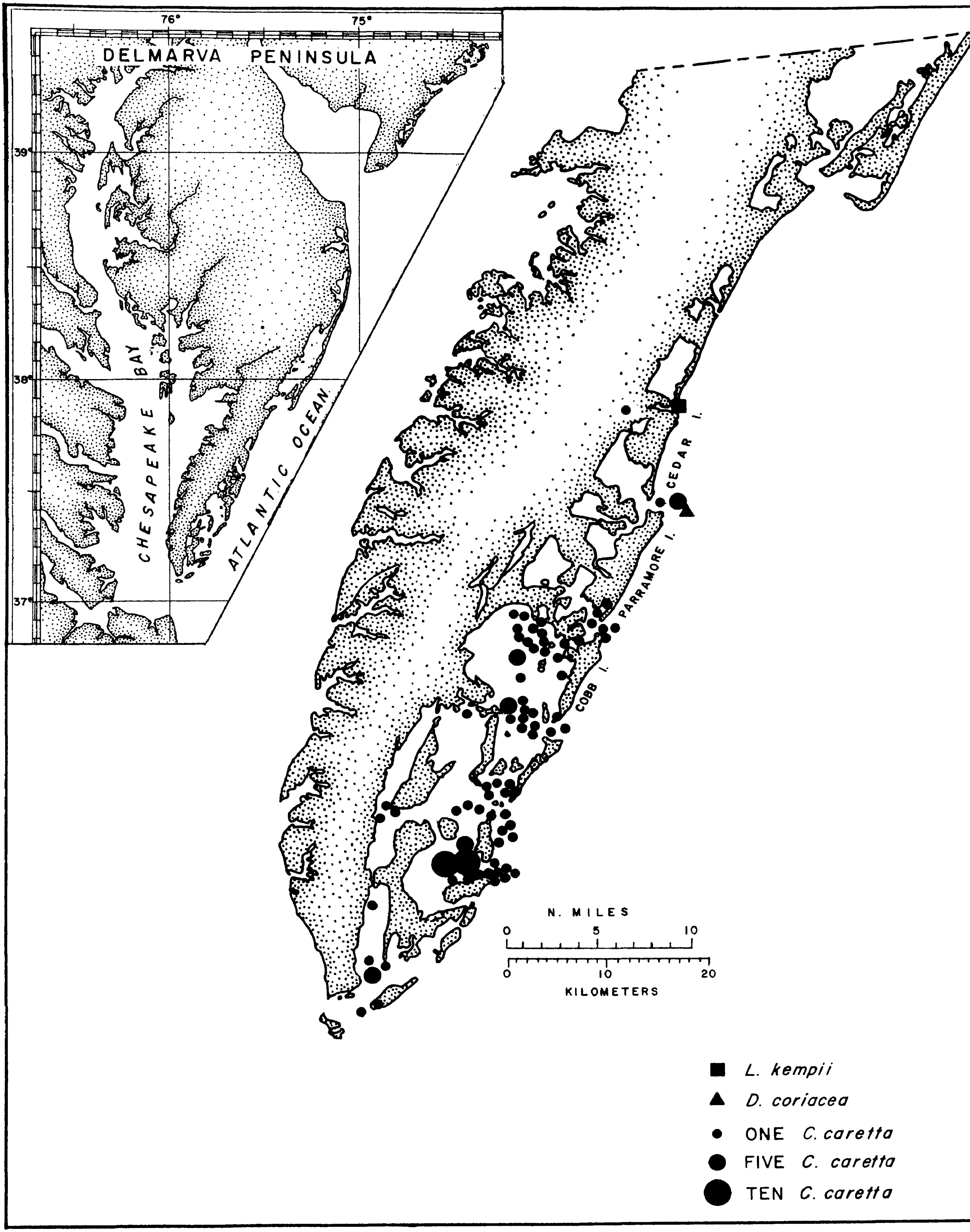

TEMPERATURE (°C)
30
28
26
24
22
20
18
16
14
12
10
8
6
APRIL
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
1980
1979
YORK RIVER
POTOMAC RIVER
CHESAPEAKE BAY
BRIDGE-TUNNEL

Figure 6. Sea turtle sightings for the Eastern Shore of Virginia. (Records supplied by the Virginia Coastal Reserve, B. Truitt).
A. 1979
B. 1980.


A
76°
75°
DELMARVA PENINSULA
39°
38°
37°
CHESAPEAKE BAY
ATLANTIC OCEAN
CEDAR I.
PARRAMORE I.
COBB I.
N. MILES
0 5 10
0 10 20
KILOMETERS
SINGLE SEA TURTLE

B


76°
75°
DELMARVA PENINSULA
39°
38°
37°
CHESAPEAKE BAY
ATLANTIC OCEAN
CEDAR I.
PARRAMORE I.
COBB I.
N. MILES
0 5 10
0 10 20
KILOMETERS
L. kempii
D. coriacea
ONE C. caretta
FIVE C. caretta
TEN C. caretta

at least five on the "Southwest Middlegrounds" and off Smith Point, Maryland. These and other areas where sea turtles were abundant are illustrated in Figure 7. Although observer effort in popular fishing locations may account for concentration pattern reports, non-fishing observers also commonly found sea turtles in these areas.

Sex

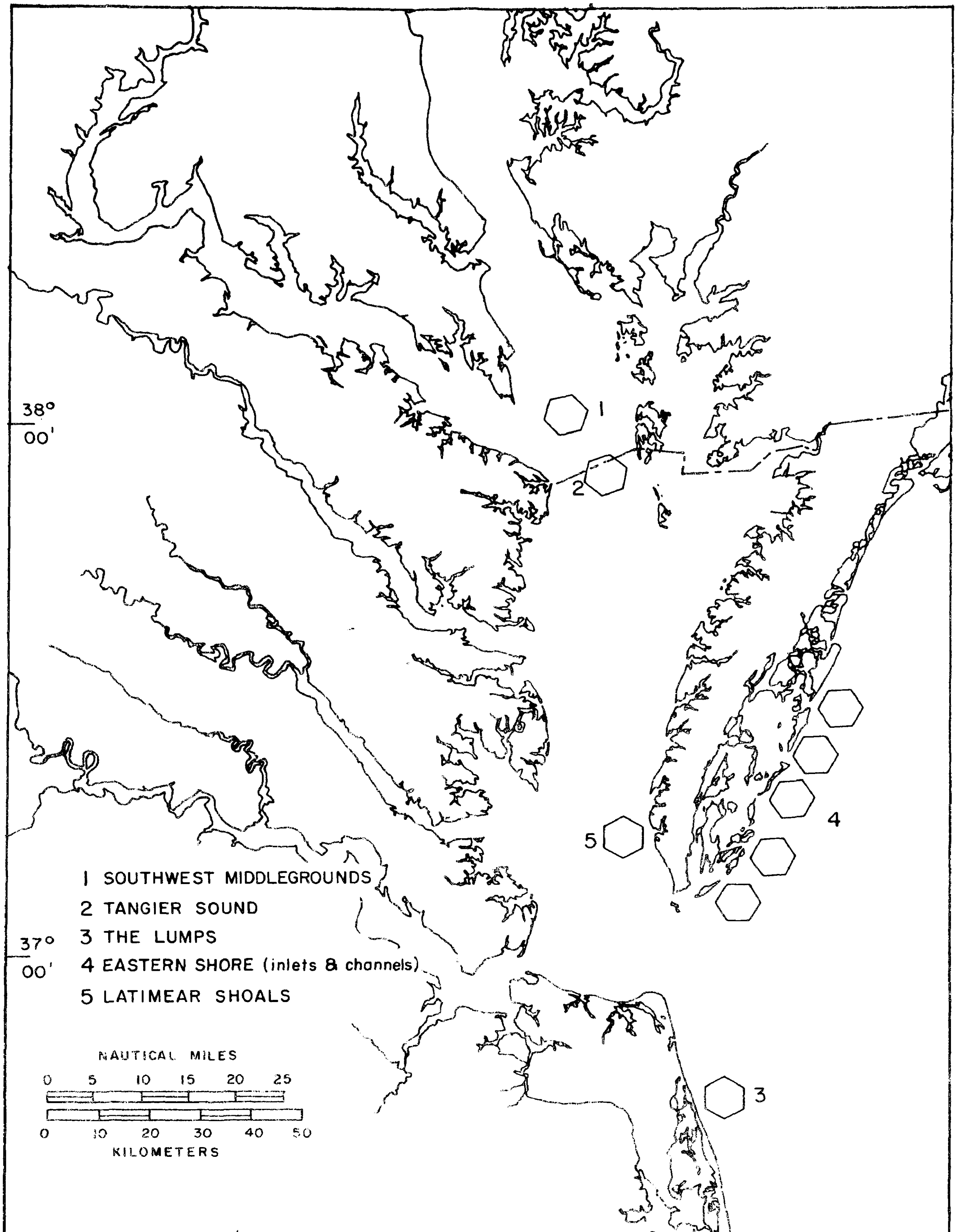
Sex was determined for 22 turtles in 1979 and for 40 turtles in 1980. Findings for 1979 include 19 female loggerheads, and one female leatherback. In 1980, 37 females, including one ridley, one leatherback, and 35 loggerheads were recorded. I have never observed a male sea turtle in the study region, although two male loggerheads were in found in 1979, as well as three in 1980 by experienced observers.

Commensals

At least 15 commensal species were associated with sea turtles in 1980, shown in Table 3. Several species of cirripeds were the most commonly occurring epizoans on live and stranded *C. caretta* for both seasons. Relative frequencies of barnacle species on 60 loggerheads are depicted in Figure 8.

Many authors have provided records of commensal sea turtle barnacles (Richards, 1930; Hiro, 1936; Schwartz, 1960; Zullo and Bleakney, 1966; Stubbings, 1967; McCann, 1969; Hughes, 1974; Monroe and Limpus, 1979; Zullo, 1979). However, little attention has been paid to the possible implications of encrustations, or to the

Figure 7. Areas of reported sea turtle concentrations, based on observer reports, 1979 and 1980.



38°
00'
37°
00'
1
2
3
4
5
1 SOUTHWEST MIDDLEGROUNDS
2 TANGIER SOUND
3 THE LUMPS
4 EASTERN SHORE (inlets & channels)
5 LATIMEAR SHOALS
NAUTICAL MILES
0 5 10 15 20 25
0 10 20 30 40 50
KILOMETERS
77° 00'
76° 00'

TABLE 3

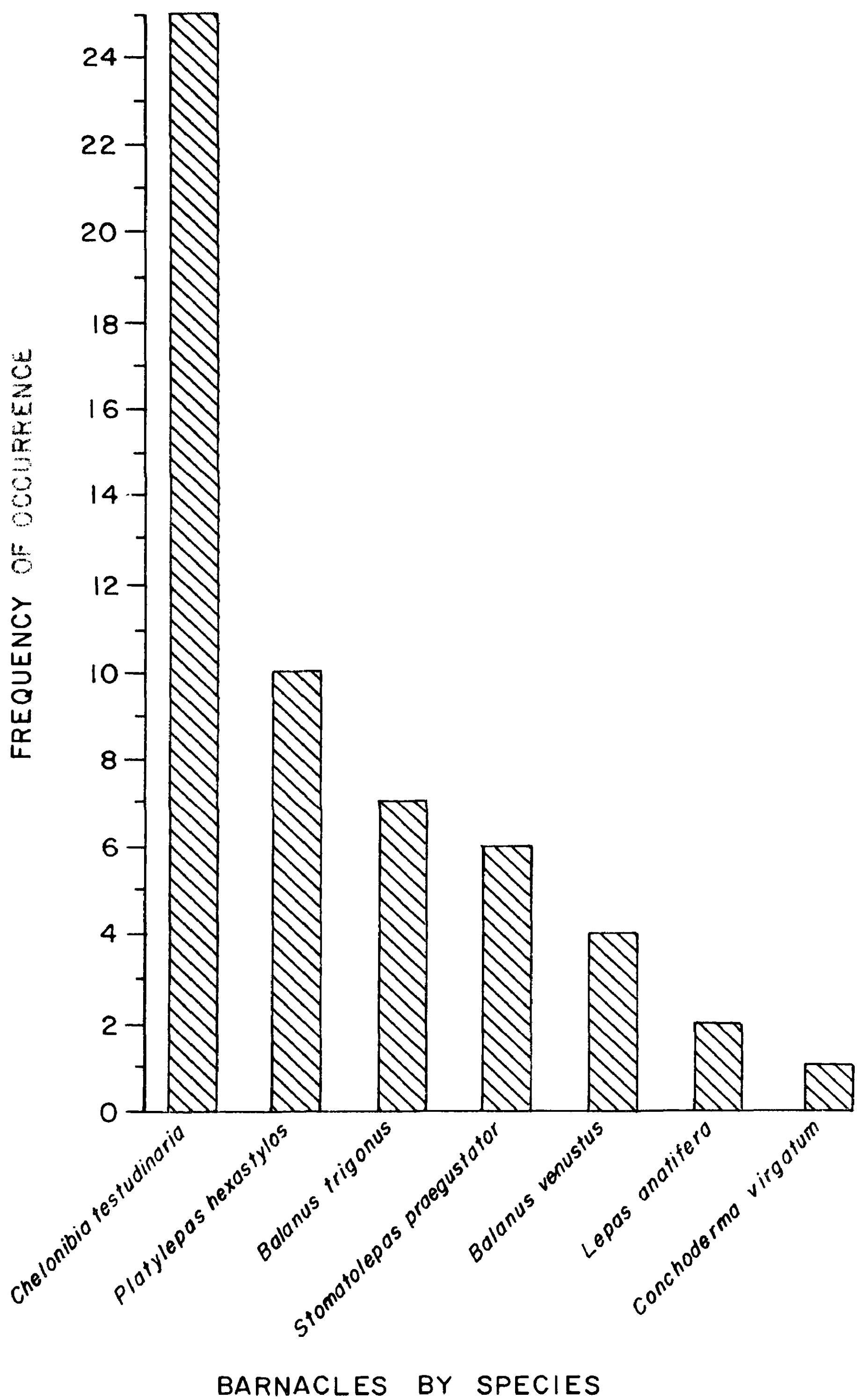
COMMENSAL ORGANISMS FOUND ON SEA TURTLES

PHYLUM CINIDARIA		
Class Hydrozoa	stolonate species	common
PHYLUM BRYOZOANS		occasional
PHYLUM MOLLUSCA		
Class Gastropoda		rare
Class Bivalvia	Crepidula fornicata (L.)	rare
	Crassostrea virginica (Gmelin)	rare
	Family Mytilidae	
PHYLUM ANNELIDA		
Class Polychaeta	Polydora ligni (Webster)	common
	Nereis succinea (Frey and Leuekart)	common
Class Hirudinea	Ozobranchus margoi (Apathy)	rare
PHYLUM ARTHROPODA		
Subclass Cirripedia	Lepas anatifera (L.)	occasional
	Conchoderma virgatum (Spengler)	rare
	Chelonibia testudinaria (L.)	abundant
	Balanus trigonus (Darwin)	occasional
	Balanus venustus (Darwin)	occasional
	Platylepas hexastylos (Fabricius)	common

TABLE 3 (concluded)

	Stomatolepas praegustator (Pilsbry)	occasional
Suborder Caprellidea	*Caprella andreae*	abundant

Figure 8. Relative frequencies of barnacles found on *C. caretta* (N=60 loggerheads).



FREQUENCY OF OCCURRENCE
0
2
4
6
8
10
12
14
16
18
20
22
24
Chelonibia testudinaria
Platylepas hexastylos
Balanus trigonus
Stomatolepas praegustator
Balanus venustus
Lepas anatifera
Conchoderma virgatum
BARNACLES BY SPECIES

commensal relationship between sea turtle barnacles and the host species (Lewis, 1978).

While studying commensal barnacles in 1980, I observed three distinct patterns of barnacle encrustations: (a) barnacles, chiefly Chelonibia testudinaria confined to carapace, head scutes, or tomium, (b) loggerheads with noticeably clean carapaces, free of barnacles as well as other commensals i.e. no barnacles, (c) barnacle encrustation profuse, dermal barnacles Platylepas hexastylos on neck, limbs, and tail (Figure 9). Thirteen out of sixty (22%) of loggerheads that carried barnacles belonged to this category. Emaciated appearance, concave plastron, and reddened pastron plates sometimes accompanied this findings. This condition was observed only a few times in 1979, and may in some way relate to the health, previous location, or activity of the 1980 loggerheads.

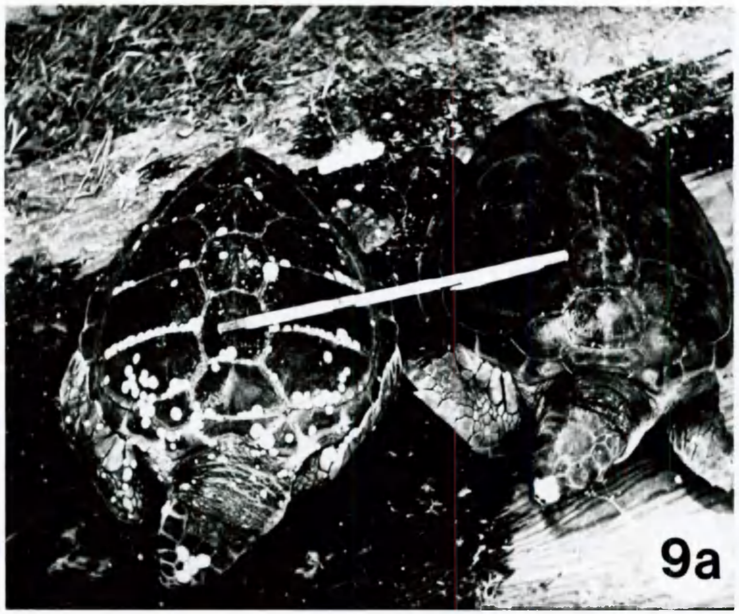
Commensals found specifically on L. kempii were the barnacles Stomatolepas praegustator taken from the mouth cavity, C. testudinaria P. hexastylos, and unidentified bryozoans. Specimens were usually very small (4-5 mm) compared to the average barnacle size found in loggerheads. Other invertebrates were rarely found on L. kempii.

Reproduction

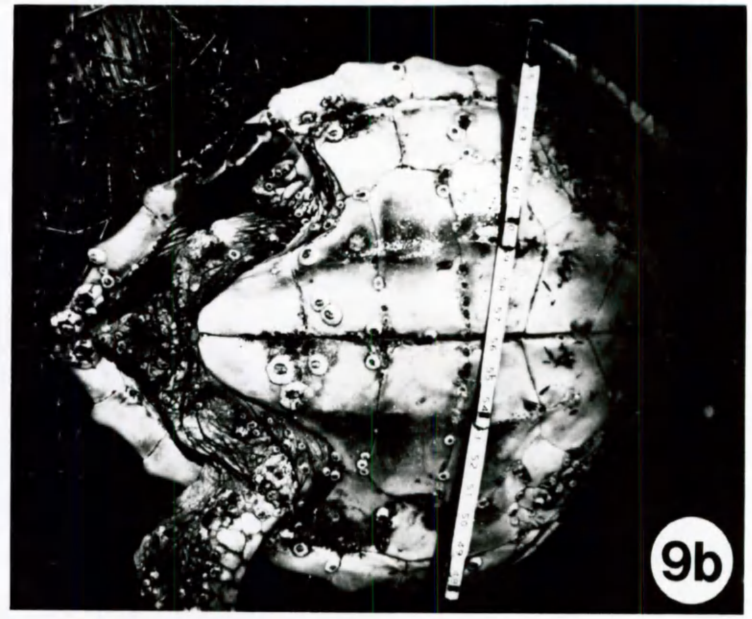
In 1980, three instances of alleged courtship behavior were reported in the study area by sportfishermen. A coupled pair of loggerheads was observed in a shallow cove near Lewisetta, Virginia. Another courting pair were seen on the "Lumps" off Virginia Beach by

Figure 9. Barnacle encrustation patterns on loggerheads.

A B



C



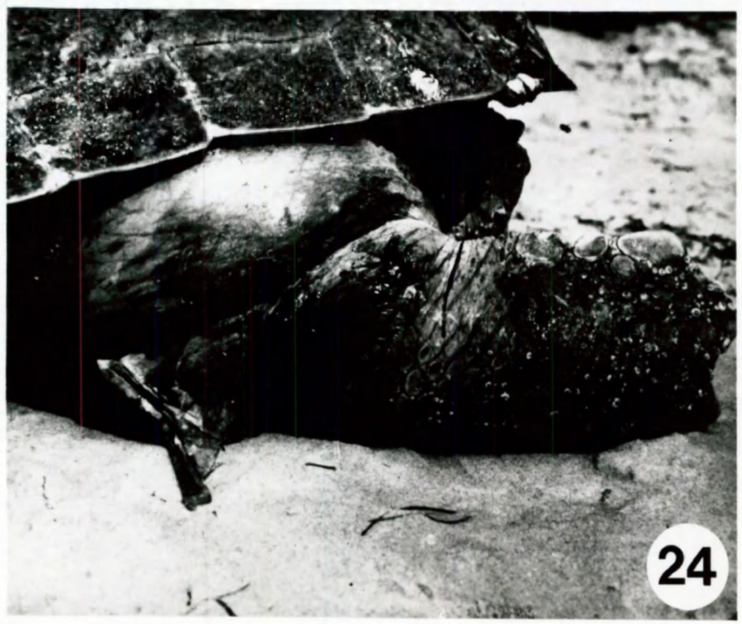


FIG.

members of a Virginia shark tagging club. On 28 July 1979, two loggerheads were observed mating 25 miles offshore of Wachapreague, Virginia. The sizes of the above turtles were not provided. Courtship activities of loggerheads may occur in the study region but have yet to be confirmed by first-hand observation.

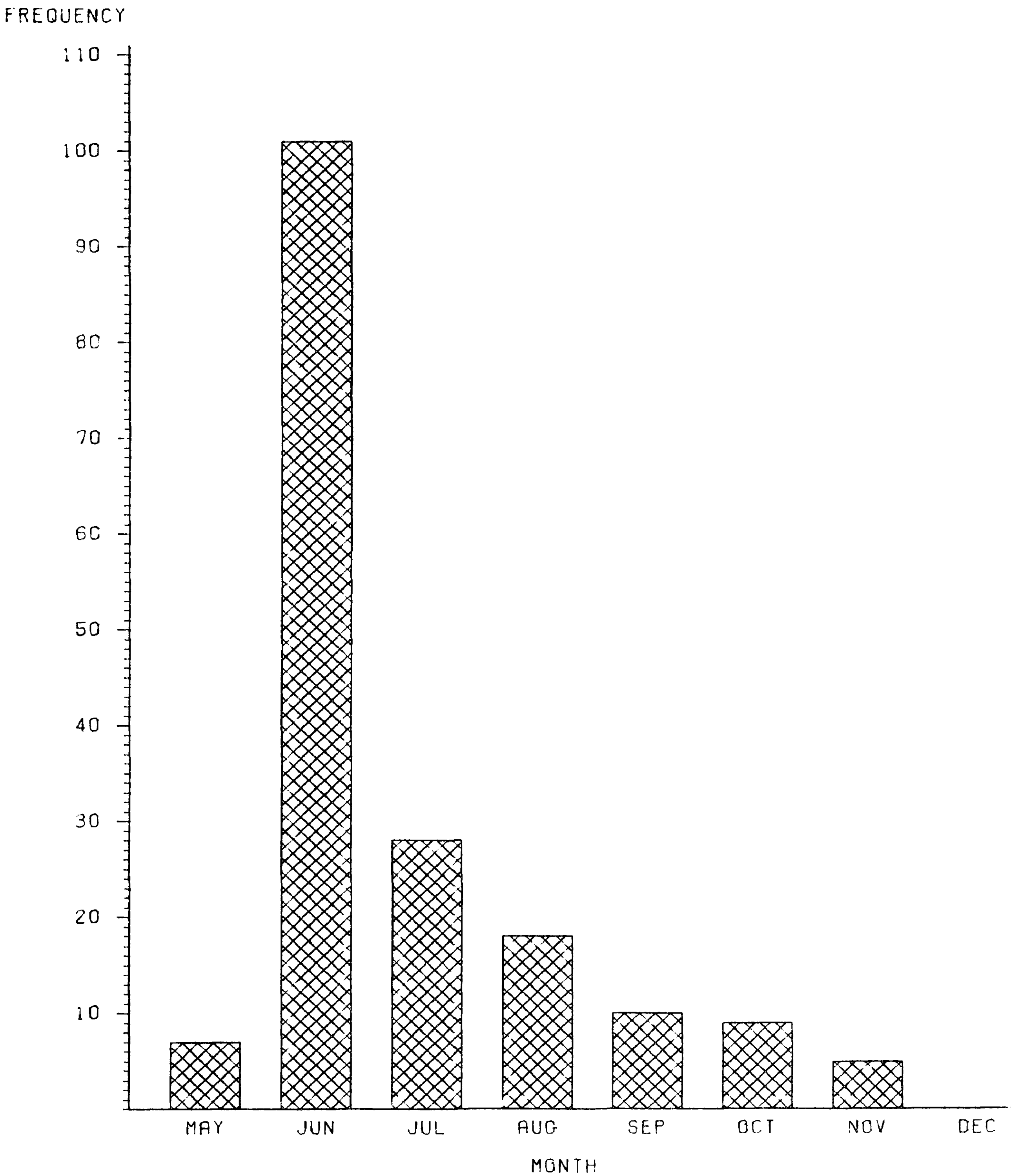
Strandings

A total of 185 carcasses were counted in 1979, including nine ridleys, two leatherbacks, and 159 loggerheads. Fifteen carcasses were not identified. In 1980, 333 carcasses were counted, including 12 ridleys, three leatherbacks, and 260 loggerheads. Fifty-eight cited on stranding forms were unidentified. Based on given sizes, it is likely that most unidentified carcasses were loggerheads.

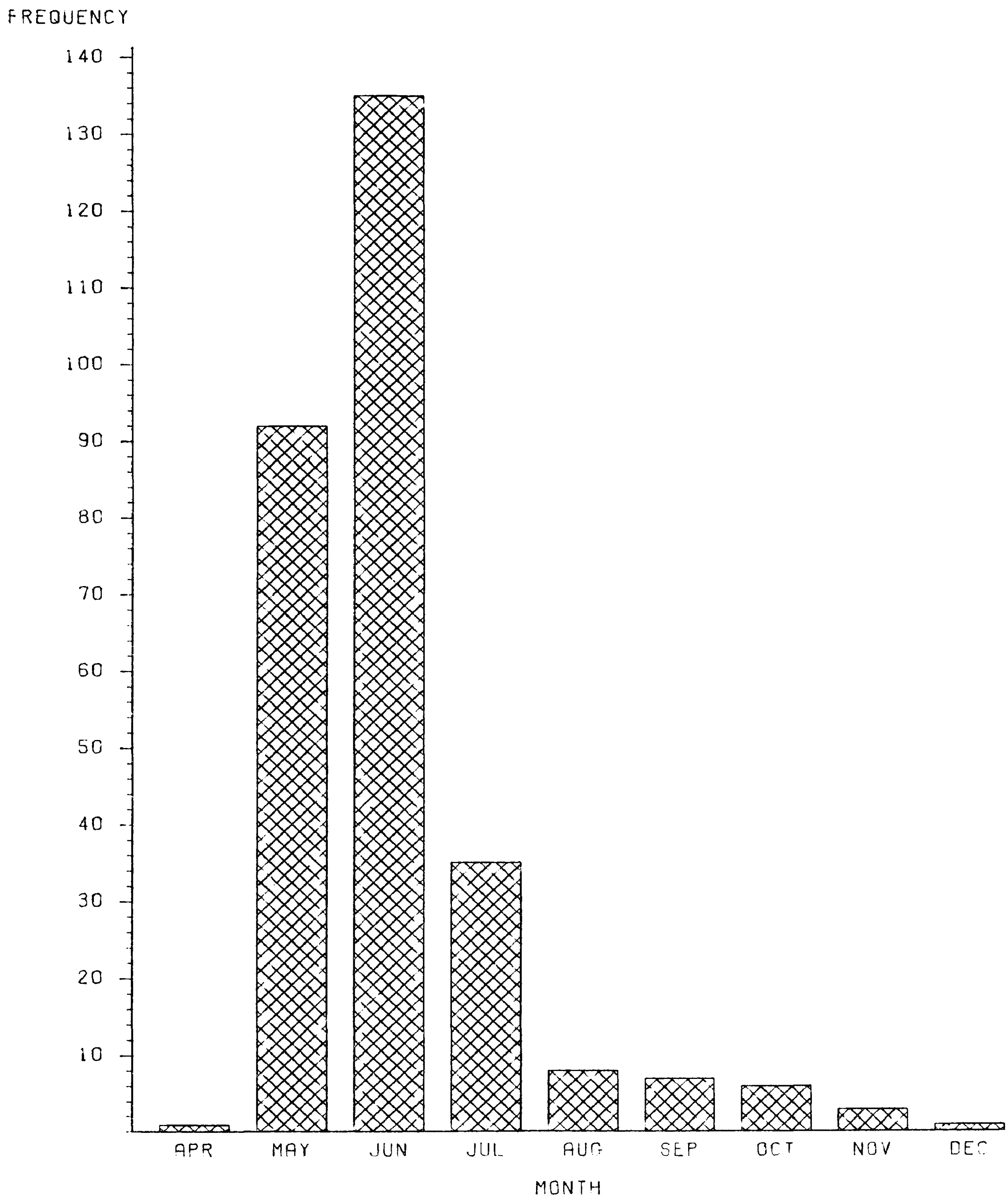
Strandings were most frequent in June for both 1979 and 1980. Strandings decreased gradually with sea turtle abundance for both seasons (Figure 10). Seasonal loggerhead mortalities of similar magnitude are known to occur in Georgia (Hillestad et al., 1977), South Carolina (Stancyk et al., 1980), Florida (Erhardt, 1977; 1978; 1979), North Carolina (Schwartz, 1976) and Texas (Rabalais and Rabalais, 1980). These deaths were attributed primarily to shrimp trawling (Hillestad et al., 1977; Ulrich, 1978; Bullis and Drummond, 1978) although commercial haul seines were implicated in a limited number of deaths (Fahy, 1954; Schwartz, 1954; Talbert et al., 1980). Shrimp trawling is not conducted in Virginia and cannot be a mortality source here. Monthly stranding abundance patterns in Virginia also

Figure 10. Sea turtle strandings by month.
A. 1979
B. 1980.

1979 STRANDINGS BY MONTH



1980 STRANDINGS BY MONTH



differed from Florida and Georgia, and from Texas where mortalities peaked in July and April, respectively.

Stranding Areas

The study area was divided into stranding zones based on proximity and similarities in stranding patterns and periods (Figure 11). For example, Back Bay NWR-False Cape State Park comprises a zone based on the Atlantic Ocean with no poundnets, but in seasonal longshore trawling. Strandings were computed per mile of zone shoreline and used to compare relative stranding frequency for given areas, as well as to compare yearly stranding patterns. Shoreline mileage was computed only from zones where sea turtles occur. Total strandings per zone are provided in Figure 12 for 1979 and 1980.

Morphometrics of Sea Turtles

Carapace measurements were taken from 346 live and stranded turtles. In 1980, loggerheads ranged from 21.6 cm CLC to 122 cm CLC, with a mean carapace length (over curvature) of 73.4 cm (N=157, SD=15.41, CV=21.01, PR>F=0.0001). *Caretta caretta* carapace lengths in 1979 ranged from 38.4 cm CLC to 122 cm CLC, with a mean carapace length of 76.8 cm (N=100, SD=16.28, CV=21.21, PR>F=0.0001). The average carapace length over curvature for both years was 74.7 cm CLC (N=257). No significant difference was found for CLC between 1979 and 1980 loggerheads ($P=0.5$, $d=1.68$, $F=1.35$, $p<0.05$).

Carapace length frequencies for *C. caretta* and *L. kempii* are given in Figures 13 and 14. Regression of CLC on CWC, as well as CWS

Figure 11. Sea turtle stranding zones and shoreline miles per zone.

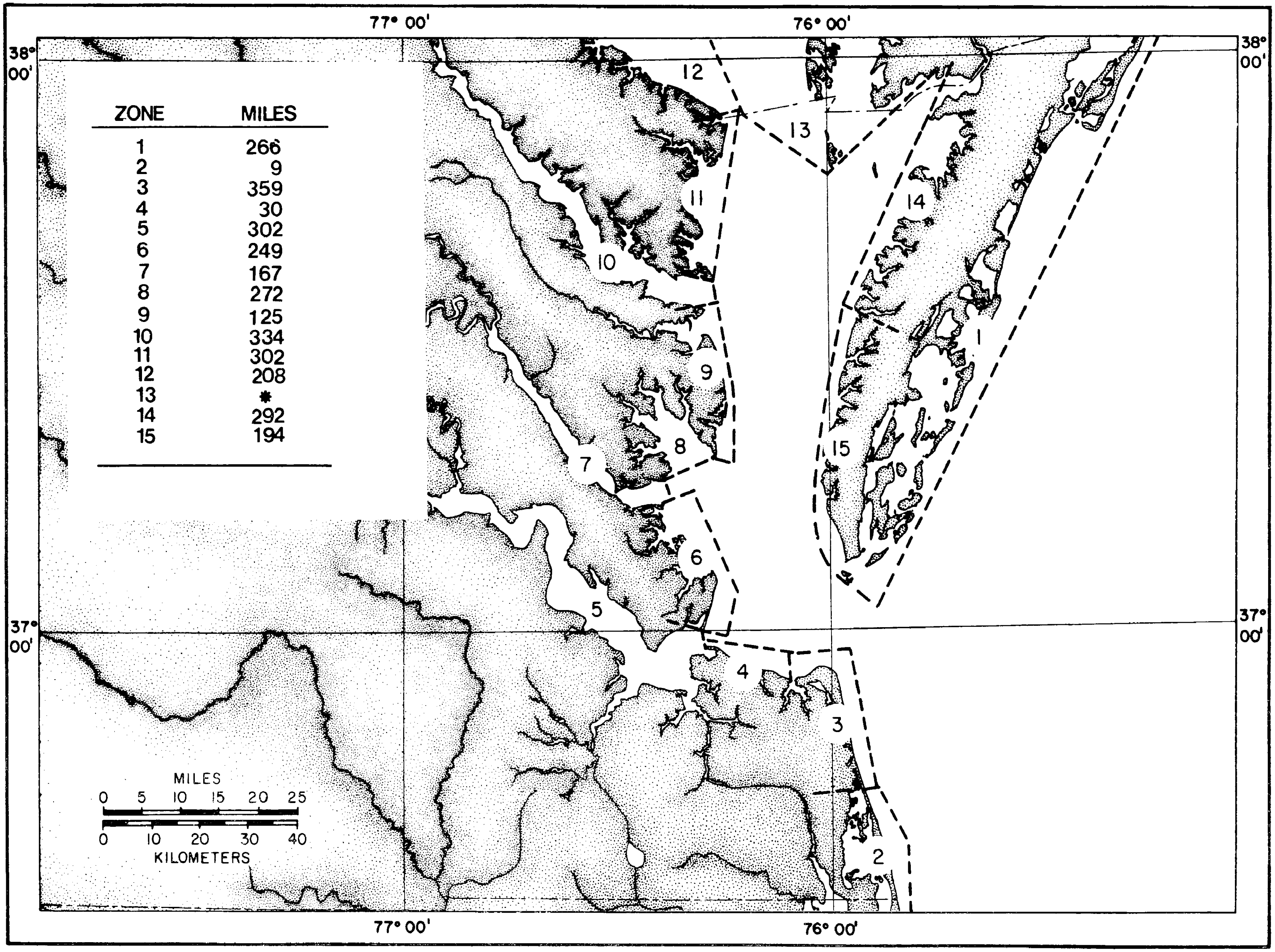
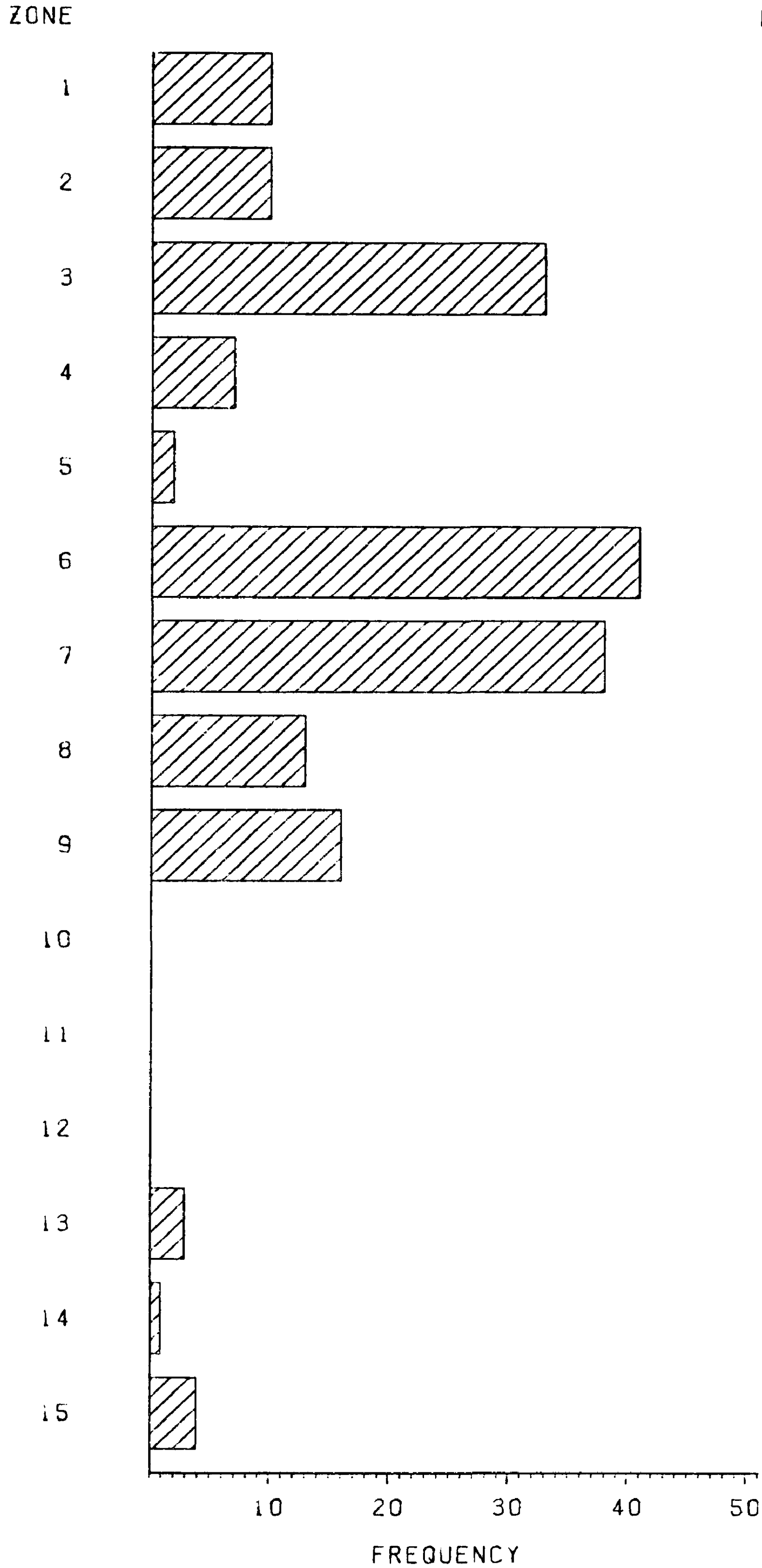

77° 00'
76° 00'
38° 00'
37° 00'
ZONE MILES
1 266
2 9
3 359
4 30
5 302
6 249
7 167
8 272
9 125
10 334
11 302
12 208
13 *
14 292
15 194
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
MILES
0 5 10 15 20 25
0 10 20 30 40
KILOMETERS

Figure 12. Sea turtle strandings per zone.
A. 1979, all species.
B. 1980, all species.
C. *L. kempii* strandings, 1979-1980.

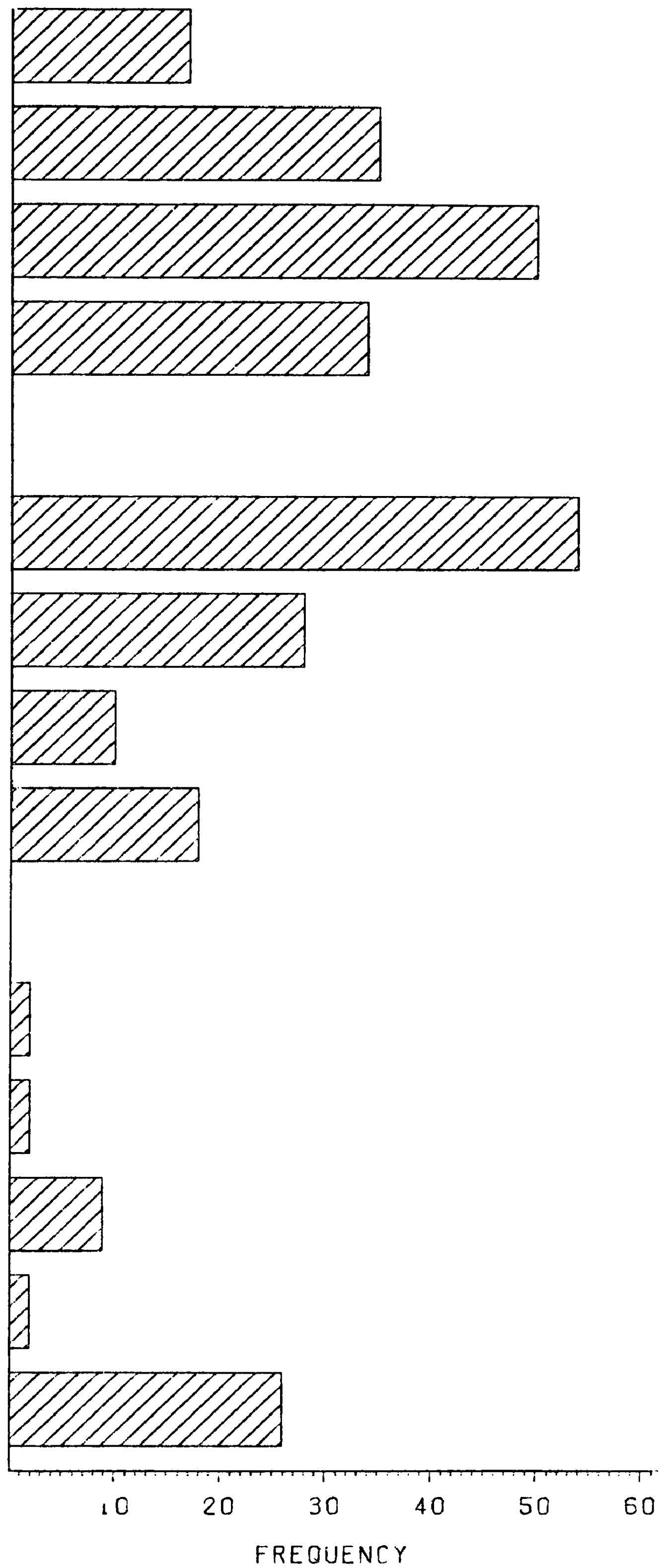
1979 STRANDINGS
PER ZONE



ZONE	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
1	10	10	5.62	5.62
2	10	20	5.62	11.24
3	33	53	18.54	29.78
4	7	60	3.93	33.71
5	2	62	1.12	34.83
6	41	103	23.03	57.87
7	38	141	21.35	79.21
8	13	154	7.30	86.52
9	16	170	8.99	95.51
10	0	170	0.00	95.51
11	0	170	0.00	95.51
12	0	170	0.00	95.51
13	3	173	1.69	97.19
14	1	174	0.56	97.75
15	4	178	2.25	100.00

INCLUDES ALL STRANDED SPECIES

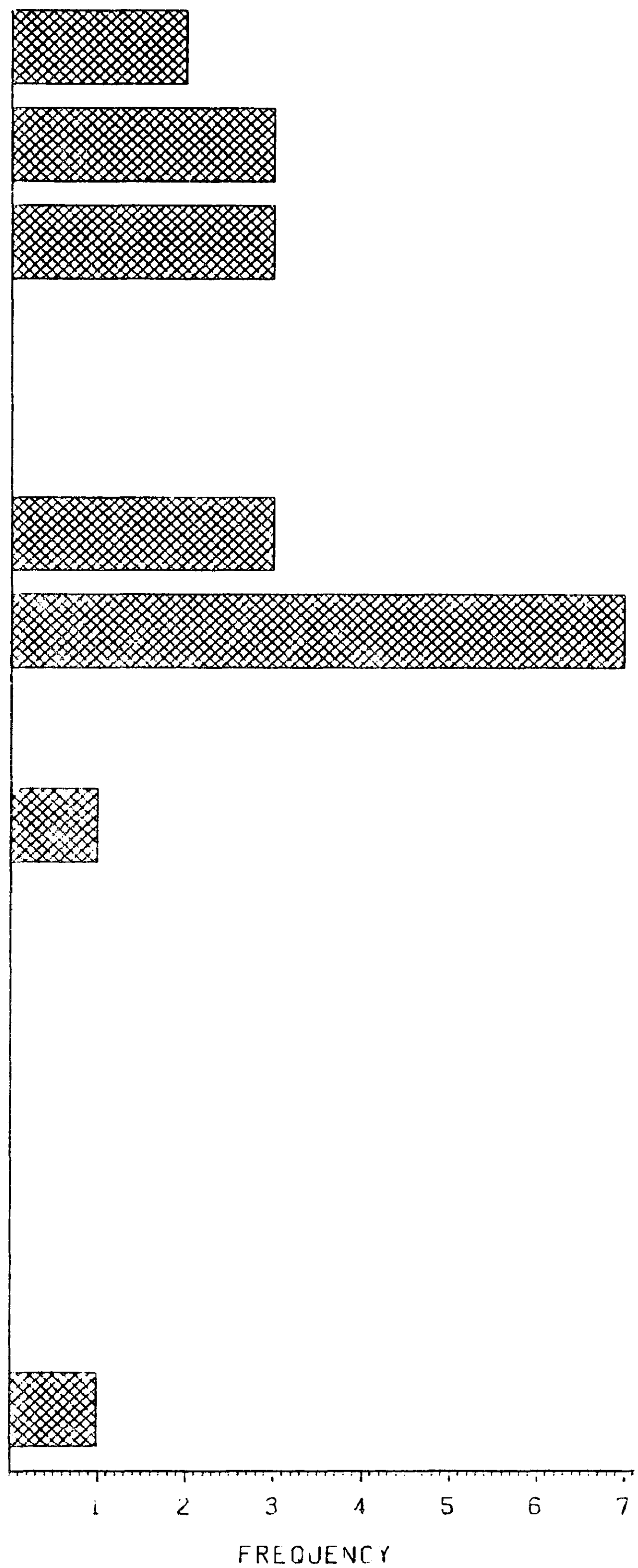
1980 STRANDINGS



ZONE	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
1	17	17	5.92	5.92
2	35	52	12.20	18.12
3	50	102	17.42	35.54
4	34	136	11.85	47.39
5	0	136	0.00	47.39
6	54	190	18.82	66.20
7	28	218	9.76	75.96
8	10	228	3.48	79.44
9	18	246	6.27	85.71
10	0	246	0.00	85.71
11	2	248	0.70	86.41
12	2	250	0.70	87.11
13	9	259	3.14	90.24
14	2	261	0.70	90.94
15	26	287	9.06	100.00

ALL STRANDED SPECIES PER ZONE

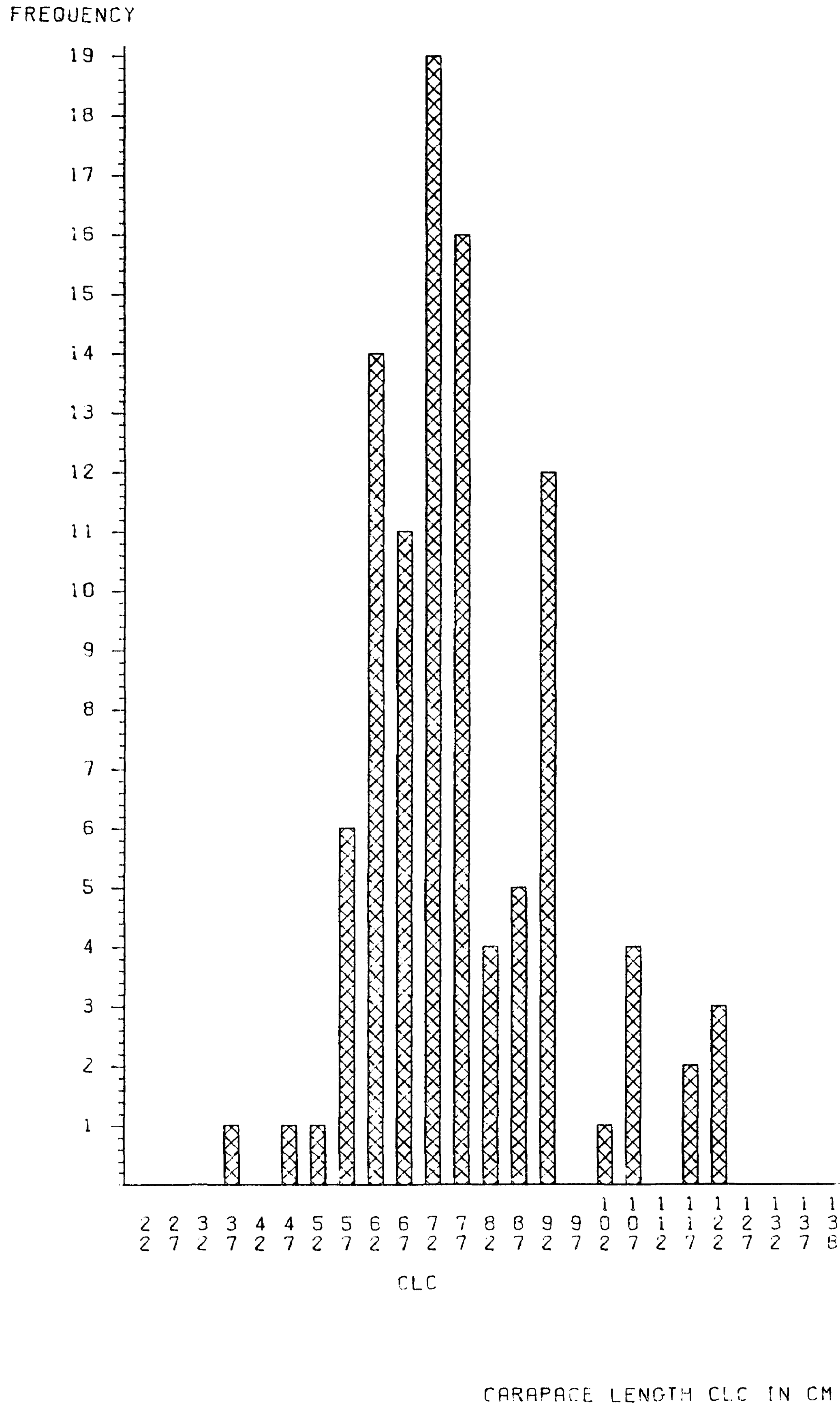
L KEMPII PER ZONE
1979 1980



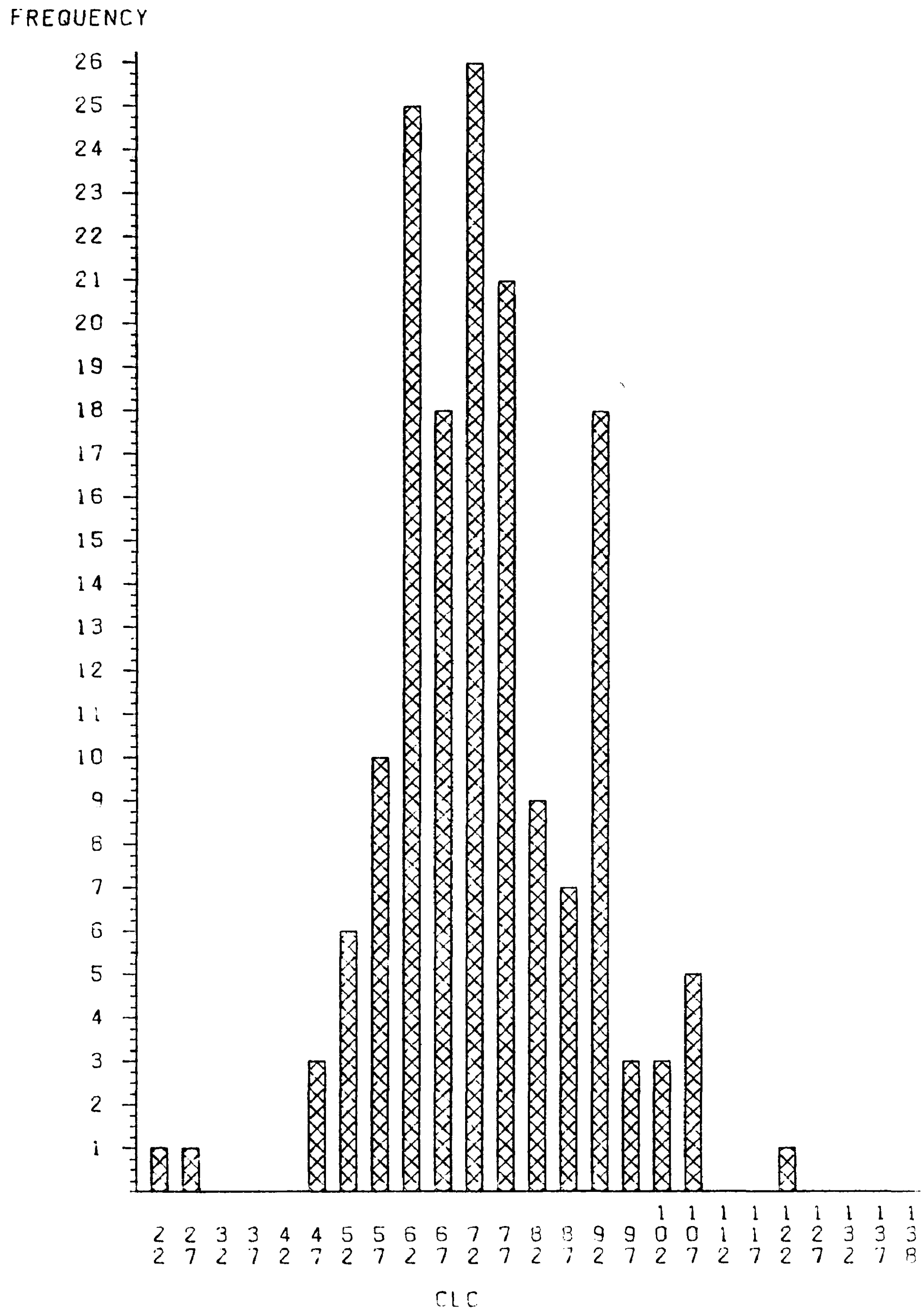
ZONE	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
1	2	2	10.00	10.00
2	3	5	15.00	25.00
3	3	8	15.00	40.00
4	0	8	0.00	40.00
5	0	8	0.00	40.00
6	3	11	15.00	55.00
7	7	18	35.00	90.00
8	0	18	0.00	90.00
9	1	19	5.00	95.00
10	0	19	0.00	95.00
11	0	19	0.00	95.00
12	0	19	0.00	95.00
13	0	19	0.00	95.00
14	0	19	0.00	95.00
15	1	20	5.00	100.00

Figure 13. Carapace length measured over curvature (CLC) frequencies for *C. caretta*, in centimeters.
A. 1979
B. 1980.

CARETTA CARETTA 1979
CARAPACE LENGTHS
OVER CURVATURE



CARETTA CARETTA 1980
CARAPACE LENGTHS
OVER CURVATURE

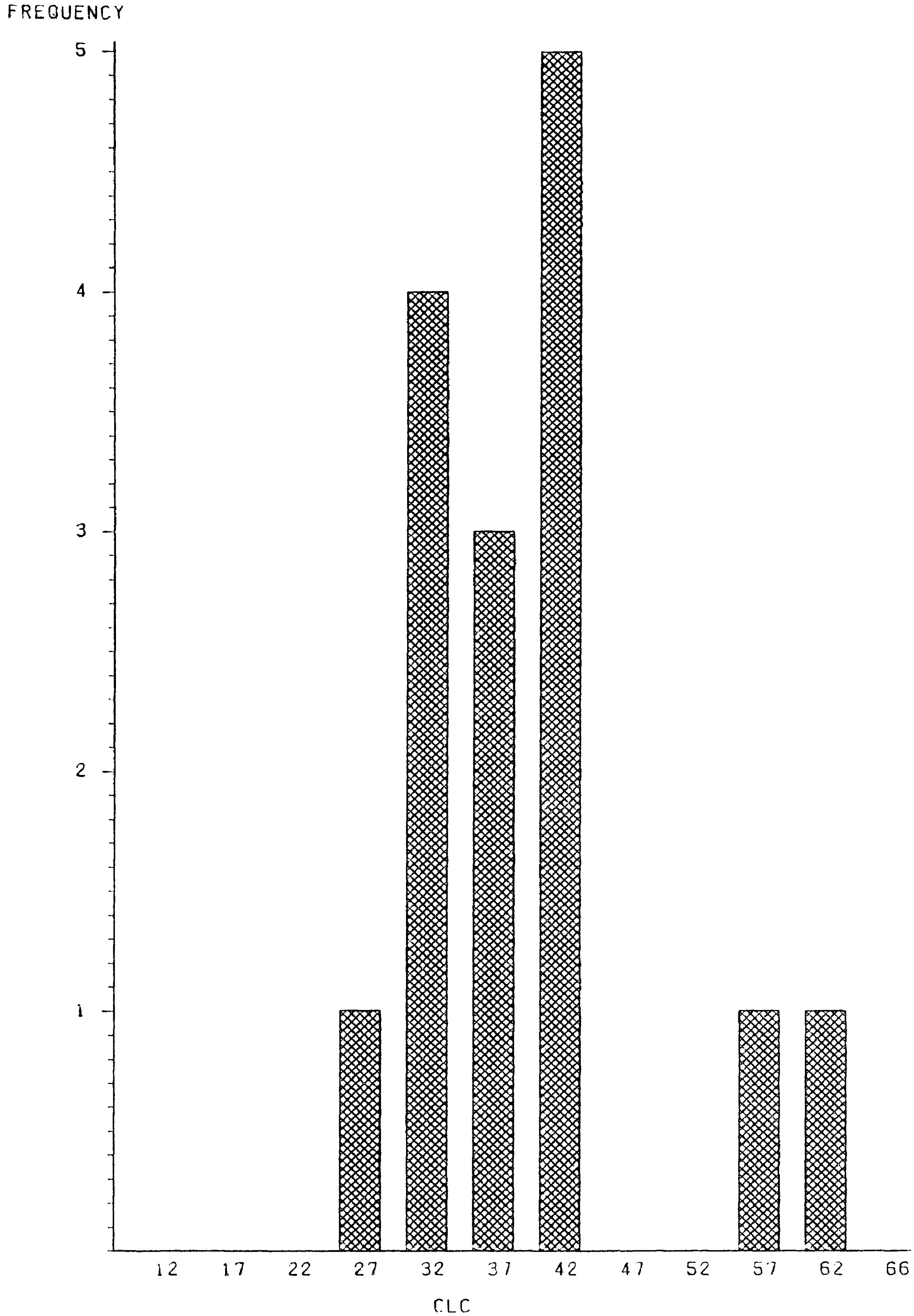


CARAPACE LENGTH<CLC>IN CM

Figure 14. Carapace length measured over curvature (CLC) frequencies for *L. kempii*, 1979-1980.

LEPIDOCHELYS KEMPII 1979 1980

CARAPACE LENGTHS MEASURED OVER CURVATURE



on CLS, has been determined for both species. These measurements have been sorted into reporting source categories. Findings are summarized in Table 4 and Figure 15. Highest positive correlation between carapace length versus width was found for measurements taken over curvature in the MT series, although all categories of carapace regressions showed positive correlation.

Morphometric data for L. kempii were pooled for 1979 and 1980. Dimensions of ridleys ranged from 25.3 cm CLC to 61.6 cm CLC, with a mean length over curvature of 39.6 cm (N=15, SD=10.04, CV=25.38). Ridleys in 1980 ranged from 25.3 cm CLC to 58.6 cm CLC, with a mean CLC of 38.4 cm. Regression analysis revealed a high degree of positive correlation of CLC versus CWC, with r^2=0.94 for MT series ridleys (N=11, CV=6.395, STD=2.6516, PR>F=0.0001).

It was possible to weigh six sea turtles during this study. Weights and carapace lengths for these individuals are found in Table 5. Additional details are provided for all ridley and leatherback records taken during this study (Table 6).

Food Habits

Fresh carcasses were infrequently available during the study. Therefore, it was only possible to sample entire stomach contents for seven individuals. No attempt was made to quantify food habits of live turtles. Contents of stomachs are provided in Table 7.

Limulus and Cancer irroratus were the most common food items found in loggerhead stomachs. This supports observer reports that

TABLE 4

REGRESSION ANALYSIS OF CARAPACE MEASUREMENTS BY REPORTING CATEGORY

Caretta caretta

CWC versus CLC

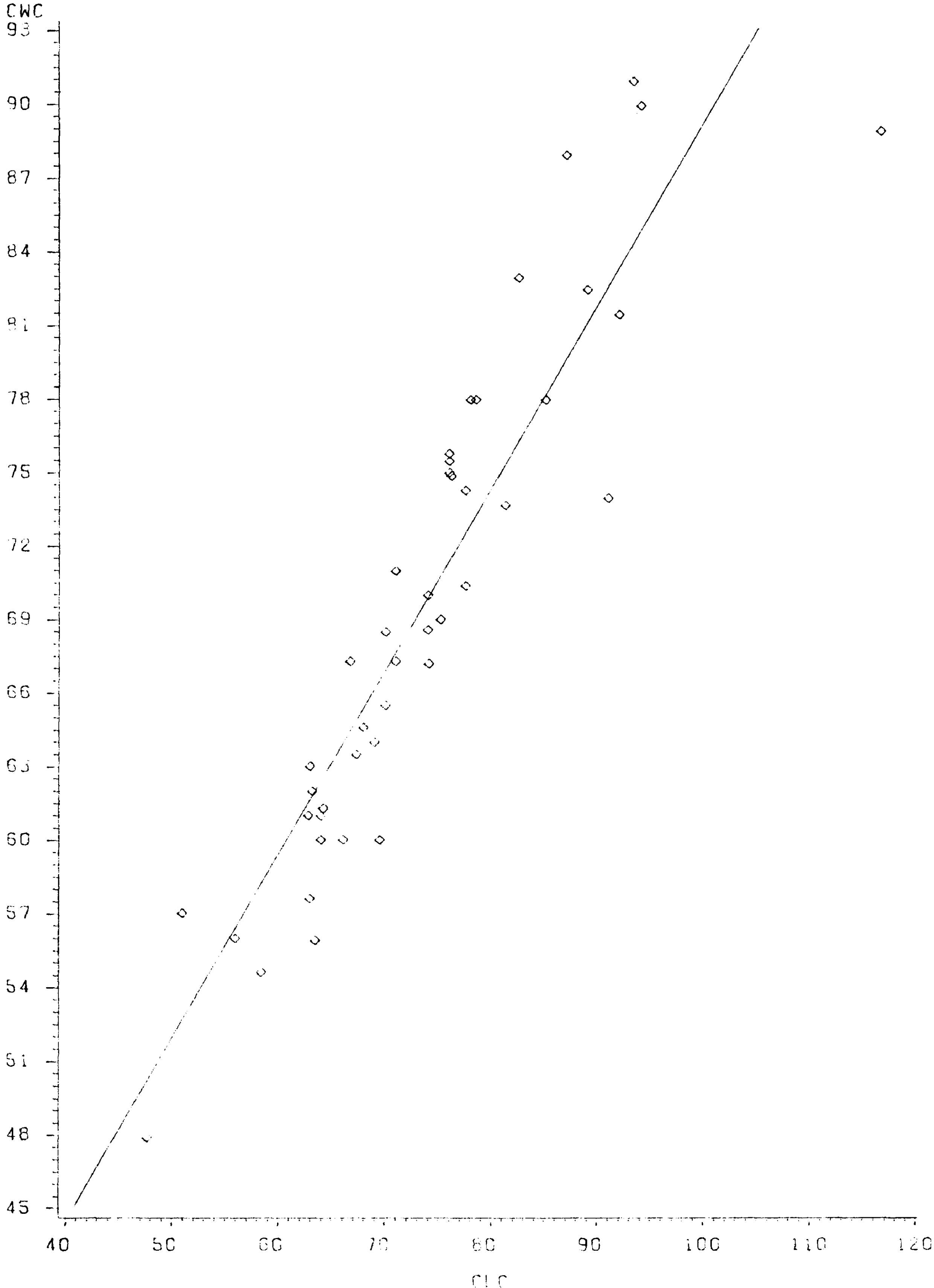
YEAR	N	r^2	CV	STD	PR>F	REPORTING CATEGORY
1979	46	0.83	6.05	4.2104	0.0001	MT 79
1980	49	0.91	4.48	2.9071	0.0001	MT 80
1979	93	0.60	12.03	8.1388	0.0001	MT 79 and SF 79
1980	144	0.60	13.87	8.8986	0.0001	MT 80 and SF 80
			CWS versus CLS			
1979	40	0.70	7.69	4.4673	0.0001	MT 79
1980	33	0.75	7.06	3.8420	0.0001	MT 80
1979	40	0.70	7.69	4.4673	0.0001	MT 79 and SF 79
1980	33	0.75	7.06	3.8420	0.0001	MT 80 and SF 80
			CWC versus CLC 1979-1980			
	95	0.87	5.45	3.6661	0.0001	MT series 79-80
	237	0.60	13.17	8.6342	0.0001	MT and SF series 79-80

Lepidochelys kempii CWC versus CLC 1979-1980

N	r^2	CV	STD	PR>F	REPORTING CATEGORY
11	0.94	6.40	2.6516	0.0001	MT 79 and MT 80

Figure 15. Carapace length versus width regressions.
A. C. caretta MT series, 1979 (over curvature).
B. C. caretta MT series, 1980 (over curvature).
C. C. caretta MT series, 1979 (straightline).
D. C. caretta MT series, 1980 (straightline).

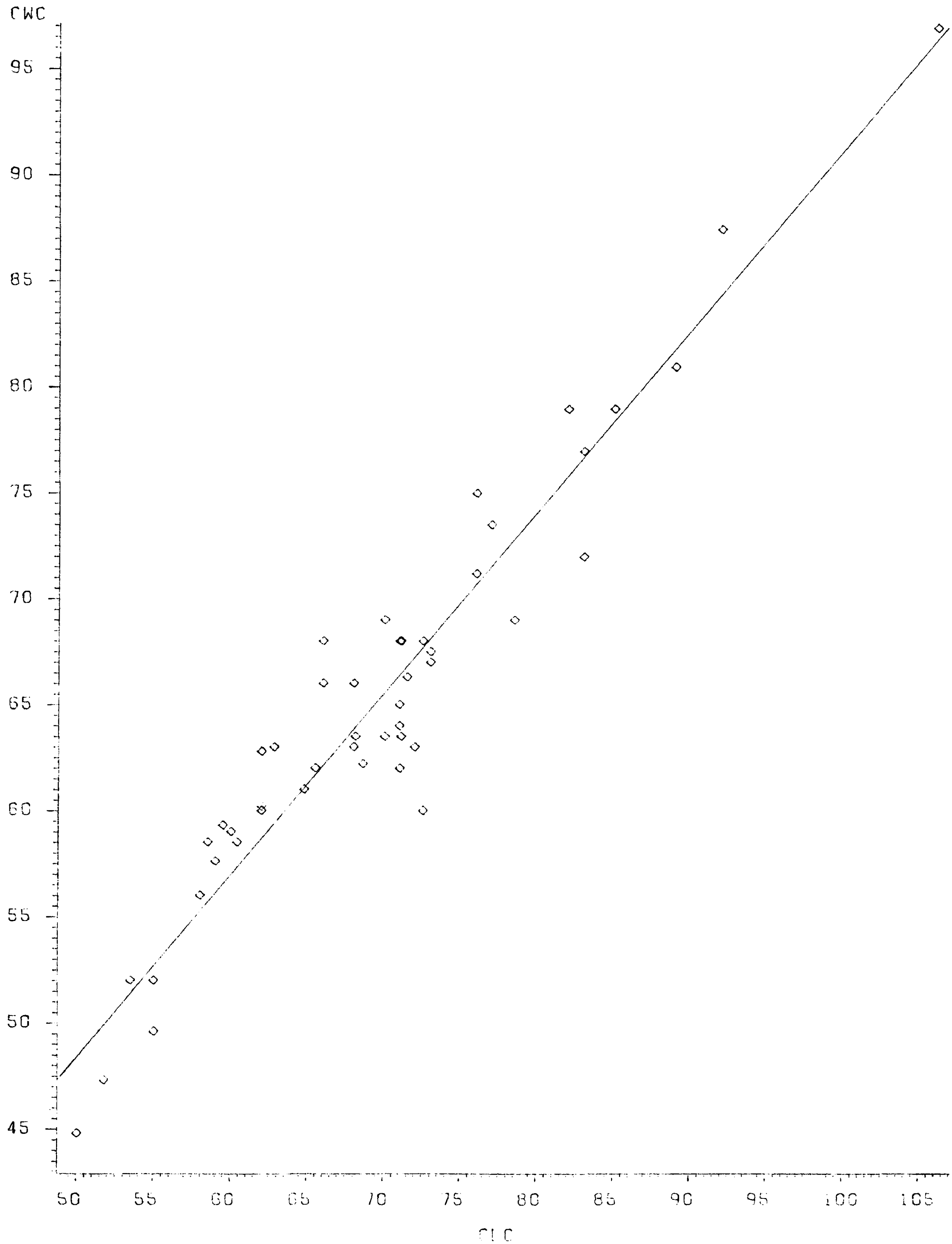
CARETTA CARETTA 1979 MT SERIES
CARAPACE LENGTH VS WIDTH REGRESSION



A

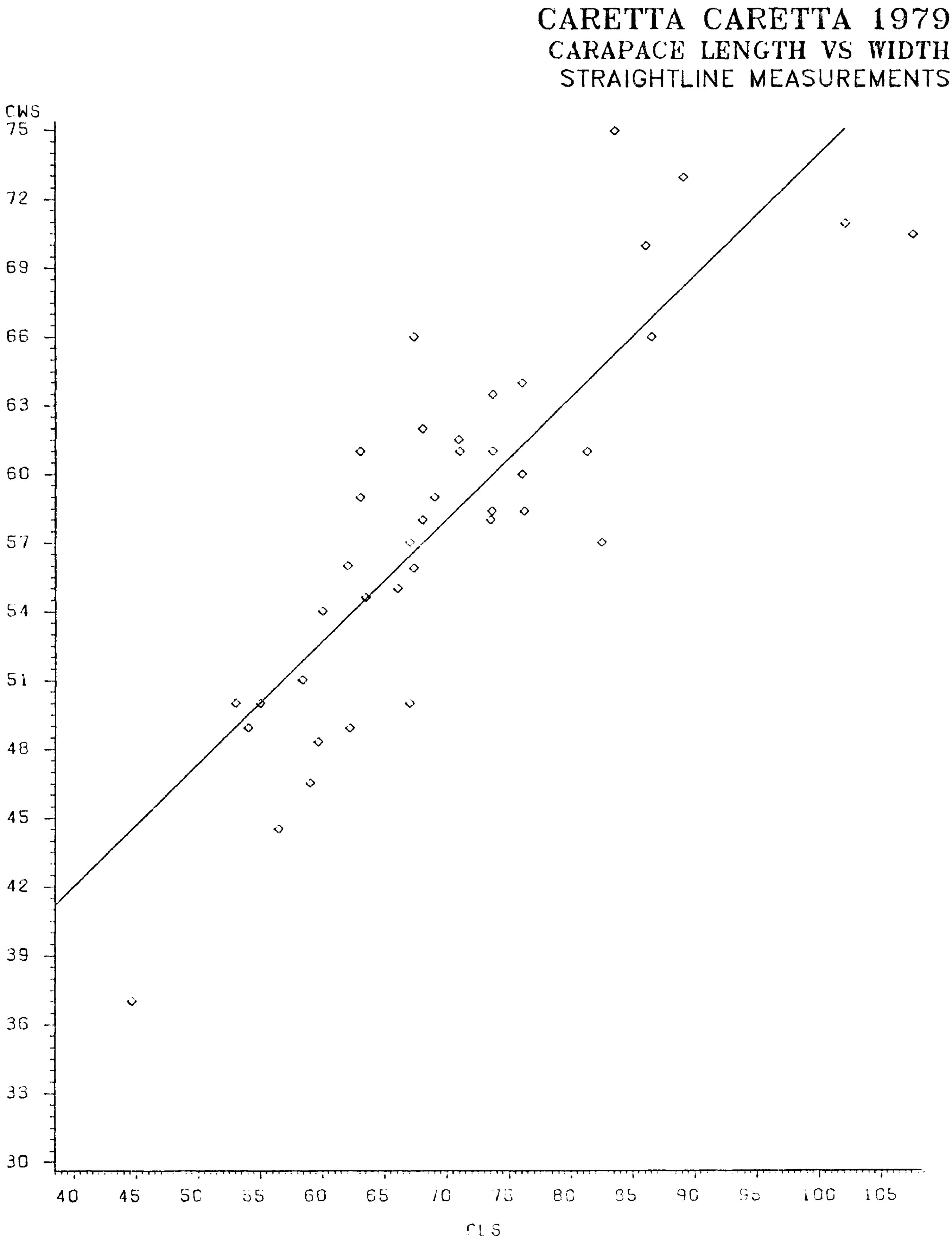
MEASUREMENTS OVER CURVATURE IN CENTIMETERS

CARETTA CARETTA 1980 MT SERIES
CARAPACE LENGTH VS WIDTH REGRESSION



B

MEASUREMENTS OVER CURVATURE IN CENTIMETERS


CARETTA CARETTA 1979
CARAPACE LENGTH VS WIDTH
STRAIGHTLINE MEASUREMENTS
CWS
75
72
69
66
63
60
57
54
51
48
45
42
39
36
33
30
40
45
50
55
60
65
70
75
80
85
90
95
100
105
CLS

CARETTA CARETTA 1980
CARAPACE LENGTH VS WIDTH
STRAIGHTLINE MEASUREMENTS

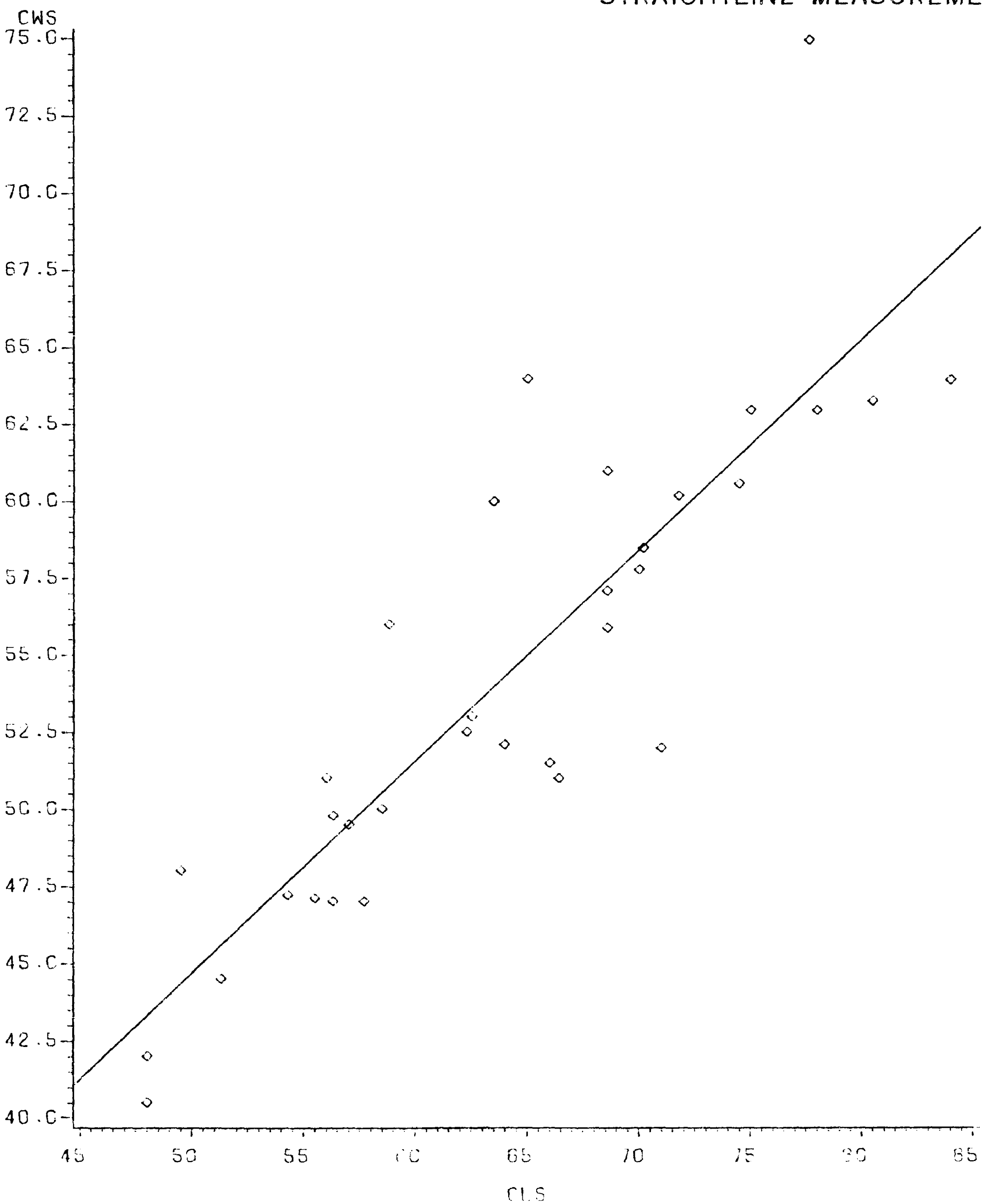


TABLE 5

WEIGHTS OF SEA TURTLES, IN KILOGRAMS

Field number	Species	Condition	CLC (cm)	Weight (kg)	Tag#
MT-10-79	*L. kempii*	stranded	41.5	7.32	
MT-59-79	*C. caretta*	alive	93.3	64.1	G110G
MT-24-80	*C. caretta*	dead in net	74.5	61.8	
MT-46-80	*C. caretta*	alive	71.0	36.6	G1010
MT-47-80	*C. caretta*	alive	51.8	16.4	G1026
MT-62-80	*L. kempii*	alive	43.0	9.67	K555

DATA SUMMARY FOR LEPIDOCHEYLS KEMPII

Field Number	Date	Location	Sex	Condition	CLC	CWC	CLS	CWS	HW	Zone	Other
MT-10-79	3 Jun 79	Cuba Island York River	U	fresh	41.5	43.5	39.0	37.0	11.0	7	
MT-13-79	11 Jun 79	Jenkins Neck	U	advanced	32.0	32.6	28.5	27.0	7.0	7	
MT-53-79	12 Jun 79	Sea Shore St. Park (SSP)	U	mild	61.6	54.6	-	-	14.6	3	
MT-60-79	27 Oct 79	Bena	U	moderate	41.9	42.5	41.3	36.8	8.9	7	
MT-61-79	7 Nov 79	Little Is. State Park	U	mild	36.0	35.3	34.9	31.8	8.5	2	
MT-25-79	25 Jun 79	Cuba Island	U	mummy	42.5	42.8	45.7	36.8	8.3	7	
11-S-79	18 Jun 79	Grand View	U	mile	30.5	20.3	-	-	5.7	6	
Sight 79	26 Jun 79	SSP	U	dead	-	-	-	-	-	3	
Sight 79	30 Jun 79	York River poundnet	U	dead	-	-	-	-	0	7	
MT-11-80	28 May 80	Poquoson	F	moderate	58.6	58.8	56.0	50.0	10.5	6	PL 44.3
MT-16-80	28 May 80	Back Bay NWR	U	adv	31.8	32.6	-	-	7.2	2	
MT-57-80	24 Sep 80	Hog Island	U	adv	-	-	30.5	25*		1	estimate*
MT-58-80	4 Oct 80	Hog Island York River	U	adv	39.4	40.6	38.1	36.2	9.5	7	PL 28.6
MT-62-80	16 Oct 80	Smith Island	U	alive	43.0	47.8	42.1	40.3	9.4	1	tags K555 K556
MT-74-80	12 Jun 80	False Cape State Park	U	moderate	25.3	25.0		.	4.5	2	PL 18.4
8-S-80	25 May 80	Buckroe Beach	U	mile	30*	19*	-	-	5.0	6	estimate*
107-S-80	1 Jul 80	Chisholm Creek	U	alive	-	-	-	-	-	6	tagged G2123
130-S-80	17 Oct 79	Fishermans Island	U	mild	43.2	44.5	-	-	9.5	15	
118-S-80	23 Aug 80	SSP	U	mild	36*	30*	-	-	7.6	3	estimate*
Tag K466	3 Jun 80	Gwynns Island	U	alive	-	-	-	-	-	8	
Tag K527	2 Jun 80	Allens Island	U	alive	40*	-	-	-	-	7	estimate*
Sight 80	9 Jul 80	New Point Comfort	U	dead	-	-	-	-	-	9	
Data Summary for Dermochleys Coriacea											
MT-20-79	18 Jun 79	Jenkins Neck	F	adv	161.0	125.0	-	-	20.0	7	
Sight 79	unknown	Seashore SP	U	dead	-	-	-	-	-	3	
MT-9-80	26 May 80	Grandview	U	adv	-	-	-	-	-	6	
MT-26-80	26 May 80	Bena	U	adv	124.0	106.0	-	-	-	7	
11-S-80	3 Jun 80	Smith Island Maryland	F	moderate	182.9	91*	-	-	-	13	estimate*

TABLE 7

STOMACH CONTENTS FOR C. CARETTA

TURTLE	CONTENTS	WET WEIGHT (grams)
MT-1-80	*Limulus polyphemus* hard parts	12.5
12 May	*Cancer irroratus* hard parts	19.2
	digested material, crustacean	15.0
		46.7
MT-4-80	*L. polyphemus* hard parts	14.2
20 May	*C. irroratus* hard parts	33.7
	digested material, crustacean	28.0
	Sargassum sp.	6.5
	Lironeca ovalis (Say)	6.6
	pebbles	1.9
	Sulcascaris sulcata, (2)	90.9
MT-7-80	*C. irroratus*	54.8
21 May	digested crab sp.	1.5
	fish vertebrate	2.0
		58.3
MT-33-80	well digested semi-solids	not available
2 June	medusa remains, tentacles	

TABLE 7 (concluded)

	2 swimmerets, *Callinectes sapidus*	
	2 shrimp, species unknown	
MT-48-80	*L. polyphemus*, hard parts	33.3
30 May	digested material, *Limulus*?	45.6
	*sand and pebbles	
		78.9
MT-59-80	well-digested crab, *Callinectes*?	not available
7 October	.5 liter viscous fluid	
	sand	

loggerheads feed on horseshoe crabs in the Bay. Sand and pebbles were also found in stomachs, indicating that loggerheads prey on benthic food items while in the study region. The remains of a clupeid was the only fish found in a loggerhead stomach (MT-7-80). An intact specimen of Lironeca ovalis (Say), an ectoparasite of bluefish (Gosner, 1971) was taken from MT-4-80. There was no additional evidence of a piscivorous diet for loggerheads in the area. Entire stomach contents of L. kempii were not retrieved, but hard parts of Callinectes sapidus and Cancer irroratus were found in at least three carcasses.

Pathology

Post mortem examinations were conducted on six loggerheads in 1980. These findings are summarized in Table 8. Full histopathological reports may be found in the Appendix. Post mortem changes, or autolysis, advanced to an extreme degree in summer heat. Most strandings I had examined during this study had undergone extensive decomposition. In a preliminary report to NMFS, Wolke (1980) found that necropsies of such individuals are generally unrewarding because tissues are rendered unsuitable for histopathological examination. In most cases, Virginia strandings were so badly decomposed that causes of death could not be verified.

Although the six carcasses examined appeared to be fresh when found, post mortem autolysis and associated tissue changes were noted in the histopathologial analysis of four out of six carcasses. Three out of six carcasses were heavily encrusted with dermal barnacles P.

TABLE 8

HISTOPATHOLOGICAL FINDINGS SUMMARY, UNIVERSITY OF RHODE ISLAND, R. WOLKE AND A. GEORGE

NUMBER	SPECIES	DATE OF STRANDING	FINDINGS
MT-1-80	C. caretta	11 May 80	trematodiasis; enteritis-granulomatous; probable drowning.
MT-7-80	C. caretta	22 May 80	endocarditis; enteritis-acute.
MT-33-80	C. caretta	2 June 80	spleen-infarction acute; hepatitis-focal, granulomatous; probable drowning.
MT-4-80	C. caretta	20 May 80	hepatitis-focal, acute; Sulcascaris sulcata.
MT-48-80	C. caretta	30 May 80	enteritis-granulomatous, verminous; trematodiasis (spirorchid); myocarditis-granulomatous, verminous.
MT-59-80	C. caretta	7 Oct 80	gastritis, granulomatous, verminous; nephritis, nonpurulent; possible parasite in muscle mesentary.

hexastylos identified above. Wolke and Erhardt (personal communication, 1981) described a similar condition in Florida strandings. Wolke linked those findings with a verminous anemic condition. Anemia has not been cited in any diagnoses of the loggerheads from this study.

Drowning was implicated as a cause of death in two turtles. Tenacious tracheal foam or fluid was found in air passes of four out of six carcasses, but these symptoms have not proven to be a reliable indication of death due to drowning (Wolke, personal communication, 1980).

Spirochids (blood flukes) have been identified in two out of six sea turtles. Mononuclear cells, focal accumulation of lymphocytes, and brown or golden pigment sometimes associated with verminous infections (Elkan, 1979) were observed in five out of six carcasses. However, bacterial infections are common as animal tissue decomposes, and may contribute to histopathological findings (Elkan, 1979).

Two ascaridioid nematodes Sulcascaris sulcata (Rudolphi, 1819) were found along with copious bloody fluid in the stomach of MT-4-80. This loggerhead was probably infected after eating the invertebrate host. Typical hosts for Sulcascaris larvae found in the study region include the scallops Aequipecten gibbus and A. irridans (Cheng, 1967), the surf clam Spisula solidissima (Perkins et al., 1975) the whelk Busycon caniculata and the moon snail Lunatia heros (Cheng, 1979). Sprent (1977) identified Chelonia mydas as the type host for

Sulcascaris. Lester *et al*. (1980) have taken late larval instars and adults from *C. caretta* in Australia, and presented evidence that *C. caretta* may be the most important host in the *Sulcascaris* life cycle.

The marine leech *Ozobranchus margoi* (Apathy) was found on three loggerheads, including two necropsied turtles. Adults and juveniles were clumped together on the left axial region of the neck, on the carapace and plastron, and internally imbedded in the upper cloacal wall of MT-59-80. Egg masses encrusted the carapace and plastron. *O. margoi* has been associated with other sea turtle species as well as loggerheads by several authors (Davies and Chapman, 1974; Hughes, 1974b; Schwartz, 1974; Saywer *et al*., 1975; Bustard, 1976). Severe leech infestation has been implicated in the pathology of both *C. caretta* and *C. mydas* in South Carolina (Schwartz, 1974) but no evidence exists that these turtles died as a direct result of leech infection.

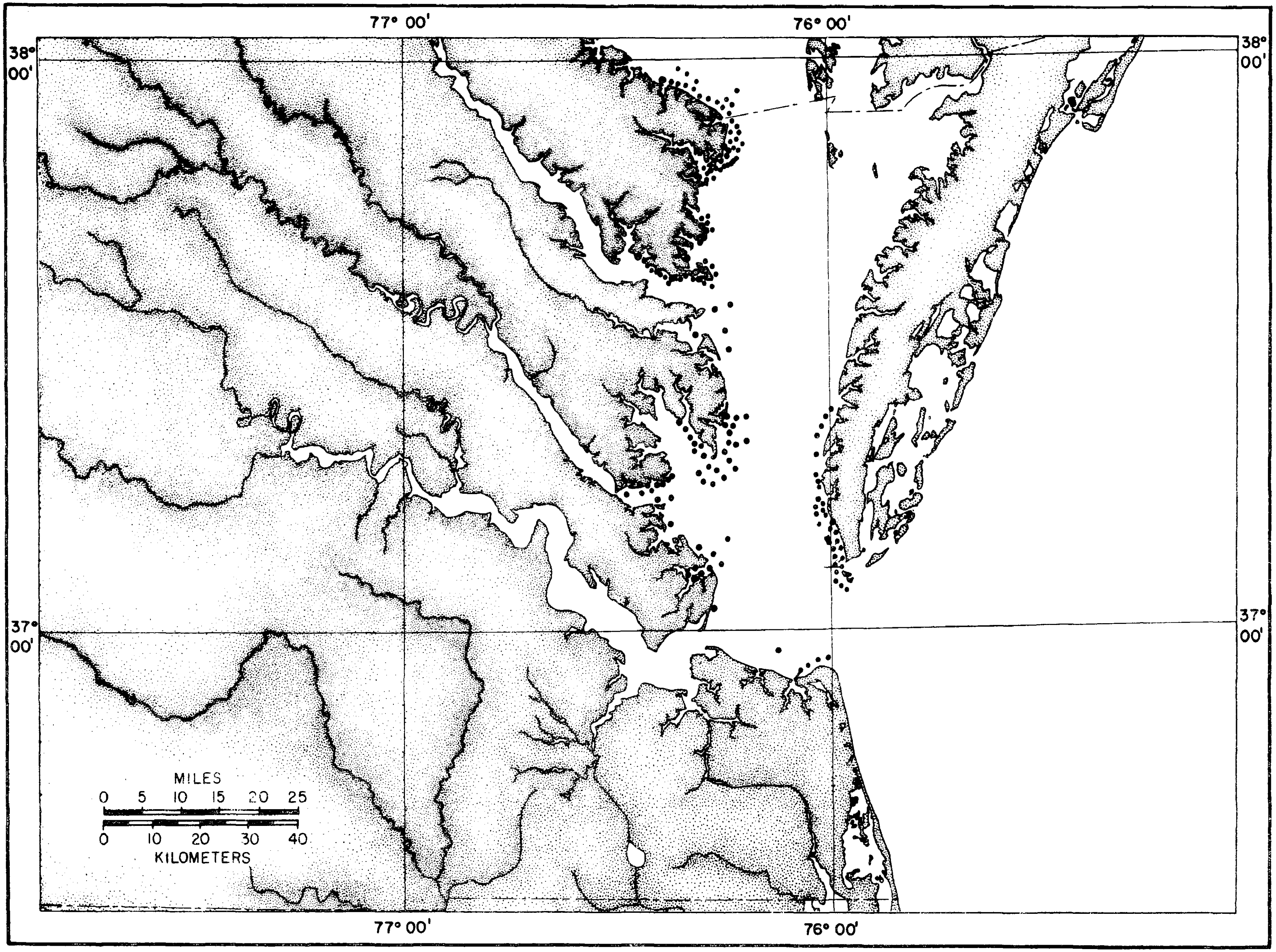
Mortality Sources

In 1979, when almost two-hundred sea turtles stranded on Virginia shoreline, it was suspected that mortalities were associated with poundnets. Location of poundnets and strandings are given in Figures 16 and 17.

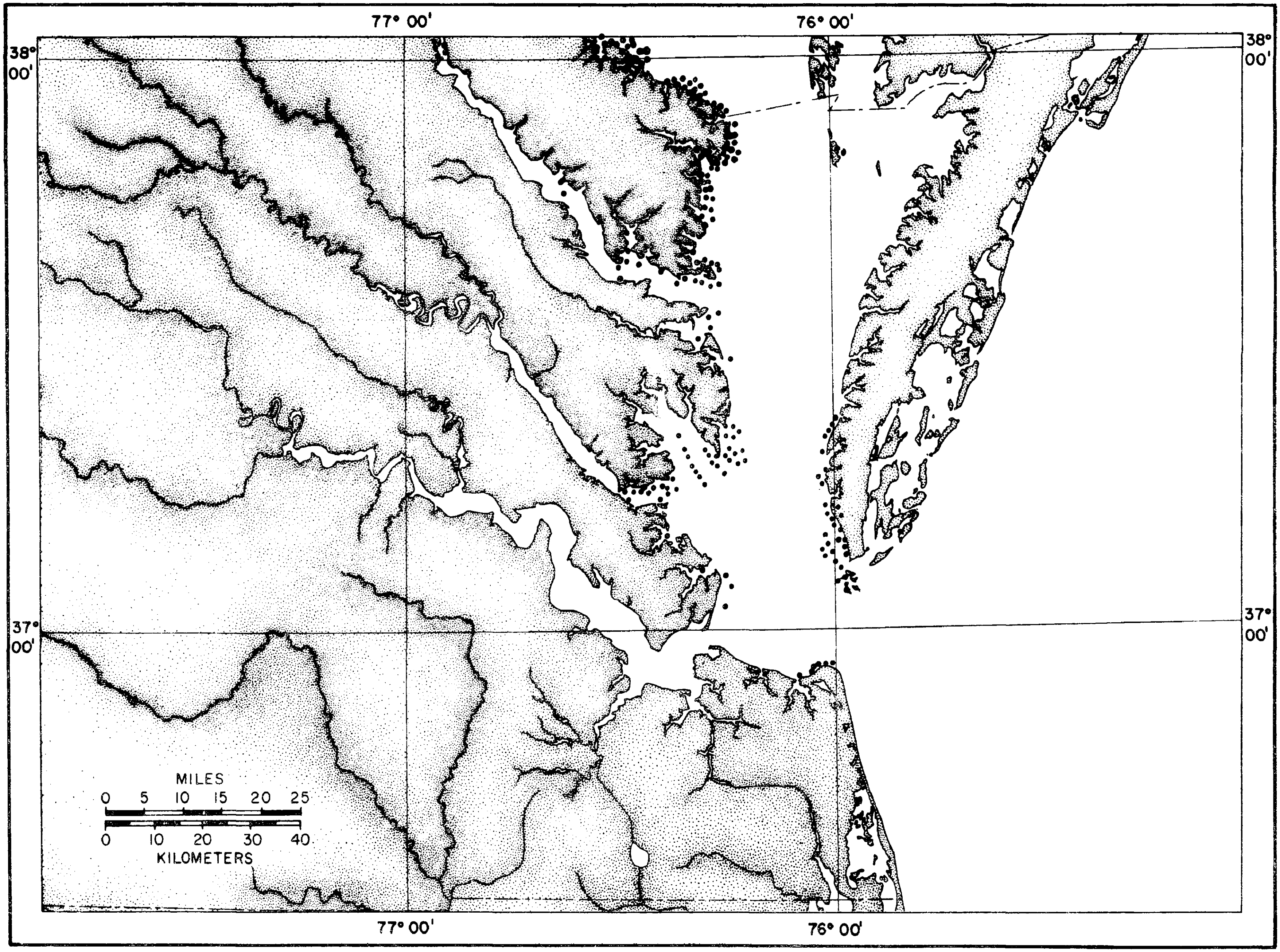
Most sea turtles that washed ashore in the study area had undergone extensive decomposition, making determination of cause of

Figure 16. Poundnet distribution based on VIMS aerial overflights.
A. May-June, 1979
B. July-September, 1979
C. October-November, 1979.

A


77° 00'
76° 00'
38° 00'
37° 00'
MILES
0 5 10 15 20 25
0 10 20 30 40
KILOMETERS

B


77° 00'
76° 00'
38° 00'
37° 00'
MILES
0 5 10 15 20 25
0 10 20 30 40
KILOMETERS

C

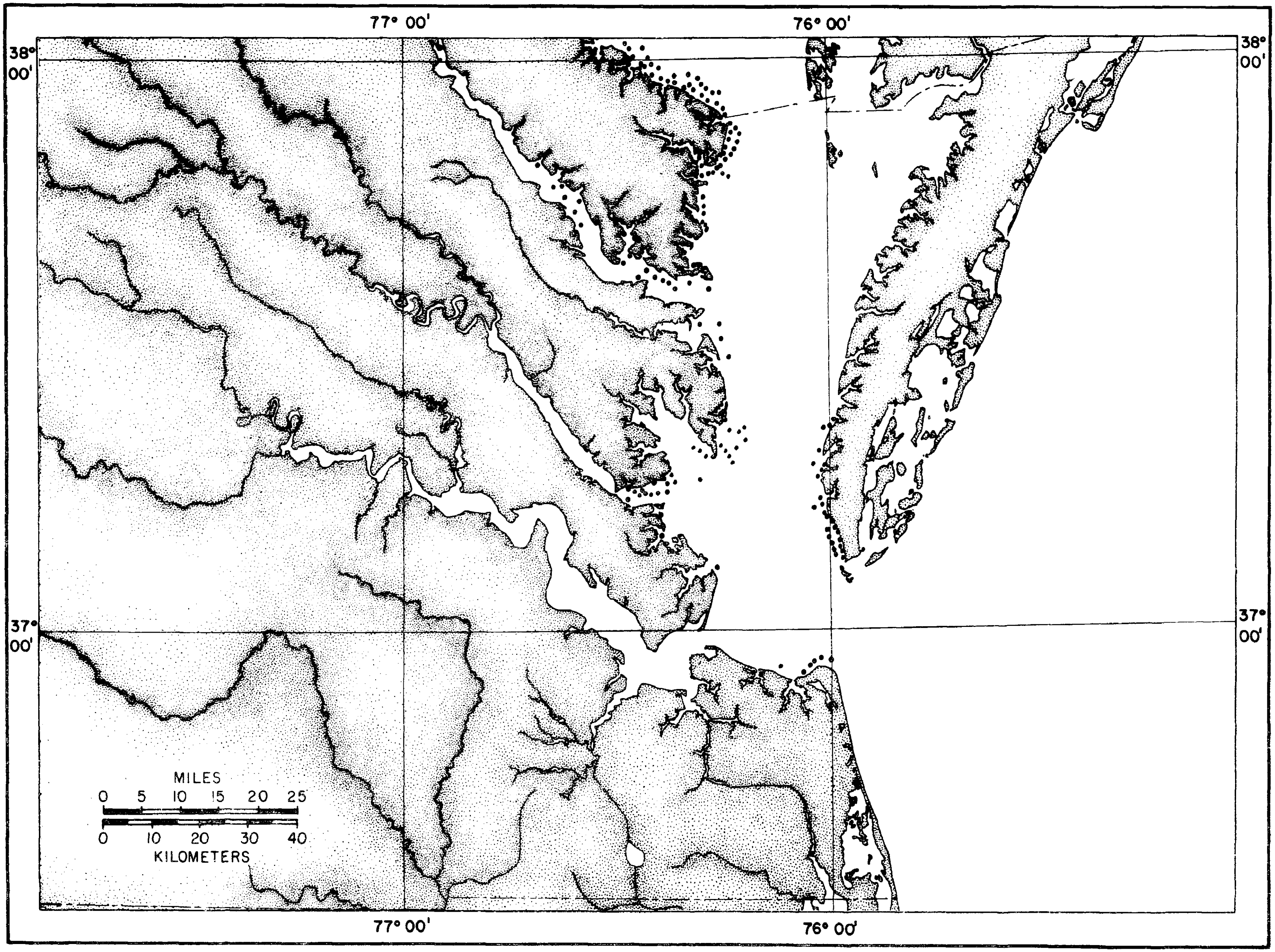
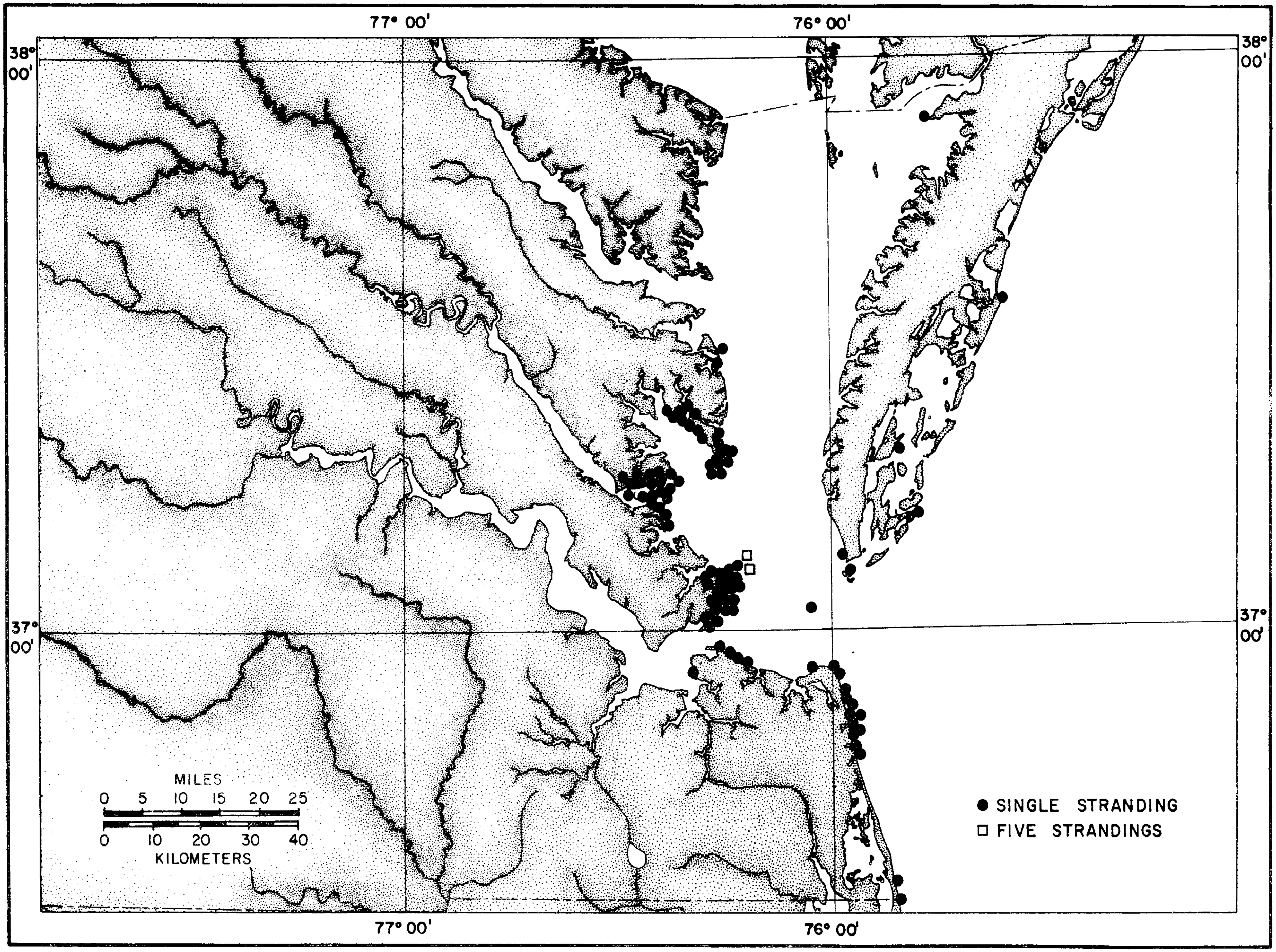

77° 00'
76° 00'
38° 00'
37° 00'
MILES
0 5 10 15 20 25
0 10 20 30 40
KILOMETERS

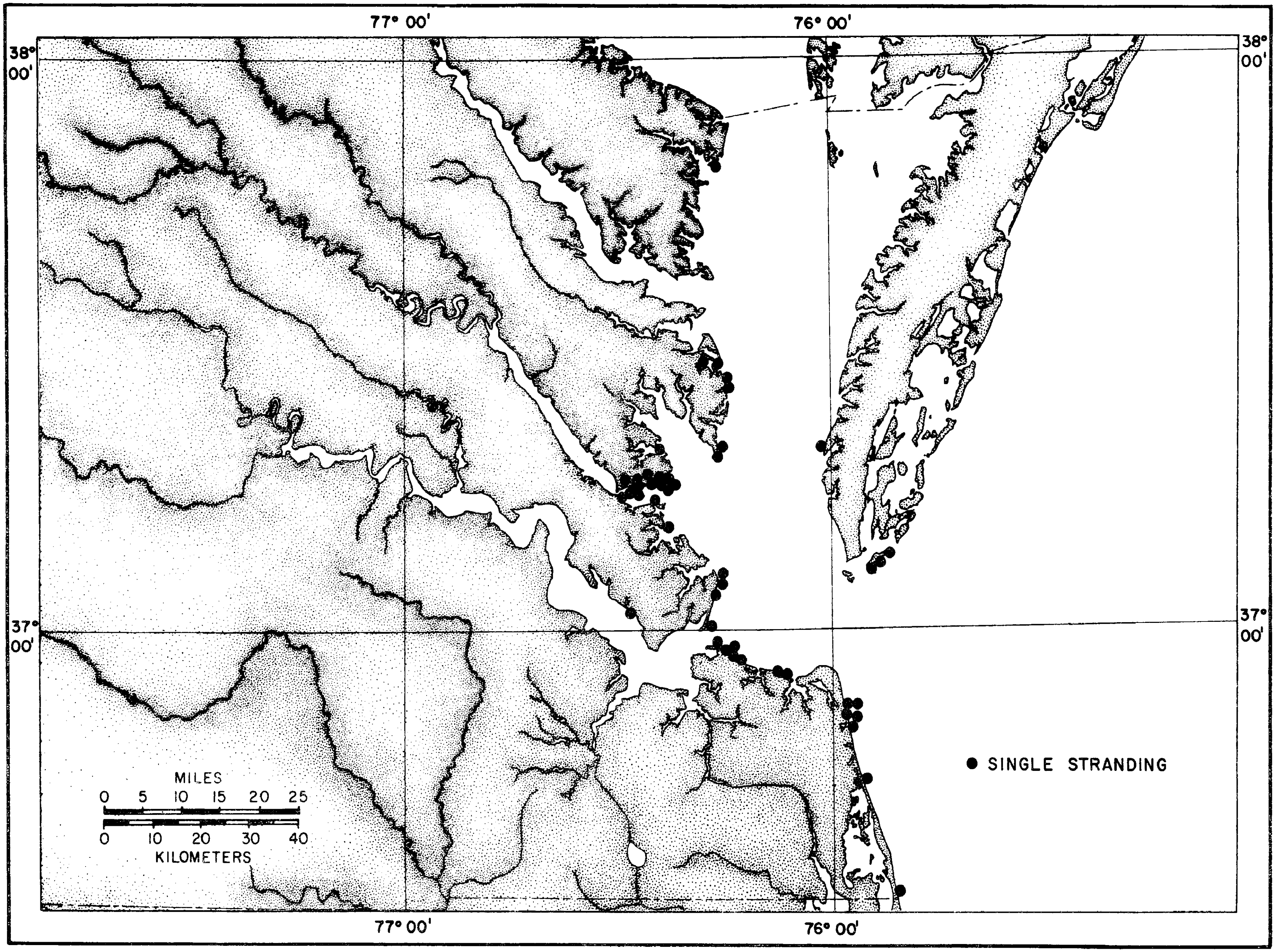
Figure 17. Sea turtle stranding locations in 1979.
A. 24 May-30 June
B. 1 July-1 August
C. 1 October-1 November.

A

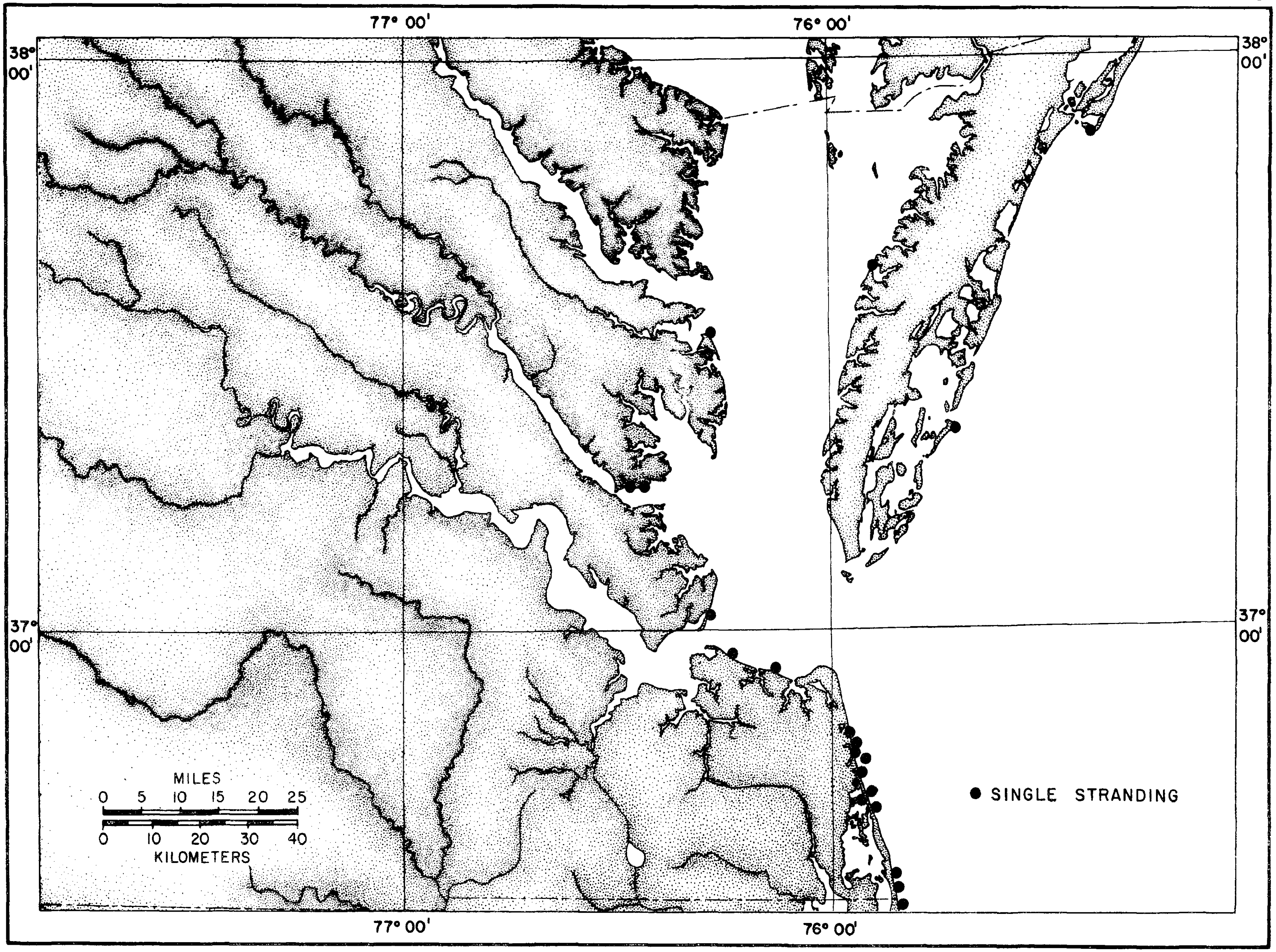


77° 00'
76° 00'
38° 00'
37° 00'
MILES
0 5 10 15 20 25
0 10 20 30 40
KILOMETERS
● SINGLE STRANDING
□ FIVE STRANDINGS

B


77° 00'
76° 00'
38° 00'
37° 00'
SINGLE STRANDING
MILES
0 5 10 15 20 25
0 10 20 30 40
KILOMETERS

C


77° 00'
76° 00'
38° 00'
37° 00'
MILES
0 5 10 15 20 25
0 10 20 30 40
KILOMETERS
● SINGLE STRANDING

death difficult. Out of 145 carcasses examined in 1979, the following have been identified as likely causes of death:

7 or	5%	dead in poundnet hedging, including one ridley and one leatherback.
9	6%	damaged by boats or propellors.
3	2%	found with bullet wounds.
1		died after rod and reel capture.
1	<1%	loggerhead died with a fractured skull inflicted with a blunt object.

For 1980, out of 214 carcasses, the following sources of mortality have been identified:

64 or	30%	dead in poundnet hedging
15	7%	damaged by boats or propellors
7	3%	killed for sale of carcass
1		died in haul seine
1	<1%	died after long line capture
2		one loggerhead and one leatherback were found entangled in crab pot lines.

Two loggerheads survived head wounds inflicted by humans. There is unconfirmed evidence that a few turtles were killed by gunshots.

Predation

Members of the Virginia Beach Sharkers club and other sport and commercial fishermen have reported findings loggerhead parts in the stomach of the Tiger shark, *Galeocerdo cuvieri*, taken off Virginia Beach and the Eastern Shore. Club members reported that tiger sharks "almost always" have loggerheads in their stomachs.

One tiger shark landed on 7 September 1980 contained the relatively intact remains of three moderate sized loggerheads (Jack Randolph, personal communication). I have found several loggerhead carcasses with large crescent-shaped wounds that had healed over. These were most likely inflicted by sharks.

In 1980 two loggerheads (carapace length estimated at 70 cm based on skull size) were found in the stomach of a tiger shark landed off Chincoteague, Virginia. Loggerheads have been recorded from Galeocerdo in North Carolina (Gudger, 1949) in New England by Shoop (1980) and in Hawaii by Balazs (1979). Tiger sharks are most common in the Virginia coastal area in the late spring and early summer (Lawler, E.F., Jr. 1976; Musick, unpublished data) and may take loggerheads as they travel through coastal waters. No other natural predators of larger loggerheads are common in the study region.

Incidental Catch and Poundnet Study

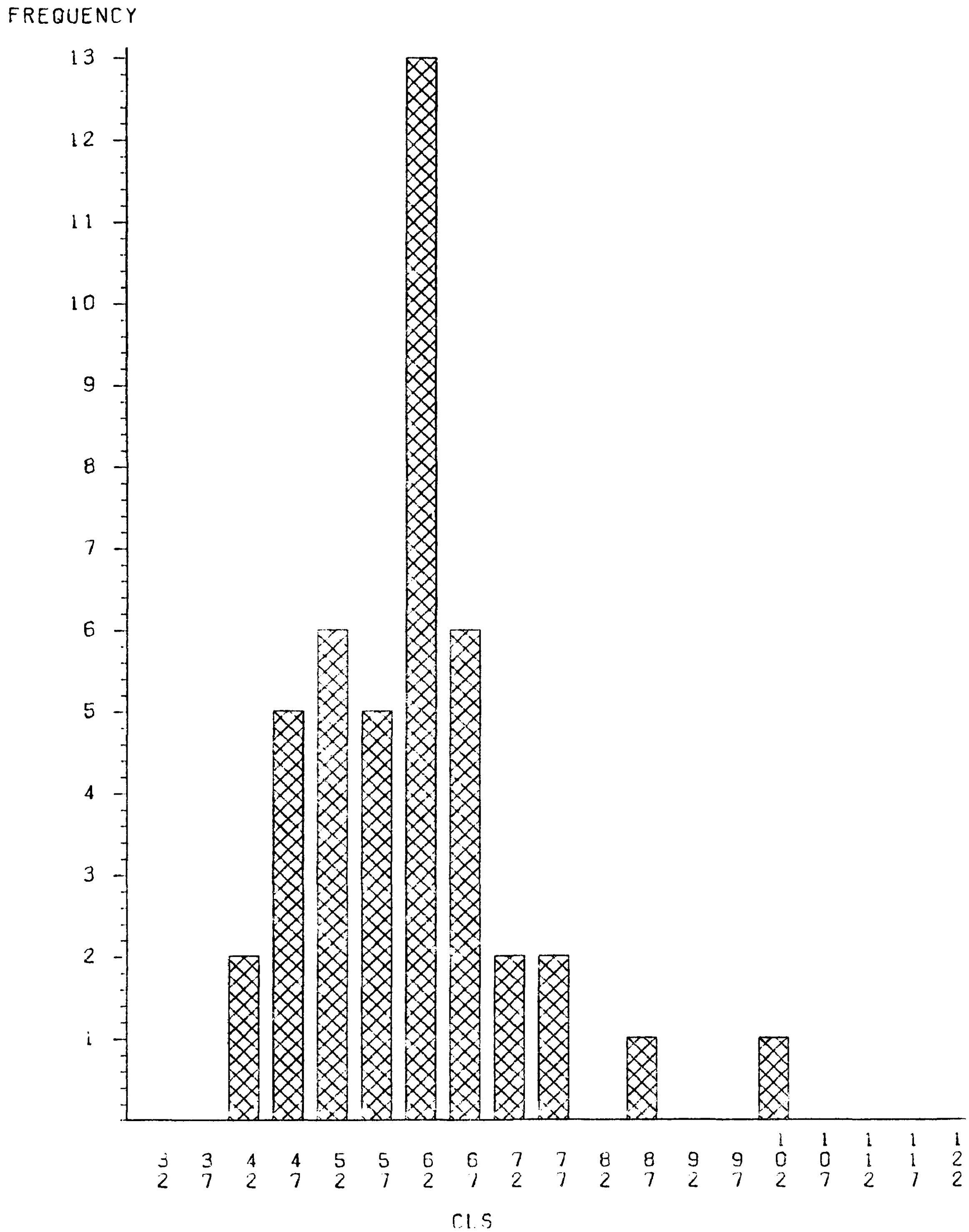
In 1980, a minimum of 284 sea turtles were reported captured alive in the head of poundnets in the study area. Seventy-five or about 26% of those were tagged before release. Three tagged turtles, including one tagged by R. Byles after long line capture (K555), were L. kempii and 72 were C. caretta. Only one male, a loggerhead from the Potomac River mouth tagged in late summer, was reported captured.

Sizes of measured sea turtles captured by watermen ranged from 46.0 to 102 cm carapace length straightline (CLS, N=43), with a mean carapace length of 61.4 cm. This value falls only slightly short of the overall mean for area loggerheads CLS=65.4 cm (N=123). Tagged turtle carapace length frequencies are provided in Figure 18. A ridley captured in a poundnet measured 40 cm CLS and K555 measured

Figure 18. Tagged sea turtle carapace lengths supplied by watermen (actual or estimated straightline length), 1980.

TAGGED TURTLES

TAGGED TURTLE CARAPACE LENGTHS



CARAPACE LENGTH STRAIGHTLINE

42.1 cm CLS. Only two adult loggerheads were reported captured by watermen.

Sea turtles were most often captured by poundnets in June, but were found regularly through early October. Monthly captures are depicted in Figure 19. Specific tagging dates have not been provided by watermen for September, October, or November turtles.

The earliest poundnet capture reported was on 5 May 1980 off Buckroe Beach. The last sea turtle tagged was reported by watermen for the first week in November on the mouth of the Potomac River. Most of the late summer tagging activity occurred in the Potomac River area, whereas few turtles were tagged in that period in the lower Bay and its tributaries.

Tagging Results

Six out of 75 sea turtles tagged in 1980 and one ridley tagged and released in Florida were reported recaptured in the study area, comprising 9% of all turtles tagged since the study began (N=77). Tagging locations are given in Figure 20. Several turtles were reported recaptured more than twice, and one (K467) as many as five times (Table 9).

Tagging and recapture locations are shown in Figure 21. Loggerhead K467 was recaptured at least twice at two different net loations. Identified as "Humpback" by the two unrelated watermen, this individual's carapace was deformed by a large hump and was heavily encrusted with *C. testudinaria*.

Figure 19. Number of turtles tagged by month (totals for September-November were not available by date).

TAGGED TURTLES

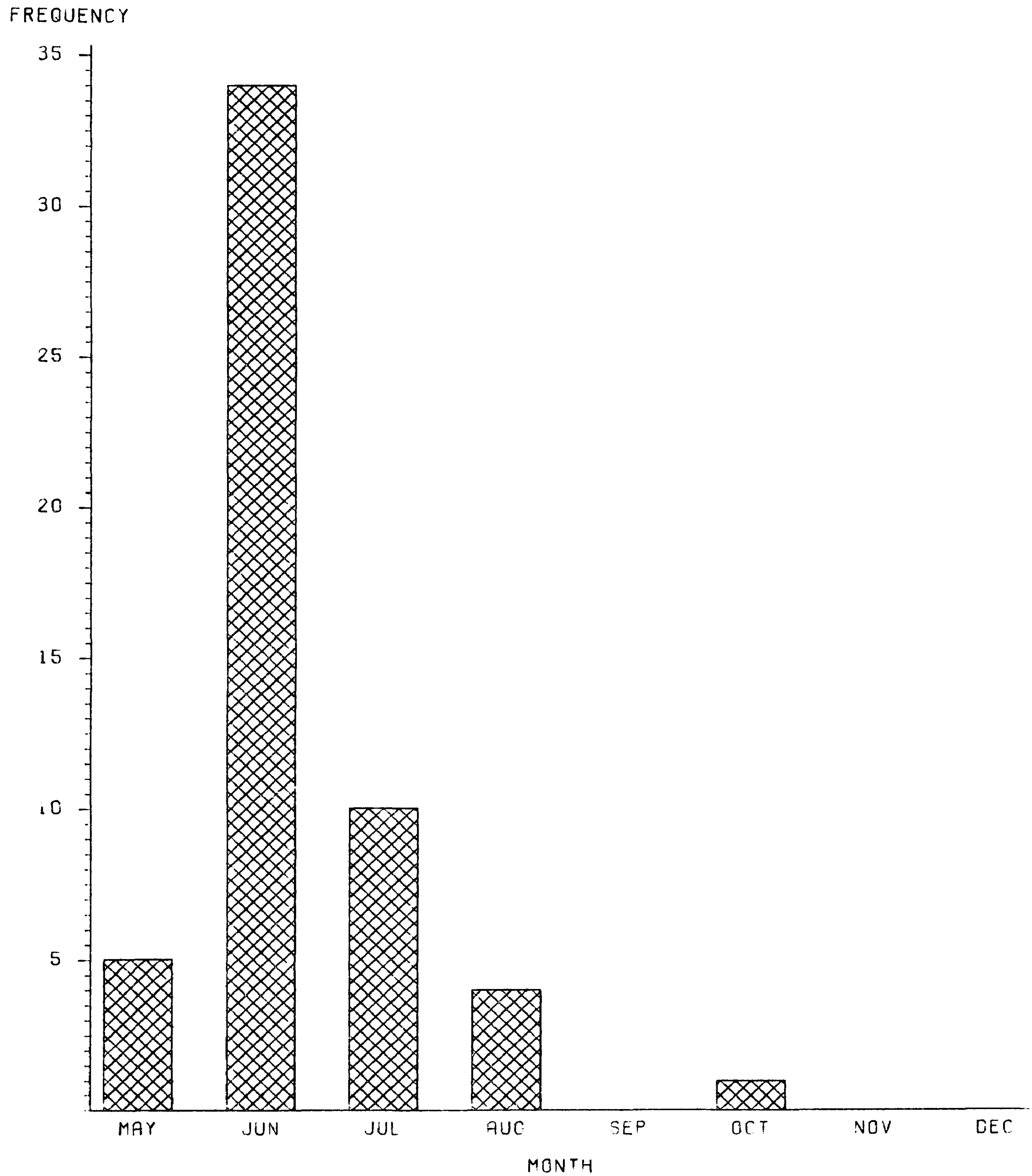


Figure 20. Tagging locations for sea turtles.

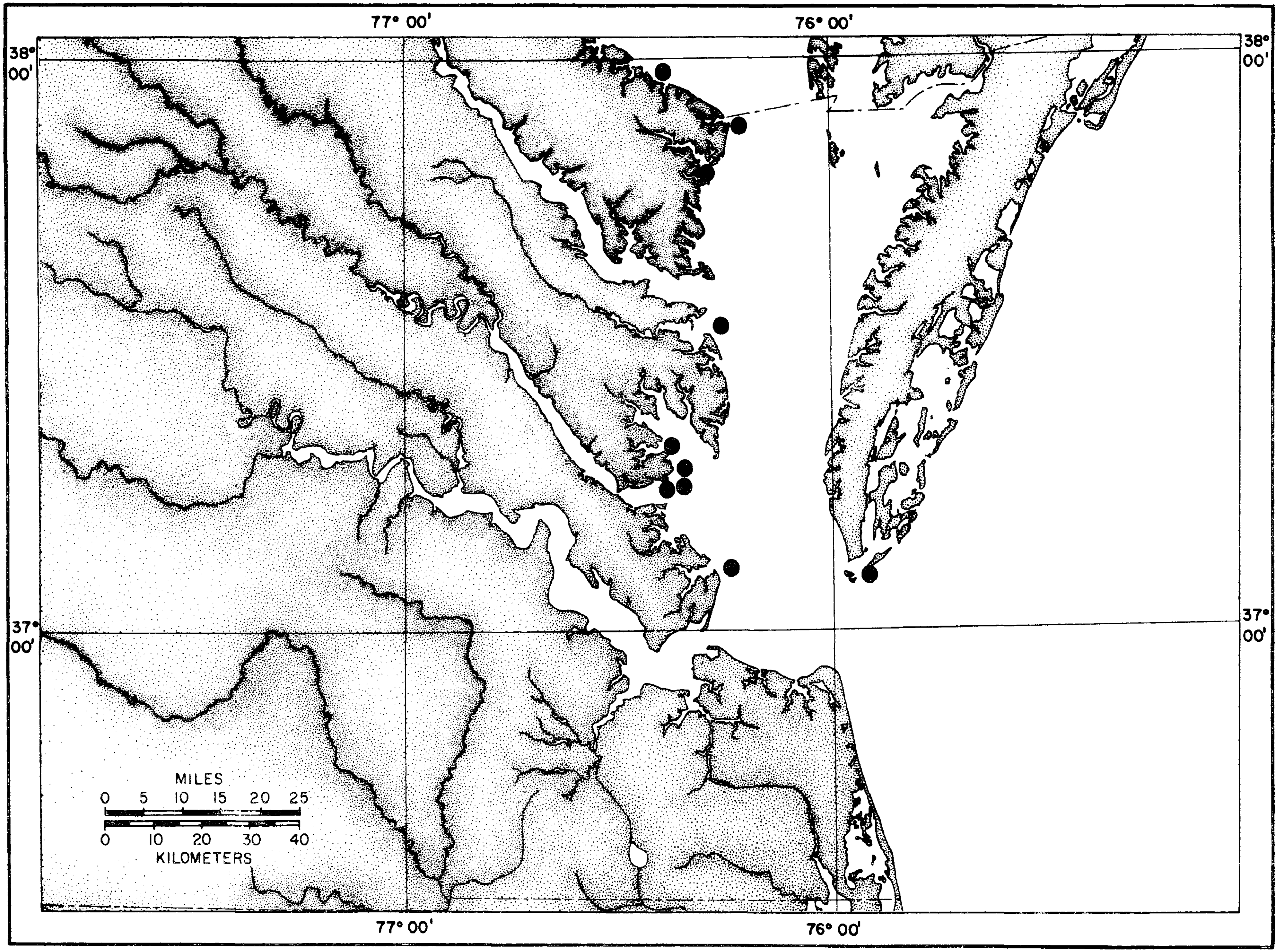

77° 00'
76° 00'
38° 00'
37° 00'
MILES
0 5 10 15 20 25
0 10 20 30 40
KILOMETERS
77° 00'
76° 00'
38° 00'
37° 00'

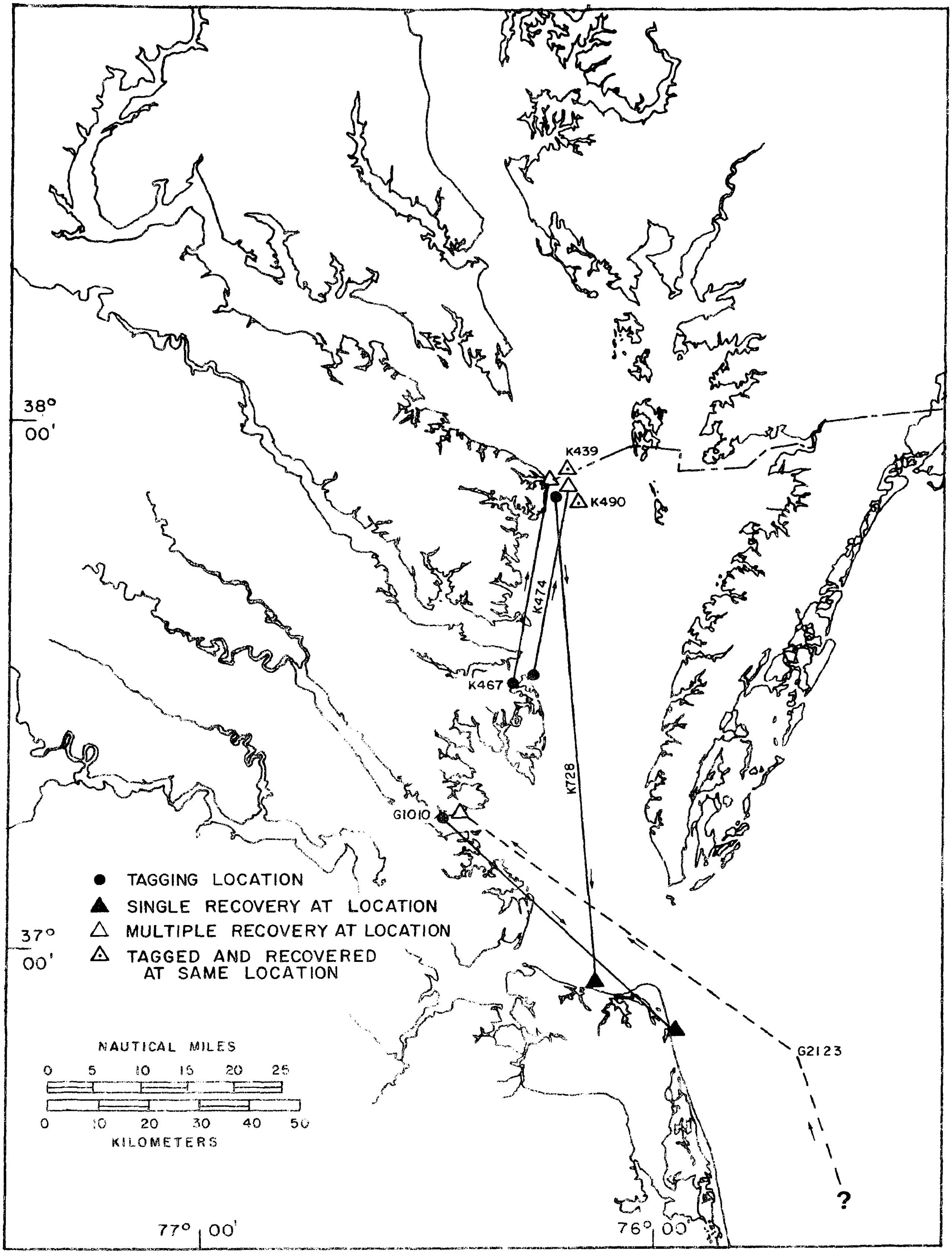
TABLE 9

1980 RECAPTURE RECORDS FOR TAGGED SEA TURTLES, *C. CARETTA*

TAG #	DATE	LOCATION	R_1	R_n	TOTAL DAYS ELAPSED
K467	4 June	Gwynn Island	Potomac River (12 Aug)	Potomac River (Oct)	122**
K439	30 June	Potomac River	Potomac River	Potomac River (Oct)	92**
K474	12 July	Gwynn Island	Potomac River (20 Aug)	Potomac River (Oct)	80**
K728	20 Aug	Potomac River	Lynnhaven (30 Oct)		73
K490	28 June	Potomac River	Potomac River	Potomac River (Oct)	94**
G1010	30 July	York River (VIMS)	Rudee Inlet (8 Aug)		9

**minimum number of days

Figure 21. Sea turtle recapture locations.



38°
00'
37°
00'
77° 00'
76° 00'
K439
K490
K474
K467
K728
G1010
G2123
?
TAGGING LOCATION
SINGLE RECOVERY AT LOCATION
MULTIPLE RECOVERY AT LOCATION
TAGGED AND RECOVERED AT SAME LOCATION
NAUTICAL MILES
0 5 10 15 20 25
0 10 20 30 40 50
KILOMETERS

On 1 July 1980, a tagged ridley was found alive in a peeler crab box on Chisholm Creek, York County, by James Boyle. This ridley had been headstarted from its natal beach in Tamaulipas, Mexico, reared in Galveston, and released from Homosasa, Florida, by NMFS on the 8th or 9th of May 1979. Thus, about 417 days had elapsed since its release in Florida. Although no measurements were taken before its release, its estimated size in relation to the peeler box differed little from the dimensions taken before its release in 1979.

Fishermen confirmed that if sea turtles were not released some distance from the net in which they were found they shortly returned. One watermen suggested that individual loggerheads returned to his net several times to feed on the "free lunch." It remains to be determined whether sea turtles actually feed on fishes while trapped in the poundnet.

Fishermen reported that sea turtles are usually found swimming on the surface in the head end of poundnets. On 16 July 1980, I observed and photographed three subadult loggerheads (CLC about 60 cm) swimming in the head of a poundnet located on Poquoson Flats. Each turtles' carapace was heavily encrusted with barnacles and green algae. The turtles swam slowly about the enclosure's perimeter, and did not seem to be agitated. Surface swimming was interrupted by dives of approximately 2 minutes.

I observed this behavior for 25 minutes from a small boat moored to the outside stake of the poundnet head. As turtles approached the boat they could be seen to about 1 1/2 meters below the water surface. The turtles appeared to be snapping at the enclosure mesh where small fishes were captured.

Poundnet fishermen have observed loggerheads crawling out over the head netting as the fish catch is scooped into their boats. Apparently, some sea turtles can escape from poundnets when the net is worked, but watermen reported that most turtles must be removed and released.

A second, more detrimental form of incidental capture involves the long runner (hedging) of poundnets. Sea turtles become entangled in the large mesh of the runner. Thus, the hedging mesh acts much as a "gillnet" for sea turtles. While surveying poundnets in 1980, I observed many dead loggerheads and one ridley hung by heads or limbs in area poundnet hedging.

Unless a carcass is removed by watermen, it begins to bloat and decompose. Eventually its flesh tears free of the mesh netting and the carcass, buoyed by decomposition gases, floats with prevailing currents until stranding. A loggerhead carcass I had found in a Poquoson poundnet hedging and marked on 28 May was reported stranded on 2 June. It had floated 5.25 nautical miles from its capture point to stranding location. Although it is possible that some sea turtle carcasses found on Chesapeake Bay shorelines are swept into the Bay from elsewhere, it is likely that most carcasses died within the study region. This conclusion is supported by the high numbers of strandings in zones six and seven where there are large numbers of working poundnets.

A total of 64 sea turtles were reported dead in the hedging section of poundnets. Three out of the ten poundnet fishermen/taggers observed dead turtles in their hedgings in 1980, comprising 46 out of the total 64 carcasses reported in poundnet hedging by all sources. These watermen worked only 13 out of an average of 221 poundnets where turtles occur or less than 7% of all of the poundnets registered in 1980 in the study region (2 May through 24 October 1980, VIMS aerial poundnet survey). Therefore, it is plausible that unidentified poundnet hedging deaths could account for many of the carcasses for which no mortality sources have been identified.

Barnacle Isotope Analysis

Sea turtle movements may possibly be traced through isotope analysis of their commensal barnacles (Killingley, 1980). This hypothesis is based on the following principals:

1. certain marine organims secrete calcium carbonate in equilibrium with the seawater in which they grew (Lloyd, 1964).

2. the temperature and salinity of seawater affects the oxygen and carbon isotope ratios incorporated in the shells of marine organisms (Urey, 1951).

3. environmental temperatures of seawater may be estimated using the paleotemperature equation (Epstein *et al.*, 1953) where

$$t°C = 16.5 - 4.3\ (\delta) + 0.14\delta^2$$

$$\delta = \text{deviation of } \frac{O^{18}}{O^{16}} \text{ ratio from a standard.}$$

Using the paleotemperature equation, Killingley (1980) demonstrated that oxygen isotope values of whale barnacle calcite shells record the seawater temperatures encountered during the whale's migration.

The paleotemperature equation is based on several assumptions dependent upon the metabolism of the sampled barnacle species and on the salinities in which it grew (Schopf, 1980).

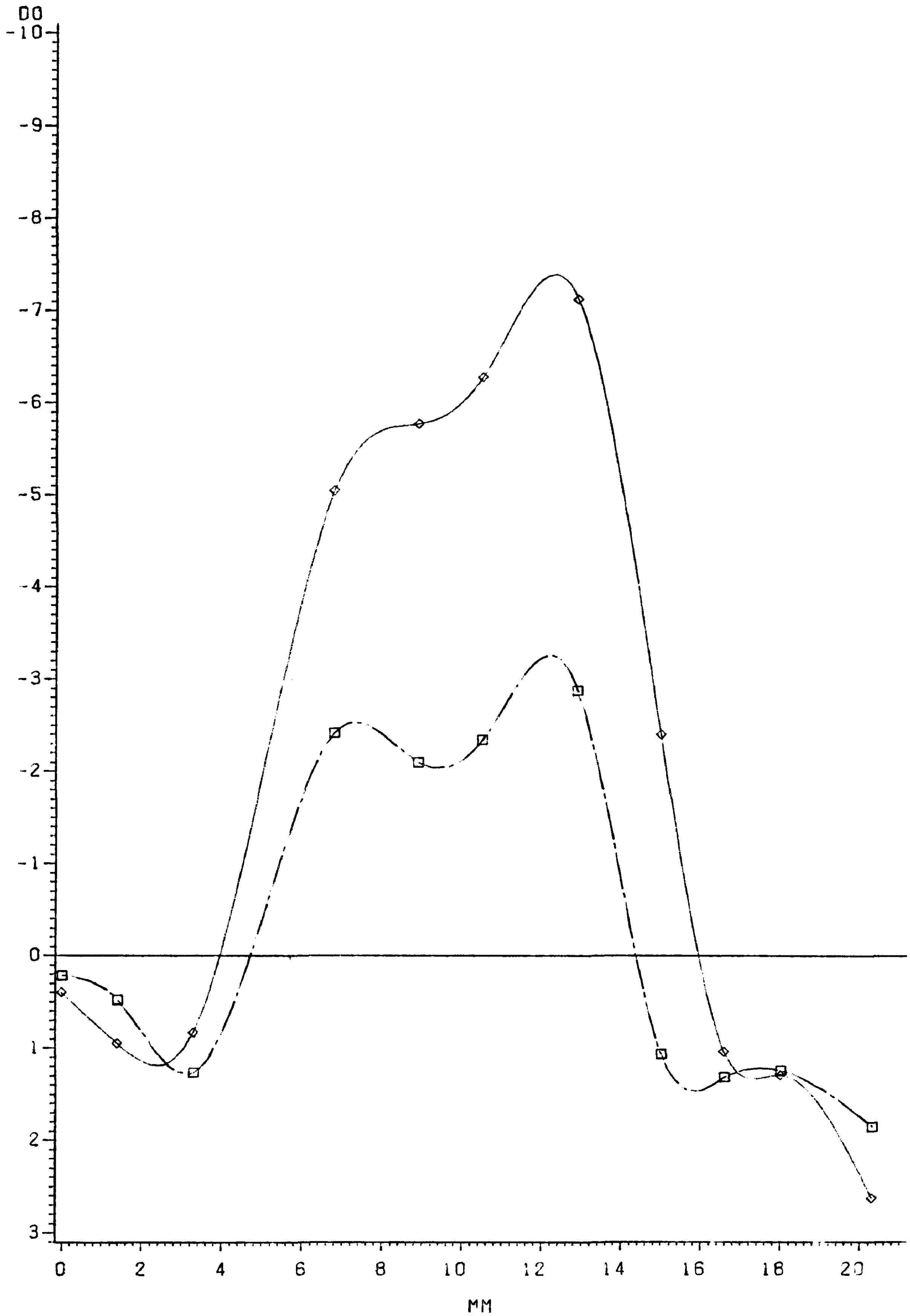
Carbon isotope ratios were used in a similar manner to distinguish between marine, estuarine, and freshwater environments. Lloyd (1966) showed that CO_2 produced locally from decayed terrestrial matter influences the carbon isotope ratio of carbonate shells. Freshwater sources are depleted in ^{13}C and yield low $\delta^{13}C$ values (Schopf, 1980). In contrast, seawater is enriched in ^{13}C from marine limestones. Further enrichment of ^{13}C occurs because phytoplankton take up the ligher isotope ^{12}C (Schopf, 1980). Estuarine waters reflect the mixing of seawater and freshwater values (Sackett and Moore, 1966).

Results from the $\delta^{18}O$ and $\delta^{13}C$ tracts of C. testudinaria taken from MT-2-80 and MT-16-80 are shown in Figure 22. Values at sample points are plotted against distance from the base of the barnacle shell.

From calculated temperatures, I proposed two migration routes for the turtle hosts, working backwards from the time of stranding. Growth rates for C. testudinaria have not been determined. Therefore,

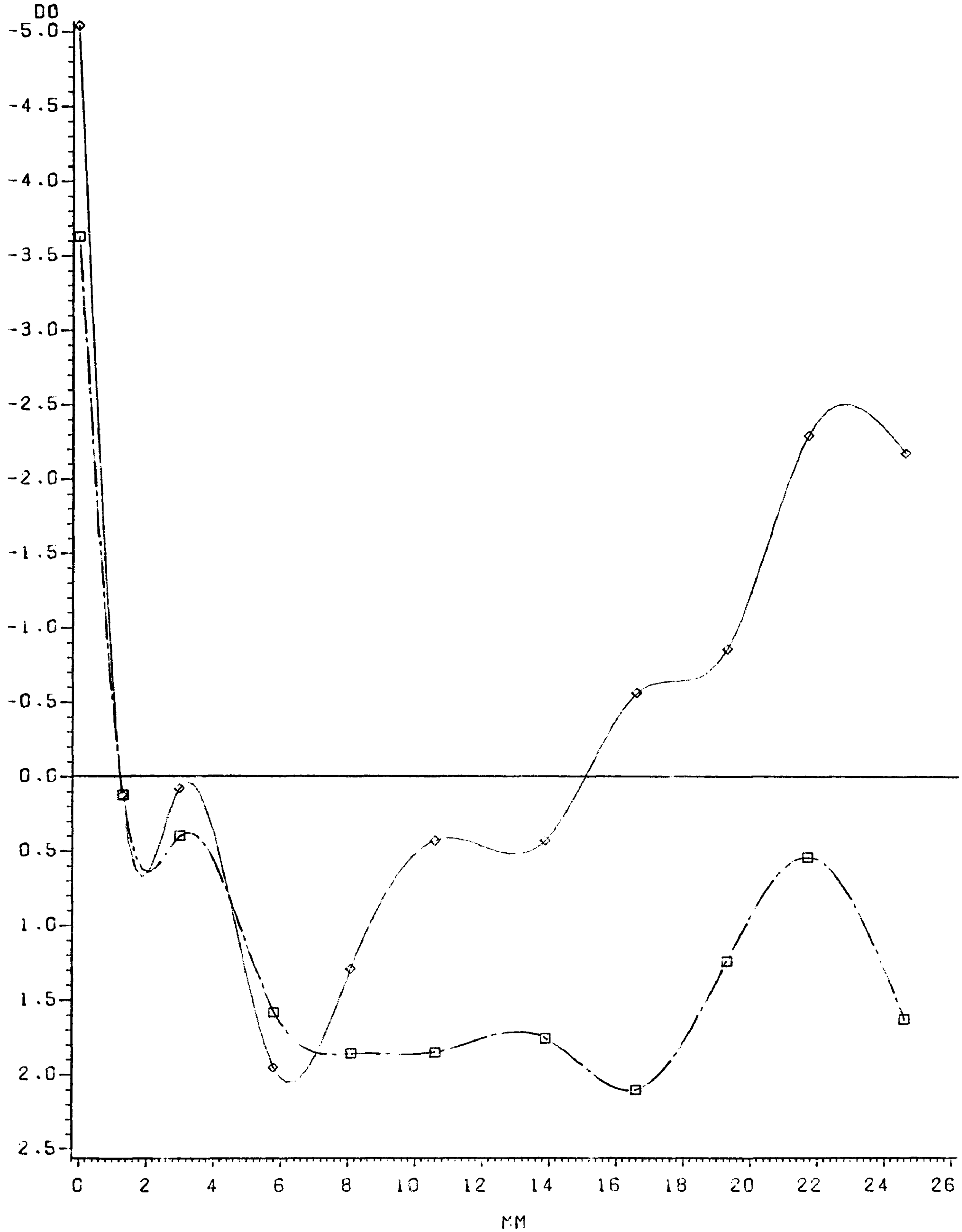
Figure 22. Variations in $\delta^{18}O$ and $\delta^{13}C$ of Chelonibia testudinaria from stranded loggerheads.
A. MT-2-80, stranded 11 May 1980.
B. MT-16-79, stranded 15 June 1979.

ISOTOPE ANALYSIS
MT/2/80 _C TESTUDINARIA_



DISTANCE FROM BASE IN MM
DIAMONDS REPRESENT DELTA O-18
SQUARES ARE DELTA C-13

ISOTOPE ANALYSIS
MT/16/79 C TESTUDINARIA



DISTANCE FROM BASE IN MM

DIAMONDS ARE D O-18
SQUARES ARE D C-13

sample points were assumed to show 20 days of growth based on predicted temperature changes during the proposed migration period. The following observations were drawn from the isotope traces of the sampled barnacles.

MT-2-80

At the base of the shell, from sample points 12 through 10, isotope composition reflects growth in temperate oceanic conditions similar to conditions encountered between points 3 through 1. From sample points 10 through 3, decreased salinity and higher temperatures may represent a season of growth in an estuarine area such as the Bay. The inflection point at sample point 8 reflects a maximum exposure to brackish water such as in the upper Bay where low salinities and high temperatures are found in late summer. A decreasing temperature track and more positive $\delta^{13}C$ were interpreted as travel out of the Bay to coastal waters. The second inflection point at sample 3 may indicate a cessation of seasonal growth which is resumed the following spring. This assumption is consistent with the temperature and salinity conditions existing when the host turtle stranded.

MT-16-79

Loggerhead MT-16-79 stranded on Ft. Monroe about 10 June 1979. Isotope values for both $\delta^{18}O$ and $\delta^{13}C$ indicate warming temperatures and decreasing salinity before the host stranded. Sample points 11 through 4 reflect an approximate 15°C decrease in temperatures under oceanic conditions. Assuming that this track represents barnacle shell growth of the previous season, the cooler waters of the mid-Atlantic could account for the lower indication of temperature. It is of interest that sample points 4 through 1 duplicate the general track made from sample points 10 through 8 of MT-2-80.

Actual temperatures and salinities were obtained for the proposed migration sample locations. These are shown in Table 10. Using those values, $\delta^{18}O$ were calculated with the paleotemperature equation and compared with those determined by isotope analysis. According to Killingley (personal communication), calculated $\delta^{18}O$ temperature values compare with actual values obtained from the samples within a few degrees.

Although the accuracy of this method in tracking sea turtle migrations with the barnacle C. testudinaria has not been determined, it is evident that movements from marine to fresher waters as well as cooler to warmer waters are recorded by sea turtle barnacles. As more samples are processed, the confidence of the model may be adjusted accordingly. Determination of growth rates of barnacles used in this analysis would especially benefit sea turtle tracking studies.

In summary, the isotope ratios were interpreted to represent host turtle movements during the lifespan of the barnacles. Both turtles traveled through temperature and salinity differences as great as 18°C and 18 °/oo, respectively. MT-2-80 appeared to have entered the study region for 2 consecutive years. Both turtles appeared to have spent considerable time in estuarine waters. From derived temperatures and

Figure 22. Variations in $\delta^{18}O$ and $\delta^{13}C$ of _Chelonibia testudinaria_ from stranded loggerheads.
A. MT-2-80, stranded 11 May 1980.
B. MT-16-79, stranded 15 June 1979.

TABLE 10

MT-16-79					MT-2-80				
SAMPLE POINT	DATE	PROPOSED LOCATION	TEMP°C	SALINITY (ppt)	SAMPLE POINT	DATE	PROPOSED LOCATION	TEMP°C	SALINITY (ppt)
11	7/10/78	Gulf Stream off SC to Outer Banks	29-30	34-35	12	4/29/79	north of Cape Hatteras	10-11	34
10	7/30/78	Gulf stream off NC	26-28	34-35	11	5/18/79	NC/VA coast boundary	16-17	32-33
9	8/20/78	VA shelf water	22-25	34					
8	9/10/78	VA shelf water	21-22	34	10	6/6/79	NC/VA coast boundary	18	32-33
7	9/30/78	VA shelf waer	20-22	34	9	6/26/79	mouth of C. Bay	21-22	17-18
					8	7/15/79	Potomac River mouth	26-28	16
6	10/20/78	VA shelf waters or north	16-17	33-34	7	8/4/79	Potomac to Tangier Sound	25	15-17
5	11/9/78	offshore mid-Atlantic Bight	?	?					
	or				6	8/24/79	Potomac to Tangier Sound	24	15-18
	3/21/79	offshore NC/VA	?	?	5	9/12/79	Tangier to mouth of C. bay	24	15-20
4	4/10/79	inshore north of Cape Hatteras	12	34	4	10/2/79	mouth of C. bay	21	20
3	5/1/79	mouth of C. Bay	13-15	28-30	3	4/1/80	north of Beaufort	13	34
2	5/21/79	mouth of C. Bay	15-17	28-30	2	4/21/80	NC/VA coast boundary	13	33-34
1	6/10/79	Ft. Monroe, VA	20	20	1	5/10/80	Back Bay NWR, VA	14	33-34

water types, it is unlikely that either turtle remained in estuarine waters during the coldest months.

DISCUSSION

It is evident that the Chesapeake Bay and Virginia nearhsore waters serve as seasonal foraging grounds for subadult loggerhead turtles. Records show that both live and dead turtles are common in the study area from May through October, with peak occurrences in June. Shoop et al. (1981) found in aerial survey that loggerheads are abundant in coastal waters within 60 meters depth as they travel north with warming sea temperatures. Loggerheads found in the Bay undoubtedly invade our waters during this spring migration. Although thermal cues may guide the invasion of the Bay, it is likely that sea turtles follow the patchy distribution of their inverterbrate prey. Loggerhead aggregations were observed most often in shallow areas, inlets, and shoals where abundant invertebrate benthic communities may be found.

Feeding habits of loggerheads in the study region conform with those of other regions. Brongersma (1972) reported that molluscs, crustaceans, and seaweed are among foods consumed by C. caretta. Hughes (1974b) and Hendrickson (1980) determined that molluscs were the preferred food items for loggerheads. The crustaceans Limulus, Cancer, and Callinectes sps. may be more representative of the loggerhead's diet in the Chesapeake region.

From several tag recapture data determined in 1980, loggerheads spend as many as 122 days in the estuary, with an average length of stay of 92.2 days (N=5). Loggerheads are reported concentrated mid-Bay, or near the mouth of the Potomac river towards the end of their stay. Sea turtles may take as few as 8 days to travel out of the Bay and south in coastal waters. It should be noted that this single record is taken from an injured loggerhead (tag G1010) that could not dive because of positive buoyancy.

Subadult loggerheads are the preponderant size class for the study region, averaging 74.7 cm CLC (N=257). Only 64 out of 257 loggerhead carapace length measurements were equal or greater than 85 cm CLC. There is a bimodal size class distribution consisting of the modal carapace length as well as a secondary mode of mature loggerheads of carapace length near 90 cm. A minimum exists in the abundance of loggerheads of the 80-85 cm class compared to those slightly smaller and larger in size. This size class may represent a potential breeding group and is also reported missing in Georgia and South Carolina loggerheads for 1978 through 1980 (J. Richardson, personal communication). The reasons for this remain to be determined. Loggerheads near the 92 cm size were relatively more common in Virginia than in catches or records of beached carcasses in Georgia and South Carolina.

The smallest loggerhead found in 1979 was 38.4 cm (CLC). In 1980, several immature loggerheads with CLC less than 26 cm were found. Turtles of this size are rarely encountered in the southeastern U.S. (Witham, 1980; Carr, 1980). Given the lack of information on the distribution of young loggerheads, several authors

(Witham, 1980; Caldwell, 1962; Brongersma, 1972; Frick, 1976) have concluded that ocean currents disperse young sea turtles.

Witham (1980) listed a tagged yearling loggerhead (A4049) that was released in Florida and recaptured the next year in Virginia. It is plausible that small Virginia loggerheads are swept passively into the Bay by currents, but from the modal sizes, it is obvious that most loggerheads in the study region are several years old. Hughes (1974b) suggested that sea turtles 3 to 4 years old are capable of directing their own movements.

By counting carcasses, poundnet catch and sightings in 1980, a minimum of 800 loggerheads were observed in the Bay. Unfortunately, no direct attempts were made to estimate the loggerhead population. Tag-recapture estimates based on a modified Schnabel estimate (Ricker, 1975) give a population estimate of close to 3,000 loggerheads for 1980. This technique has been used with reasonable certainty for nesting females on Cape Canaveral by Erhart (1979), but has not been adjusted specifically for subadult loggerheads in unrestricted areas. Aerial overflight strip surveys conducted at the entrance of the Chesapeake Bay (Byles and Blaylock, in prep) yield a density of 0.118 loggerheads per km^2 for the area (SD=$\pm$0.102). The time spent on the surface by turtles, diel activity patterns, water clarity and observer efficiency could seriously bias this estimate. Given these constraints, it is likely that long term tag-recapture studies of sea turtles might be the most suitable method for estimating sea turtle abundance in the Chesapeake Bay.

Origins of Virginia Sea Turtles

Carr (1980) reported factors in support of "developmental migration" of sea turtles. He and other authors (Caldwell, 1962; Brongersma, 1972; Hendrickson, 1980) proposed that sea turtles utilized developmental habitats for growth and for segregation of non-breeding individuals. Hughes (1974b) found almost complete segregation between adult and young loggerheads in areas of Africa. It has been suggested that segregation of mature and subadult sea turtles may occur as juveniles find feeding niches out of the home range of nesting females (Bustard, R. H. and C. Limpus, 1971; Hughes, 1974b; Carr, 1980; Hendrickson, 1980).

Segregation of non-breeding loggerheads into remote but rich feeding areas such as the Chesapeake Bay and Virginia barrier islands would minimize energetic expenditures of nesting loggerheads on beaches to the south. Foraging time spent on travel by subadults would also be minimized. Although adults are found in the study region, nesting occurs only sporadically on ocean beaches, and is not known to occur in the Bay (Musick, 1979). Given the relatively small number of mature loggerheads, nesting is not likely to be a major activity of area loggerheads (Byles and Musick, unpublished report 1981), although the potential size of the breeding populations here need to be evaluated.

Lepidochelys kempii

The abundance of *L. kempii* in the study area is undoubtedly greater than indicated by records (N=23). Their small size compared to typical loggerheads make ridleys less conspicuous and more likely to be overlooked by observers. It is also possible that small turtles reported as loggerheads may have been ridleys. Recent interviews with watermen not previously contacted provided additional counts of live ridleys for 1979 and 1980.

Although ridleys were found on both Atlantic and Bay shorelines in the study region, stranding and live poundnet captures of ridleys were concentrated in the lower York River. Ridleys were also taken by poundnets near Fisherman's Island. This distribution may be an artifact of sampling effort but the paucity of ridleys in poundnets from other areas support the likelihood that ridleys aggregate in the grass beds at the mouth of the York River.

Small ridleys have also been found in New England waters (Lazell, 1976, 1980; Carr, 1980; Shoop, 1980). Many of these turtles were reported to be "coldstunned" by falling temperatures (Lazell, 1980). Carr suggested that the New England ridleys are transported to those waters by the Gulf Stream. Carr presented evidence that Gulf Stream eddies and Ekman drift may wash ridleys inshore across the New England shelf. Despite the total numbers of ridleys found in that area, Carr viewed the population as demographically dead. In contrast, Lazell (1980) declared the area a "critical habitat" for Kemp's ridley sea turtles based on the frequency of strandings and sightings.

Virginia ridleys differ from New England ridleys in several aspects. Sizes of most Virginia ridleys are larger than those found in New England. In Virginia, ridleys have been found most often in June and October, whereas New England strandings peak in November (Bob Prescott, personal communication).

The Gulf Stream is located at least 150 km offshore of the Virginia coast. Eddies generally do not cross shelf break near Virginia (Ruzecki, 1979), and none have been observed during peak abundance months in 1979 or 1980 (Figure 23). Alternatively, Virginia ridley abundance seems to indicate two waves of movements north and south, respectively. These movements may be directed by water temperature or prey distribution. As in New England, longshore currents might be a factor in transporting smaller ridleys into the Bay. It remains to be determined whether subadult ridleys tagged in Virginia will return to their alleged natal beaches in the Gulf of Mexico.

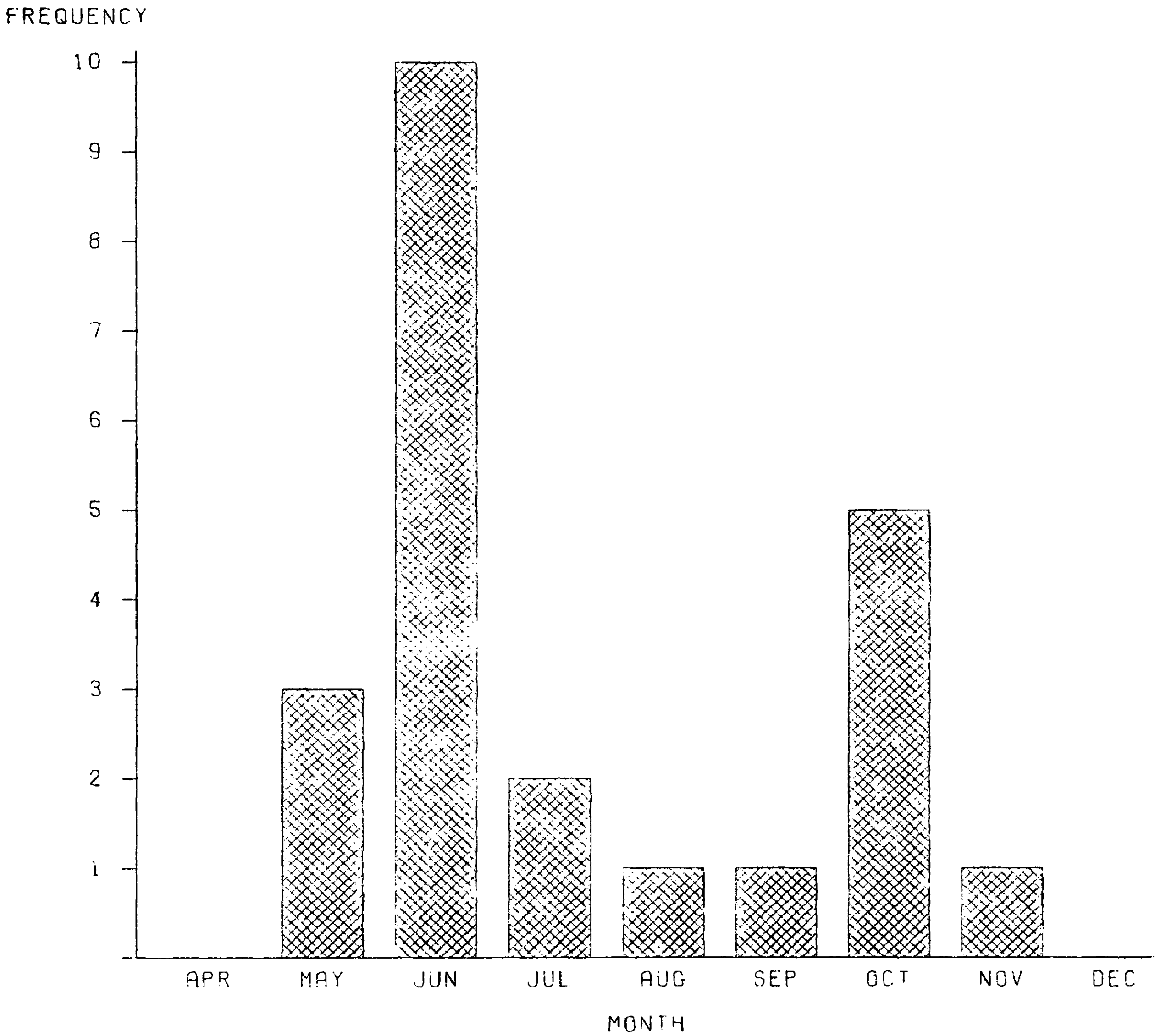
Dermochelys coriacea

Six leatherbacks (five carcasses) were counted in the study area since 1979. Watermen have reported catching large leatherbacks (identified as rubberbacks) in Bay poundnets, although only one has been found tangled in net hedging during this study.

Several authors have discussed the occurrence of *D. coriacea* in northern coastal waters (MacAskie and Forrester, 1962; Bleakney, 1965; Brongersma, 1972; Lazell, 1976, 1980; Threlfall, W., 1978; Musick, 1979; Shoop, 1980) but there is little data available on the role of *D. coriacea* in the estuary (Hardy, 1969).

Figure 23. *L. kempii* records per month, 1979-1980.

LEPIDOCHELYS KEMPII
RECORDS FOR 1979 AND 1980



LIVE AND STRANDED RIDLEYS PER MONTH

Historically, four leatherbacks were reported in the upper Bay by Hardy (1973). On 3 June 1980, a leatherback was found freshly stranded on Smith Island, Maryland, almost 175 km from the mouth of the Bay. Local salinity was between 15 to 20 ppt (J. Taft cruise, CBI, 1980). Watermen have reported catching leatherbacks in the Potomac, Piankatank, and York rivers. Thus it is likely that a limited number of leatherbacks enter the Bay and its tributaries while traveling north in shelf waters. Hardy (1973) determined that leatherbacks do not spend much time in the Bay, and I have found no evidence to indicate otherwise.

Sea Turtle Commensal Organisms

Zullo and Bleakney (1966) proposed that the migration and dispersal of sea turtles may be traced by examining their commensal barnacles. Seven species of cirripeds were found on sea turtles in the study area. All but one, *Balanus trigonus*, are known to be cosmopolitan, subtropical or temperate species (Newman and Ross, 1976; Stubbings, 1967; Wells *et al.*, 1966) and therefore contribute little to tracing the former dispersal of their hosts. *B. trigonus* is not known to occur north of Cape Hatteras, North Carolina (Victor Zullo, personal communication). *B. trigonus* was found on at least 11 loggerheads that I had examined during this study, suggesting that the host turtles had migrated from southern regions. Other epizoan species are common fauna for the study area (Wass, 1972; McErlan *et al.*, 1973) and therefore probably reflect the recent location of host turtles.

Hughes (1974b) determined that changes in the type and pattern of barnacle encrustations may indicate changes in developmental behavior of host turtles. Lepas sp. were frequently found on South African loggerheads, whereas C. testudinaria were predominant on larger sized turtles. Lepas was found on five Virginia loggerheads during this study, all with CLC over 60 cm.

Sea turtle barnacles are obligatory commensals (Newman and Ross, 1976), yet little is known about the interrelationships of turtle barnacles and their hosts (Lewis, 1978). If barnacle settling requirements and growth factors were known, information regarding the possible location and behavior could be obtained for their turtle hosts. Isotope analysis of sea turtle barnacles might provide additional evidence for tracing the movements of sea turtles.

Mortalities

In 1979, noting the abundance of poundnets in areas of frequent strandings, it was suspected that some mortalities were associated with poundnets. In 1980, 30% of all carcasses counted were found in poundnet hedging. While surveying for poundnet captures in Poquoson and York counties, I found that the constrictions formed by poundnet mesh twine, as the carcass bloats, are characteristic (Figure 24).

Based on constriction features, I was able to judge that some beached carcasses had previously floated free of poundnet hedging. I reviewed slides of strandings in 1979 and found similar constrictions

Figure 24.* Damage caused by poundnet mesh wrapped around a loggerhead's limb.

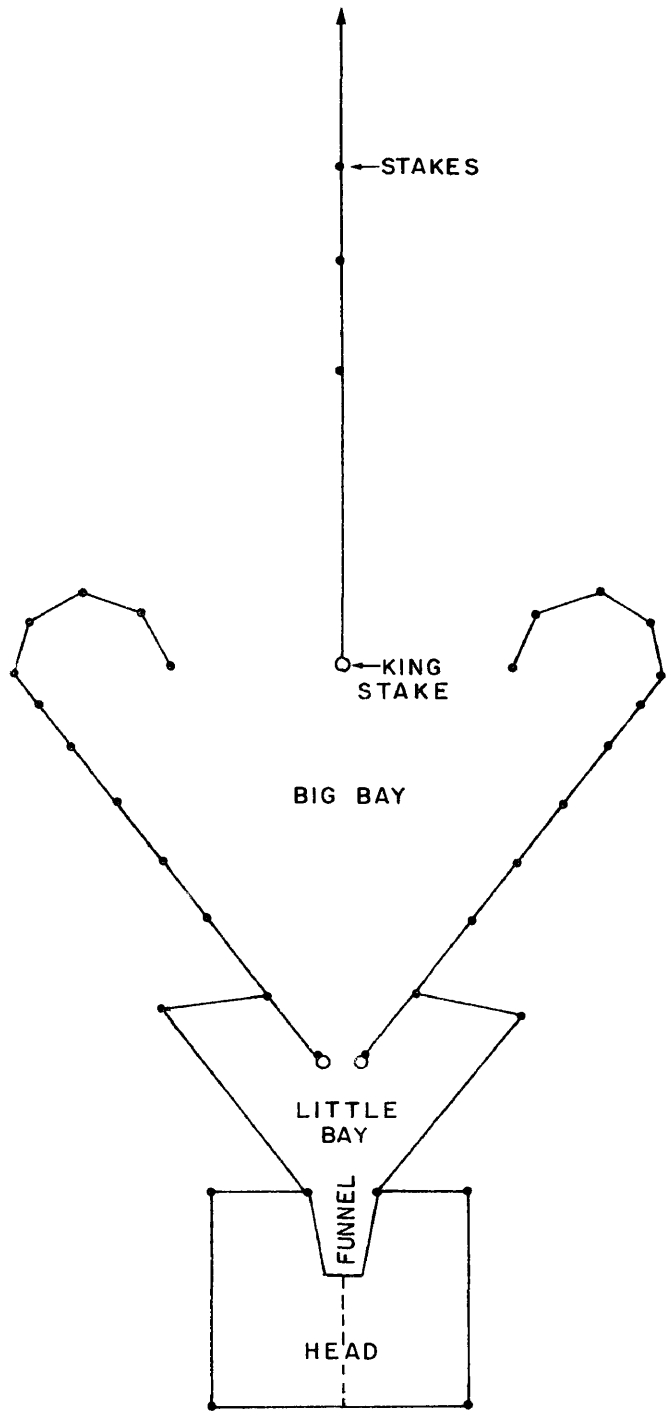
* see Figure 9

on many of those turtles. Poundnet captures undoubtedly account for greater than 30% of Virginia mortalities.

Watermen report that some nets simply do not catch turtles in the hedging, while others do. This observation is supported by a substantial poundnet incidental catch of live turtles from stranding zones 10 through 12, versus the low number of strandings for those areas.

A poundnet consists of a head or "pound" enclosed by a large mesh bag and a series of nets (hedging or runner) hung by poles to divert fish into the head (Reid, 1955) (Figure 25). Fish enter the head from heart-shaped bays via an inwardly directed funnel. Netting mesh size varies according to the function of the net section. The hedging runs as much as 1000 feet along the river slope from shallow water into the head end of the net. The head usually lies in deeper water. The hedging consists of large mesh (approximately 16 inches stretched mesh for the lower Bay) set on stakes set about 18 feet apart. The hedging is lined up with the funnel entrance and is sometimes "reefed" to prevent billowing at the base. Hedging mesh size vary slightly among localities and depends on local current conditions and the size of fishes that are sought. Mesh size must be large enough so that fish are not inadvertently gilled. Watermen report that using smaller mesh in the hedging tends to increase net fouling and requires increased maintenance.

Figure 25. Lower Chesapeake Bay poundnet, adapted from Reid, 1955.



Adapted from Reid, 1955

Poundnets vary slightly in the length and type of funnel, in mesh and structure of the head, but overall variation in construction of nets within the Bay is not great (Reid, 1955). Greatest variation among poundnets is found in runner orientation, hedging mesh size, and in water depth. These factors may affect sea turtle captures, but water turbidity, time of day, and tidal currents may also influence a turtle's reaction to encountering the hedging.

I believe that any runner mesh size large enough to accommodate a turtle's fin or head may entangle turtles that swim into it. I observed that smaller mesh size in hedging may snag a turtle carapace but should not immobilize the turtle. Ogren et al. (1977) found that adult loggerhead reactions to encountering shrimp trawls enhanced their probability of capture. It is likely that as sea turtles encounter poundnet mesh, they struggle to escape and further entangle their heads or fins.

Most poundnet hedging that captured sea turtles had large mesh (12 to 16 inches) and were found in the lower Bay. No turtles were reported entangled in mesh sizes of 8 inches or less. Small mesh hedging is used by watermen from Gwynns Island and north. A large mesh is necessary in fishing areas of strong currents. Strong currents may sweep turtles against the runner mesh and diminish chances of escape.

How sea turtles die in poundnet hedging remains to be determined. C. caretta is capable of withstanding prolonged anoxia under conditions dependent on environmental temperature and metabolic state (Felger et al., 1976; Lutz et al., 1980), yet turtles apparently die while submerged in poundnet mesh. These deaths may be similar to traumas resulting in death in shrimp trawls. In a preliminary unpublished report to NMFS, Lutz (1980) determined that asphyxia, aspiration of sea water, or metabolic shock may all lead to a turtle's death while submerged.

The question of the role of disease, parasitism, or toxic exposure has been posed to investigators studying sea turtle mortalities. Although some studies have examined the level of pollutants in stranded sea turtles (Hillstead et al., 1974; Thompson, 1974; Stoneburner et al., 1980), information pertaining to the pathology of the above factors is scanty at best.

Despite the presence of spirorchid parasites in two out of six carcasses, whether spirorchids occur naturally in healthy sea turtles has not been determined. Possible effects of sublethal pollution in coastal zones has been discussed by Frazier (1980). High levels of heavy metals, especially mercury, have been identified in loggerhead tissue from strandings (R. Schopkohl, personal communication). Witham found several stranded sea turtles whose oral cavities were occluded by pelagic tar balls. Drawing conclusions from the findings of the six histopathological exams of this study would be unwarranted. Nonetheless, these results introduce potential topics for future sea turtle pathology studies.

Profuse dermal barnacle encrustation patterns may be significant in mortality studies. That this condition may be symptomatic of traumatized turtles is striking, when such individuals are compared to turtles with a normal epizoan load. On 27 May, I observed and assisted a watermen in tagging two loggerheads found in his poundnet. K462 had a deep reddish brown carapace free of unusual commensals. Its eyes were clear, skin color appeared normal and the turtle vigorously resisted restraint. In contrast, K464 had a markedly different demeanor characteristic of "barnacle bills." Its skin was encrusted with P. hexastylos. Its eyes were recessed and cloudy, and its overall vigor was poor compared to its companion turtle. Other individuals with this condition were found throughout 1980. This condition was not found to be prevalent in 1979 loggerheads.

Unusual fouling patterns have been described for loggerheads dredged from the Cape Canaveral ship channel by Carr et al. (1980), for anemic turtles necropsied by Wolke (personal communication) and for cold-stunned turtles by Erhardt (personal communication). Ogren and McVea (manuscript) discussed evidence that emaciated loggerheads with abnormal fouling patterns, damaged carapaces, and lethargic behavior may have been previously stressed by unseasonably low temperatures. Future tagging studies of these individuals may reveal whether hypothermia or disease processes affect the physical appearance and fouling patterns of loggerheads.

While not all causes of Virginia sea turtle mortalities have been identified, it is evident that poundnet accidental capture is a major factor. In 1980, 30% of all reported dead turtles were found in poundnet hedging. Sea turtles are subject to two forms of capture in poundnets: 1. entanglement in hedging mesh, which can result in death due to drowning, 2. impoundment in the head of the net, where turtles are confined alive until removed and released by watermen. Preventing sea turtle deaths in poundnet will be a particularly difficult management task.

Poundnet fishermen have used the same net design for more than 100 years, and fishing constraints preclude alteration of basic net structure. Although the use of small mesh hedging might reduce accidental turtle mortalities, poundnets in areas of strong currents would be heavily fouled in a short time and rendered unsuitable for fishing. Nonetheless, incidental deaths in the hedging must be substantially reduced if we are to protect existing populations of subadult loggerheads and ridley turtles in the Bay.

A more subtle problem lies in the conflicts presented in excluding turtles from poundnet heads. It became evident during this study that poundnet fishermen provide the most efficient access to live sea turtles. Locating and sampling live sea turtles in the Bay, within the constraints of the Endangered Species Regulations, will otherwise be difficult and time-consuming. Poundnet head captures provide a practical opportunity to examine and to tag sea turtles.

In 1981 preliminary mortality counts for May-June were considerably lower than for the same period in 1979-1980. Poundnet hedging deaths were confined to specific nets and were concentrated in mid-June. This suggests that accidental deaths in poundnet hedging may be defined by temporal and spatial patterns which relate to whether turtles travel through areas where poundnets with specific construction or orientation features are set. Although large-mesh hedging nets are more likely to entangle turtles, some rarely capture them. This implies that other factors contributing to entanglement are involved. Sick or previously stressed turtles may be more prone to capture by nets (R. Wolke, personal communication). It is recommended that accidental turtle deaths in the Bay may be reduced through characterization of conditions of capture and through continued collaboration with poundnet fishermen.

The Sea Turtle Conservation Strategy report adopted by consensus of world sea turtle researchers included as a priority that incidental catch of sea turtles must be eliminated or reduced to very low level (World Conference on Sea Turtle Conservation, November 1979). Additional studies of sea turtle movements within Chesapeake Bay, and sea turtle reactions to poundnet encounters are needed to develop methods that prevent incidental capture deaths.

SUMMARY

1. The Chesapeake Bay estuary is an important seasonal foraging area for sea turtles. Subadult loggerheads are the preponderant group and occur in the Bay and its tributaries to lower than 50% seawater. Mature loggerheads (*Caretta caretta*) comprise less than 25% of all turtles counted. Twenty-three ridleys (*Lepidochelys kempii*) and six leatherbacks (*Dermochelys coriacea*) were found in the Bay from May 1979 through 1980. Ridley sea turtles are probably more common in Virginia than indicated by records.

2. Commensal organisms show that some Virginia loggerheads have southeastern U.S. origins, based on barnacle distributions and isotope ratio analysis. In both 1979 and 1980, turtles entered the Bay in May and were most abundant in June. By mid-November, turtles were absent from the study region.

3. In 1979, 185 carcasses were stranded in the Bay area. Totals for 1980 included 333 strandings. Loggerheads comprised 81% of total carcasses, while ridleys and leatherbacks amounted to 5%. Incidental capture, boat damages, and mutilation were among major identified causes of mortalities. Histopathological findings for six necropsied loggerheads examined in 1980 included drowning and verminous or bacterial infections in their diagnoses.

4. In 1980, over 284 sea turtles were found alive in poundnets. Seventy-five turtles were tagged and released in the study area. Six recaptured loggerheads showed an average length of stay of

92.2 days between tagging and final recapture in the Chesapeake area.

5. Poundnet incidental turtle catch occurs in two forms, including possible death from entanglement in hedging mesh, and confinement alive in the head of the net. Both capture types require additional study and management consideration in order to protect existing Chesapeake Bay sea turtles.

Marine Resource Advisory

A Sea Grant Marine Advisory Service of the College of William and Mary

ADVISORY NO. 16 APRIL 1981

VIRGINIA MARINE TURTLE STRANDING FORM

Date of Find __________ (Please respond as soon as possible).

LOCATION
(be as accurate as possible) ____

____

IDENTIFICATION OF TURTLE (see reverse side of sheet) ______________________________
positive unsure

SEX ____ Male (tail extends well beyond rear edge of top shell).
____ Female or Immature (tail to, or shorter than edge of top shell).

Have you ever seen marine turtles in this area before? Yes____ No____ Explain: ______________

____

MEASUREMENT DATA (Measure along the central ridge (curve) front to rear edge and side to side at widest point).

Top shell length______inches (along curve)

Top shell width______inches (along curve at widest part)

Head width______inches (at widest point)

Tag No. and description______________
(if tagged) ______________

CONDITION OF TURTLE

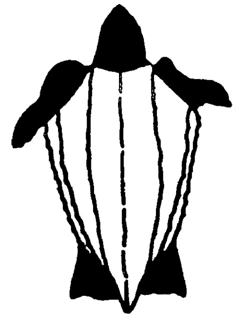
___*Shell and body intact, little or no foul odor or bloating.*

___Shell not intact and/or body bloated and discolored.

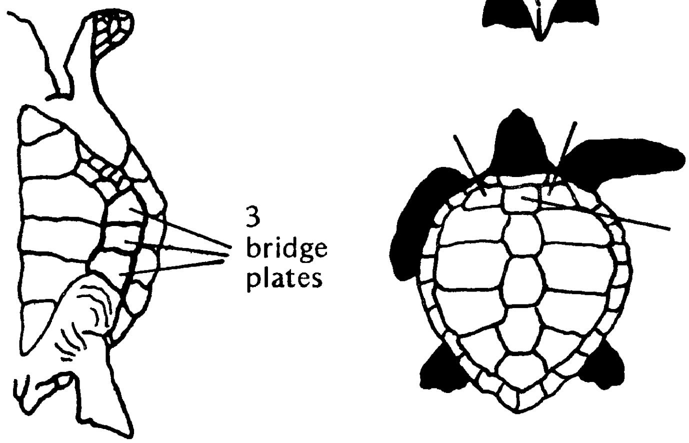
___Skeleton only.

It is important to note any MUTILATION of the body, missing limbs, gashes, missing eyes, wounds, etc., in order to determine possible cause of death. Please list all/any such signs that describe the turtle's condition:

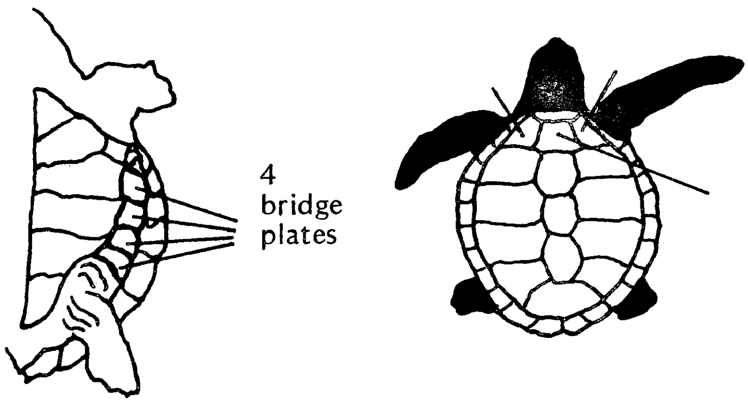
Please RETURN THIS FORM to: MARINE TURTLES, Virginia Institute of Marine Science, Gloucester Point, VA 23062, Tel. (804) 642-2111, Ext. 151.



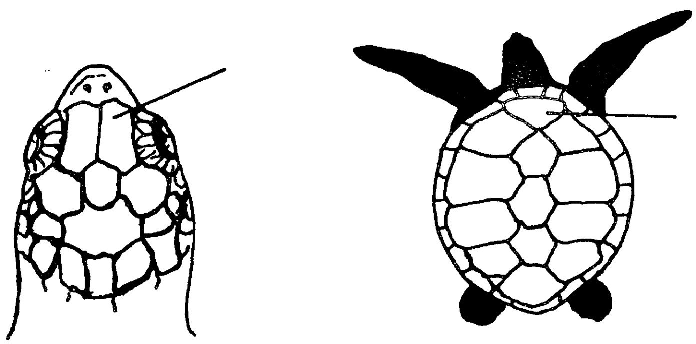
ATLANTIC LEATHERBACK: Seven longitudinal ridges on a leathery top shell, without plates. Our only black marine turtle. Lower part of head, limbs and body may be spotted with white or yellow. Often very large (to 7 feet).



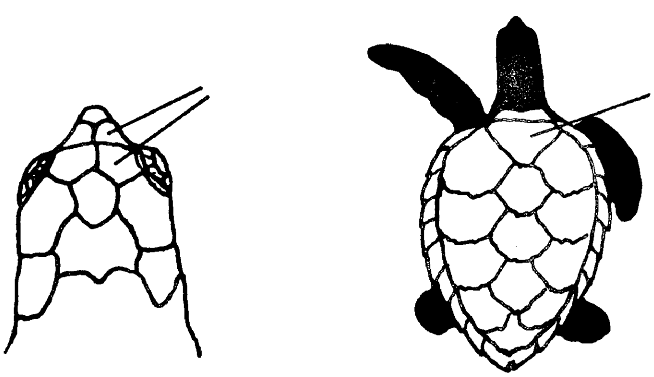
ATLANTIC LOGGERHEAD: Top shell reddish brown in color. Has "extra" pair of shoulder plates touching neck plate. May be large (>100 lbs.). Three plates on lower shell bridge.



ATLANTIC RIDLEY: Top shell grey and almost circular. May be some white on head, limbs and bottom shell. Has "extra" pair of shoulder plates touching neck plate. Usually small size in Virginia (< 40 lbs.). Four plates on lower shell bridge.



ATLANTIC GREEN: Top shell is broad, with plates barely overlapping, if at all. Olive to brown color (sometimes mottled). Has large triangular central plate touching neck plate and two plates between eyes.



ATLANTIC HAWKSBILL: Top shell shield-shaped, dark brown or tortoise shell in color; plates on top shell broadly overlapping. Has large triangular central plate touching neck plate and four plates between eyes.

VIRGINIA MARINE TURTLE STUDY 1980

Directions for tagging cooperators covered under Federal Permit

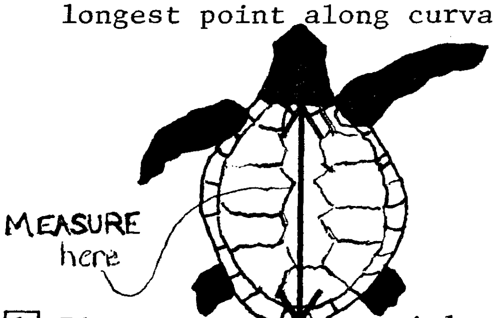
We are conducting a study of Virginia's marine turtles, the most abundant which are the loggerhead and ridley turtles. We have been granted permission by U.S. Fish and Wildlife to tag sea turtles in order to determine their local and seasonal movements as well as their behavior in area pound nets. At present we do not know the origins of these sea turtles or where their nesting beaches are. With your help we hope to answer some of these questions by following the paths of tagged turtles within and beyond Virginia waters. Your assistance in this project will help efforts to prevent extinction of these long-lived animals.

IF YOU FIND A SEA TURTLE IN YOUR POUND NET OR TRAWL:

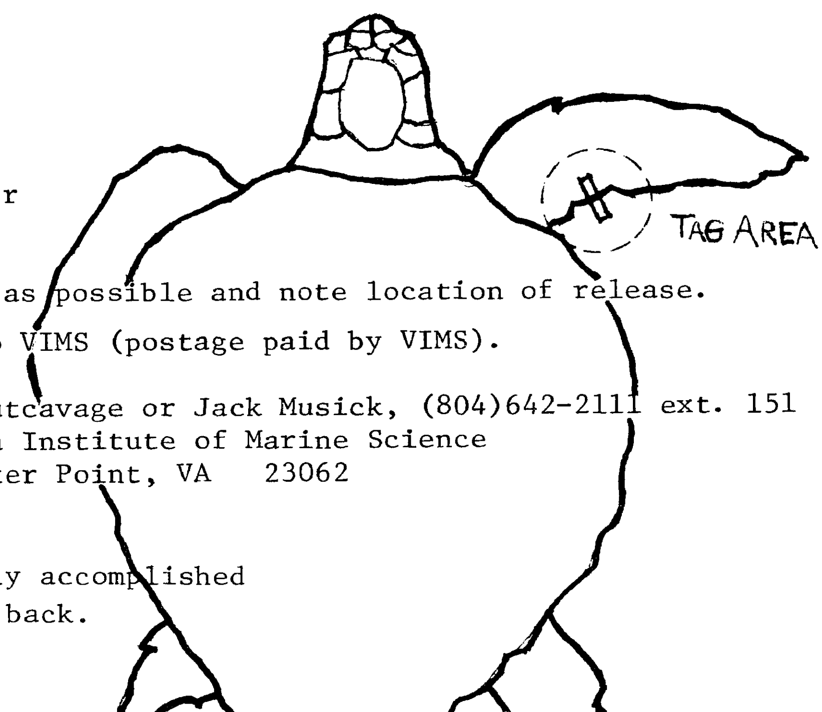
All sea turtles are classified as endangered species and are protected by Federal and state wildlife regulations. It is important to handle sea turtles with care so that they are not injured or killed. All live turtles must be returned to the wild. Stunned turtles should be left on their backs on deck, out of direct sunlight until they revive, and then returned directly to the wild. Stunned turtles should be revived by pumping on the bottom shell with your foot to stimulate breathing. It is unlawful to take any parts or remains of dead sea turtles. Animal parts may be taken by permitted agencies (such as VIMS or NMFS) for scientific study only.

TAGGING STEPS

1. Remove animal from the net, place on its back on deck and determine its condition.
2. Note the kind of sea turtle (see ID) and its tail length.
3. Look for a tag on the right front flipper and record that number (the turtle may have been tagged at an earlier date).
4. Take a length measurement of the top shell down the center at the longest point along curvature.



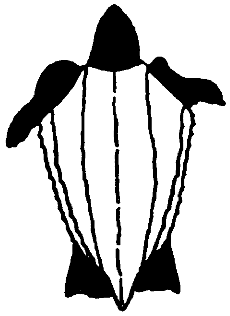
5. If you have been supplied with tags by VIMS, tag live sea turtles on the trailing edge of the RIGHT FRONT flipper, about one quarter way down from the shoulder where the flipper is very thin.*



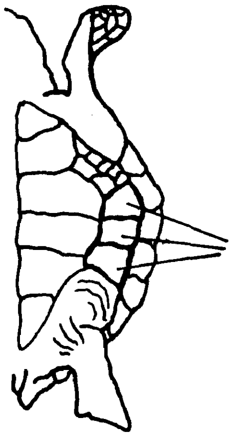
6. Please note any special marks, cuts, or lines.
7. Return animal to the water as quickly as possible and note location of release.
8. Complete sea turtle card and return to VIMS (postage paid by VIMS).

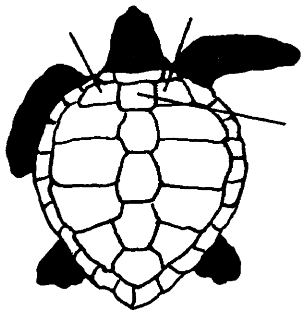
FOR FURTHER INFORMATION CONTACT: Molly Lutcavage or Jack Musick, (804)642-2111 ext. 151
Virginia Institute of Marine Science
Gloucester Point, VA 23062

*Tagging may be most easily accomplished by turning turtle on its back.

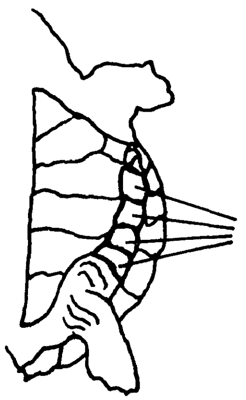


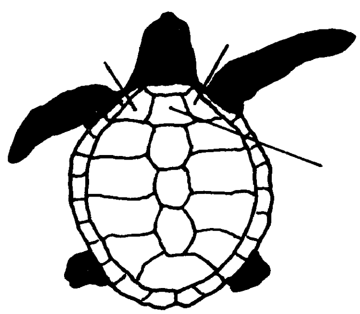
ATLANTIC LEATHERBACK: Seven longitudinal ridges on a leathery top shell, without plates. Our only black marine turtle. Lower part of head, limbs and body may be spotted with white or yellow. Often very large (to 7 feet).



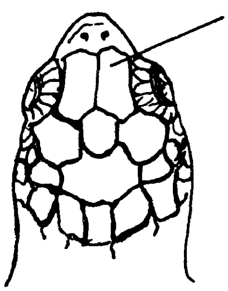


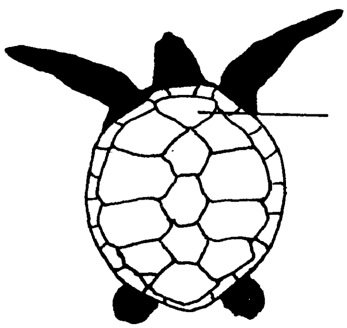
ATLANTIC LOGGERHEAD: Top shell reddish brown in color. Has "extra" pair of shoulder plates touching neck plate. May be large (> 100 lbs.). Three plates on lower shell bridge.



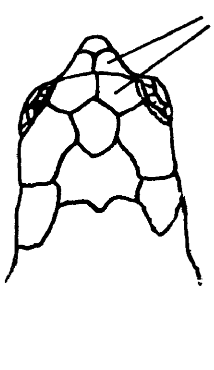


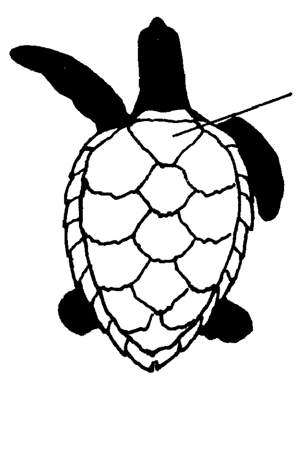
ATLANTIC RIDLEY: Top shell grey and almost circular. May be some white on head, limbs and bottom shell. Has "extra" pair of shoulder plates touching neck plate. Usually small size in Virginia (< 40 lbs.). Four plates on lower shell bridge.





ATLANTIC GREEN: Top shell is broad, with plates barely overlapping, if at all. Olive to brown color (sometimes mottled). Has large triangular central plate touching neck plate and two plates between eyes.





ATLANTIC HAWKSBILL: Top shell shield-shaped, dark brown or tortoise shell in color; plates on top shell broadly overlapping. Has large triangular central plate touching neck plate and four plates between eyes.

REFERENCES

Balazs, G. H. 1979. Loggerhead turtle recovered from a tiger shark at Kureatoll. Elepaio 39(12):145-147.

Blanck, C. E. and R. H. Sawyer. 1981. Hatchery practices in relation to early embryology of the loggerhead sea turtle, Caretta caretta (Linne). J. Exp. Mar. Biol. Ecol. 49:163-177.

Bleakney, J. S. 1965. Reports of marine turtles from New England and eastern Canada. Canadian Field Nat. 79:120-128.

Brongersma, L. D. 1972. European Atlantic turtles. Zoologische Verhandelingen No. 121:1-318.

Bullis, H. R., Jr. and S. B. Drummond. 1978. Sea turtle captures off the Southeastern United States by exploratory fishing vessels 1950-1976. Fla. Mar. Res. Publ. No. 33:45-50.

Bustard, R. H. and C. Limpus. 1971. Loggerhead turtle movements. Br. J. Herpetol. 4(9):228-229.

Bustard, H. R. 1976. Turtles of coral reefs and coral islands. IN Jones, O. A., and R. Endean, eds. Biology and geology of coral reefs. 3(Biology 2):343-368.

Byles, R. A. and J. A. Musick. 1981. Nesting of loggerhead sea turtles Caretta caretta, in Virginia. Unpublished report.

Byrd, W. 1737. Natural history of Virginia or the newly discovered Eden. The Helvetion Society, Bern, Switzerland (trans. R. C. Beatty and W. J. Malloy, Dietz Press, Richmond, VA 1940).

Caldwell, D. K. 1959. The logghead turtles of Cape Ronian, South Carolina. Bull. Florida St. Mus. 4:319-348.

Caldwell, D. K. 1962. Growth measurements of young captive Atlantic sea turtles in temperate waters. Los. Ang. Cty. Mus. Contrib. Sci. 50.

Caldwell, D. K. 1962. Comments on the nesting behavior of loggerhead sea turtles based primarily on tagging returns. O. J. Fla. Acad. Sci. 25(4):287-302.

Caldwell, D. K., A. Carr, and L. H. Ogren. 1959. Nesting and migration of the Atlantic loggerhead turtle. I. Bull. Fla. State Mus. Biol. Serv. 4(10):309-318.

Caldwell, D. K., A. F. Carr, and L. H. Ogren. 1959. Nesting and migration of the Atlantic loggerhead turtle. Bull. Florida St. Mus. 4:295-308.

Carr, A. 1980. Some problems of sea turtle ecology. Amer. Zool. 20:489-498.

Carr, A., and D. K. Caldwell. 1956. The ecology and migration of sea turtles. I. Results of field work in Florida, 1955. Am. Mus. Novit. 1793:1-23.

Carr, A., L. Ogren, and C. McVea. 1980-81. Apparent hibernation by the Atlantic loggerhead turtle *Caretta caretta* off Cape Canaveral, Florida. Biol. Conserv. 19:7-14.

Cheng, T. C. 1967. Marine molluscs as hosts for symbioses. With a review of known parasites of commercially important species. Adv. Mar. Biol. 5, 424 p.

Cheng, T. C. 1979. Larval nematodes parasitic in shellfish. MFR Paper 1345. 40(10):39-42.

Davies, R. W. and C. G. Chapman. 1974. First record from North America of the Piscicolid leech, *Ozobranchus margoi*, a parasite of marine turtles. J. Fish. Res. Board Can. 31:104-106.

Elkan, E. 1979. Some problems in reptilian pathology. Brit. J. Herp. 6(1):

Epstein, S., Buchsbaum, R., Lowenstam, H. A. and Urey, H. C. 1953. Revised carbonate-water isotopic temperature scale. Geological Society of America Bulletin 64:1315-1326.

Erhardt, L. M. 1977. Threatened and endangered species of the Kennedy Space Center. Semi-annual report to the National Aeronautics and Space Admin. John F. Kennedy Space Center Contract No. NAS 10-8986. (June 30, 1977).

Erhardt, L. M. 1978. Threatened and endangered species of the Kennedy Space Center. Annual report to the National Aeronautics and Space Admini. John F. Kennedy Space Center. Contract No. NAS 10-8986.

Erhardt, L. M. 1979. Threatened and endangered species of the Kennedy Space Center. Volume 5 of the semi-annual report to the National Aeronautics and Space Admin. John F. Kennedy Space Center. Contract No. NAS 10-8986 pp. 1-214 (January 5, 1979).

Fahy, W. E. 1954. Loggerhead turtles, *Caretta caretta caretta*, from North Carolina. Copeia 1954:157-158.

Felger, R. S., Clifton, K. and P. Regal. 1976. Winter dormancy in sea turtles: independent discovery and exploitation in the Gulf of California by two local cultures. Science, NY, 191:283-285.

Frazier, J. G. 1980. Marine turtles and problems in coastal management. Pages 2395-2411 IN B. L. Edge, Ed. Coastal Zone '80, Vol. III. Proc. Second Symposium on Coastal and Ocean Management.

Frick, J. 1976. Orientation and behavior of hatchling green turtles, (Chelonia mydas). Anim. Behav. 24(4):849-857.

Gosner, K. L. 1971. Guide to identification of marine and estuarine invertebrates. John Wiley and Sons, Inc.

Gudger, E. 1949. Natural history notes on tiger sharks, Galeocerdo tigrinus, caught at Key West, Florida, with emphasis on food and feeding habits. Copeia 1949 (1):39-47.

Hardy, J. D., Jr. 1962. Comments on the Atlantic Ridley Turtle Lepidochelys olivacea kempi, in the Chesapeake Bay. Ches. Sci., 3(3):217-220.

Hardy, J. D. 1969. Records of the leatherback turtle, Dermochelys coriacea coriacea (Linnaeus) from the Chesapeake Bay. Bull. Md. Herp. Soc. 5(3):92-96.

Hardy, J. D. 1973. Endangered amphibians and reptiles of Maryland: A special report. Bull. Md. Herp. Soc. 9(3):70-94.

Hardy, J. D., Jr. and R. J. Mansucti. 1962. Checklist of amphibians and reptiles of Calvert County, Maryland. Nat. Res. Inst. Ches. Biol. Lab. Ref. No. 62-64, 12 p.

Harriott, T. 1590. A briefe and true report of the New Found Land of Virginia.

Hendrickson, J. R. 1980. The ecological strategies of sea turtles. Amer. Zool. 20:597-608.

Hillestad, H. O., R. J. Reimold, R. R. Stickney, H. L. Windom, and J. H. Jenkins. 1974. Pesticides, heavy metals and radionuclide uptake in loggerhead sea turtles from South Carolina and Georgia. Herp. Rev. 5(3):75.

Hillestad, H. O., J. I. Richardson and G. W. Williamson. 1977. Incidental capture of sea turtles by shrimp trawlermen in Georgia. Report c/o NMFS Contr. No. 03-7-042-35129.

Hiro, F. 1936. Occurrence of the cirriped Stomatolepas elegans on a loggerhead turtle found at Seto. Annot. Zool. Japon. 15(3);312-320.

Hughes, G. R. 1974a. The Sea Turtles of South-East Africa. I. Status, morphology and distributions. Investl. Rep. Oceanog. Res. Inst., No. 35.

Hughes, G. R. 1974b. The Sea Turtles of South-East Africa II. The biology of the Tongaland Loggerhead Turtle Caretta caretta L. with comments on the Leatherback Turtle Dermochelys coriacea L. and the Green Turtle Chelonia mydas L. in the study region. Investl. Rep. Oceanog. Res. Inst., No. 36.

Jeffries, W. B. and H. K. Voris. 1979. Observations on the relationship between Octolasmis greyi (Darwin, 1851) (Cirripedia, Thoracica) and certain marine snakes (Hydrophiidae). Crust. 37(2):123-127.

Killingley, J. S. 1980. Migrations of California grey whales traced by Oxygen - 18 Variations in their epizoic barnacles. Science 207:759-760.

Lawler, E. F., Jr. The biology of the sandbar shark Carcharhinus plumbeus (Nardo, 1827) in the lower Chesapeake Bay and adjacent water M.S. Thesis, College of William and Mary, Williamsburg, VA.

Lazell, J. D. 1976. This Broken Archipelago. Demeter Press, NY.

Lazell, J. D. 1980. New England waters: critical habitat for marine turtles. Copeia 1980(2):290-295.

LeBuff, C. R. and R. W. Beatty. 1971. Some aspects of nesting of the loggerhead turtle, Caretta caretta caretta (Linne) on the Gulf Coast of Florida. Herpetolgica 27:153-156.

Lester, R. J. G., D. Blair, and D. Heald. 1980. Nematodes from scallops and turtles from Shark Bay, Western Australia. Aust. J. Mar. Freshwater Res. 31:713-717.

Lewis, C. A. 1978. A reivew of substratum selection in free-living and symbiotic cirriped. Pages 207-218 IN Chin, F. and Rice, M. E., eds. Settlement and metamorphosis of marine invertebrate larvae.

Lloyd, R. M. 1964. Variations in the oxygen and carbon isotope ratios of Florida Bay mollusks and their environmental significance. J. of Geology 72:84-111.

Lloyd, R. M. 1966. Oxygen isotope enrichment of sea water by evaporation. Geochemica et Cosmochimica Acta 30:801-814.

Lutz, P. L., J. C. LaManna, M. R. Adams, and M. Rosenthel. 1980. Cerebral resistance to anoxia in the marine turtle. Resp. Physiol. 41:241-251.

MacAskie, J. B., and C. R. Forrester. 1962. Pacific leatherback turtles (Dermochelys) off the coast of British Columbia. Copeia 1962:646.

Massman, W. 1957. Discussion following Status of the Sea turtle fishery in Florida, page 463. IN Trans. 22nd North American Wildlife Conference, March, 1957. Publ. Wildlife Mng. Inst., Wire Bldg., Washington 5, D.C.

McCann, C. 1969. First southern hemisphere record of the playlepadine barnacle Stomatolepas elegans (Costa) and notes on the host Dermochelys coriacea (Linne) N.Z.N. Mar. F.w.res. 3:112-118.

McErlan, A., C. Kerby, and M. W. Wass. 1972. Eds. Biota of the Chesapeake Bay. Chesapeake Sci. 13 Supp.

Monroe, R. and C. J. Limpus. 1979. Barnacles on turtles in Queensland waters with descriptions of three new species. Mem. Qd. Mus. 19(3):197-223.

Mrosovsky, N. and P. C. H., Pritchard. 1971. Body temperature of Dermochelys coriacea and other sea turtles. Copeia 1971:624-631.

Mrosovsky, N. 1980. Thermal Biology of Sea Turtles. Am. Zool. 20:531-547.

Musick, J. A. 1972. Herptiles of the Maryland and Virginia Coastal Plain. Pages 213-239, IN M. L. Wass, ed. A check list of the biota of lower Chesapeake Bay. Special Scientific Report No. 65. Va. Inst. of Mar. Sci., Gloucester Point, VA.

Musick, J. A. 1979. The marine turtles of Virginia (Families Cheloniidae and Dermochelyidae) with notes on identification and natural history. Va. Inst. Mar. Sci. Educational Series 24, Gloucester Point, VA.

Newman, W. A. and A. Ross. 1976. Revision of the balanomorph barnacles; including a catalog of the species. San Diego Soc. Nat. Hist., Memoir 9:1-108.

Ogren, L., J. W. Watson, Jr. and D. Wickham. 1977. Loggerhead sea turtles, Caretta caretta, encountering shrimp trawls. MFR Paper 1270 Vol. 39. Nov.

Owens, D. W.,, J. K. Hendrickson, V. Lance, and J. P. Callard. 1979 A technique for determining sex of immature Chelonia mydas using a radioimmunoassay. Herpetologica 34:270-273.

Perkins, F. O., D. E. Zwerner, and R. K. Dias. 1975. The hyperparasite (Haplosporea), and its effects on the surf clam

Urosporidium spisuli sp. N. H industry. J. Parsitol. 61(5):944-949.

Pritchard, P. C. H. and R. Márquez. 1973. Kemp's ridley turtle or Atlantic ridley. I.U.C.N. Monograph No. 2, Morges, Switzerland.

Pritchard, P. C. H. 1971. The leatherback or leathery turtle, Dermochelys coriacea. I.U.C.N. monograph. (I):1-39.

Rabalais, S. C. and N. N. Babalais. 1980. The occurrence of sea turtles on the south Texas coast. University of Texas Marine Science Institute Contr. No. 400.

Reid, G. K. 1955. The poundnet fishery in Virginia, Part 1. History gear description, and catch. Comm. Fish. Rev. 17(5):1-15.

Richards, H. G. 1930. Notes on the barnacles from Cape May County, New Jersey. Proc. Acad. Nat. Sci. Phila. 82:143-144.

Richardson, J. I., T. H. Richardson and M. W. Dix. 1978. Population estimates for nesting female loggerhead sea turtles (Caretta caretta) in the St. Andrew Sound area of southeastern Georgia, U.S.A. Pages 34-38 IN G. E. Henderson, ed., Proceedings of the Florida and inter-regional conference on sea turtles, 24-25 July 1976, Jensen Beach, Florida. Fla. Mar. Res. Publ. No. 33. 66 pp.

Ricker, W. E. 1978. Computation and interpretation of biological statistics of fish populations. J. Fish. Res. Board Can. Bull. 191.

Ruzecki, E. P. 1979. On the water masses of Norfolk Canyon. Ph.D. Diss., University of Virginia, Charlottesville, VA.

Sackett, and Moore. 1966. Isotopic variations of dissolved inorganic carbon. Chemical Geology 1:323-328.

Sawyer, R. T., A. R. Lawler, and R. M. Overstreet. 1975. Marine leeches of the eastern United States and the Gulf of Mexico with a key to the species. J. Nat. Hist. 9:633-667.

Schopf, T. J. M. 1980. Paleoceanography. Harvard University Press.

Schwartz, A. 1954. A record of the Atlantic leatherback turtle (Dermochelys coriacea) in South Carolina. Herpetologica. 10:7.

Schwartz, F. J. 1960. The barnacle Platylepas hexastylos encrusting a green turtle, Chelonia mydas, from Chincoteague Bay, Maryland. Chesapeake Sci. 1(2):116-117.

Schwartz, F. J. 1967. Maryland turtles. Univ. Md., Nat. Res. Inst., Education Series (79), 38 p.

Schwartz, F. J. 1974. The marine leech Ozobranchus margoi (Hirudinea: Pisciocalidae), epizootic on Chelonia and Caretta sea turtles from North Carolina. J. Parasitol. 60(5):889-890.

Schwartz, F. J. 1976. Status of sea turtles, Cheloniidae and Dermochelidae, in North Carolina. J. Elisha Mitchell Sci. Soc. 92(2):76-77.

Shoop, C. R. 1980. Sea turtles in the northeast. Maritimes. 24(4):9-11.

Shoop, C. R., T. C. Doty and N. E. Bray. 1981. Sea Turtles between the region of Cape Hatteras and Nova Scotia. Chapter IX IN Characterization of marine mammals and turtles in mid- and north-Atlantic areas of the U.S. Outer Continental Shelf. Annual Report for 1979 CETAP, University of Rhode Island. Kingston, Rhode Island. April, 1981.

Sprent, J. F. A. 1977. Ascaridoid nematodes of amphibians and reptiles: Sulcascaris. J. Helminth. 51:379-387.

Stancyk, S. E., O. R. Talbert, and J. M. Dean. 1980. Nesting activity of the loggerhead turtle Caretta caretta in South Carolina, II. Protection of nests from raccoon predation by transplantation. Biol. Conserv. 18:289-298.

Stoneburner, D. L., M. N. Nicora and E. R. Blood. 1980. Heavy metals in loggerhead sea turtle eggs (Caretta caretta): Evidence to support the hypothesis that demes exist in the Western Atlantic population. J. Herpetol. 14(2):171-175.

Stubbings, H. G. 1967. The cirriped fauna of tropical West Africa. Bull. Brit. Mos. (Nat. Hist.) Zool. 15(6):229-319.

Talbert, O. R., Jr., S. E. Stancyk, J. M. Dean and J. M. Will. 1980. Nesting Activity of the Loggerhead Turtle (Caretta caretta) in South Carolina, I: A Rookery in transition. Copeia 1980(4):109-718.

Threlfall, W. 1978. First record of the Atlantic leatherback turtle (Dermochelys coriacea) from Labrador. Can. Field. Nat. 92:287.

Thompson, N. P., P. W. Rankin, and D. W. Johnston. 1974. Polychlorinated biphenyls and P, P-DDE in green turtle eggs from Ascension Island, South Atlantic Ocean. Bull. Environ. Contam. Toxicol. 11(5):399-406.

Ulrich, G. F. 1978. Incidental catch of loggerhead turtles by South Carolina commercial fisheries. Rept. to Nat. Mar. Fish. Serv. on contract No. 03-7-042-35121.

Urey, H. C., H. A. Lowenstam, S. Epstein, C. and R. McKinney. 1951. Geol. Soc. Am. Bull. 62:399.

Wass, M. L. ed. 1972. A check list of the biota of lower Chesapeake Bay. SSR No. 65. Va. Inst. Mar. Sci., Gloucester Point, VA.

Wells, H. W. 1966. Barnacles of the north western Gulf of Mexico. Quat. Jour. Florida Acad. Sci. 29:81-95.

Witham, R. 1980. The "lost year" question in young sea turtles. Amer. Zool. 20:525-530.

Wolke, R. 1980. Preliminary sea turtle necropsy report. Report to Nat. Mar. Fish. Serv. on Order #NA-80-GE-A-00066.

Wolke, R. and A. George. 1981. A sea turtle necropsy manual. In press.

Zullo, V. A. 1979. Marine flora and fauna of the Northeastern United States. Arthropod: Cirripedia. NOAA Tech. Report NMFS Circular 425.

Zullo, V. A. and J. S. Bleakney. 1966. The Cirriped Stomatolepas elegans (Costa) on leatherback turtles from Nova Scotian Waters. Can. Field-Nat. 80:162-165.

VITA

Maryellen Lutcavage

Born in Hazleton, Pennsylvania, July 14, 1955. Graduated from Hazleton Senior High School in 1973. Received B.A. with double major in Biology and Environmental Studies from University of Pennsylvania, Philadelphia, Pennsylvania, in 1977. Became a graduate student at the Virginia Institute of Marine Science, College of William and Mary in 1978. Completion of Masters degree August 1981.

Date Submitted	ANIMAL PATHOLOGY RECORD DEPARTMENT OF ANIMAL PATHOLOGY COLLEGE OF RESOURCE DEVELOPMENT UNIVERSITY OF RHODE ISLAND KINGSTON, R. I. 02881	Accession No. K892 Date Received 6-17-80

Veterinarian	Address	Phone
Wolke	as above	

Owner	Address
Molly LutcaVage	Virginia Institute of Marine Scineces, Gloucester Pt.,VA 23062

Ident.	Animal	Breed	Color	Age	Sex	Weight	Prev. Acces.
	Caretta	caretta		subadult	F?		MT-1-80

Clinical Diagnosis:

History and Clinical Summary:

Stranded Back Bay May 11,1980 and placed in freezer. Heavily encrusted with barnacles on all surfaces. Turtle has little odor/no bloat. Eyes protruding, bloody. Livor mortis. Scutes RIC, R2C gone. Rear carapace deformed (hump). Barnacle occludes right nostril. Red fluid and bubbles flow from mouth with greenish hues. Bubbles and viscous fluid also found in upper trachea. Lungs inflated and very wet with watery, red fluid. Body fat substantial and green. Stomach full of hard crab parts. Intestine contained green and brown algae (Sargassum). Small orange - red dots on anal and

Specimen Submitted	Preservation	Condition of Specimen When Received at Lab:
Live Animal ☐ Dead Animal ☐ Tissues ☒	Fresh ☐ Frozen ☐ Fixed ☒	good

Biopsy Data Exact Location	Size	Duration	Encapsulated	Lymph node involvement
			YES ☐ NO ☐	YES ☐ NO ☐

Autopsy Data Natural Death ☐	Mode of Euthanasia	Time and Date of Death	Time and Date of Autopsy
		unknown	6-11-80

Tissues Submitted:

Findings:

abdominal plastron plates. CLC (curvature) 73.0 cm CWC: 67.0 cm CLS (straight line) 68.6 cm CWS 57.2 cm. Weight 65-70 lbs. Hw: 15.0 cm

a) Heart: postmortem autolysis; no significant lesion (NSL).
b) Heart: NSL
c) Duodenum: postmortem slough; lamina propria infiltrated with mononuclear cells. Pancreas: NSL
d) Intestine: postmortem slough; lamina propria infiltrated with mononuclear cells - appears to have been chronic infection. Brown-Brenn revealed no bacteria. Pancreas: NSL

e) Pancreas: NSL Heart: a few focal areas of old migrations of parasites?

f) Heart: NSL. Prussian blue stain indicated that scattered brown pigment is not iron possible trematode pigment.

~~Continued on reverse~~

Diagnoses	Classification	
probable drowning Trematodiasis. Enteritis -Granulomatous	E-4-b P-6-2-a	Tissues saved ☐ Photographs ☐ Radiographs ☐

Pathologist	Date Prepared	Fee
R. E. Wolke		

White - ORIGINATOR Yellow - VETERINARIAN Pink - PATHOLOGIST

Date Submitted	ANIMAL PATHOLOGY RECORD DEPARTMENT OF ANIMAL PATHOLOGY COLLEGE OF RESOURCE DEVELOPMENT UNIVERSITY OF RHODE ISLAND KINGSTON, R. I. 02881	Accession No. K890 Date Received 6-13-80

Veterinarian	Address	Phone
Wolke/George	as above	

Owner	Address
Molly Lutcavage	Virginia Institute of Marine Sciences, Gloucester Pt.

Ident.	Animal	Breed	Color	Age	Sex	Weight	Prev. Acces.
	Caretta	caretta		sub adult	F		MT-4-80

	Clinical Diagnosis	

History and Clinical Summary:

Stranded 20 May 1980 Dog Beach, Ft. Monroe, VA. Little or no odor or bloat. Eyes protude slightly. Heavily encrusted with barnacles - all body areas including carapace and skin. Blood flowed from mouth and nostrils. Weight about 50 lbs. CLC 71.5 cm CWC 66.3 cm CLS 65 cm CWS 64 cm PL 51.2 cm PW 48.0 cm HW 14.7 cm Appears healthy from overall color, body fat, and plastron. Blood from mouth lacks bubbles. Small area at red dots fromleft thigh and plastron. Body cavity full of red fluid about 2 liters. Con't. below

Specimen Submitted	Preservation	Condition of Specimen When Received at Lab:
Live Animal ☐ Dead Animal ☐ Tissues ☒	Fresh ☐ Frozen ☐ Fixed ☒	good

Biospy Data Exact Location	Size	Duration	Encapsulated	Lymph node involvement
			YES ☐ NO ☐	YES ☐ NO ☐

Autopsy Data Natural Death ☐	Mode of Euthanasia	Time and Date of Death	Time and Date of Autopsy
		unknown	5/20-80

Tissues Submitted: heart liver intestine

Findings:

Heart, soft, spongy, and appears enlarged. Lungs inflated with fluid - watery and red. Liver appears gray and grainy. Body fat greenish-gray and in moderate amount. Stomach full of Limulus, Calinectes, lady crab parts and Sargassum.. Two round worms in stomach. Lower GI tract full of digested food and claws.

a) heart: severe congestion, probably agonal changes associated with chronic failure; edema; accumulation of clotted blood in spongous portion of myocardium.

b) heart: as in a

c) Liver - acute congestion, probably agonal
focal accumulation of lymphocytes and golden brown pigment

d) intestine - congestion; post mortem autolysis

Diagnoses	Classification	
Hepatitis - focal, acute.	Q2-1g Q2-2c	Tissues saved ☐ Photographs ☐ Radiographs ☐

Pathologist	Date Prepared	Fee
R. E. Wolke		

White - ORIGINATOR Yellow - VETERINARIAN Pink - PATHOLOGIST

g) Intestine: focal granulomas - trematode eggs (probable spirorchid) surrounded by giant cells and inflammatory cells. Some inflammatory cells contain brown pigment. Pycnosis. Some postmortem changes.

Date Submitted	ANIMAL PATHOLOGY RECORD DEPARTMENT OF ANIMAL PATHOLOGY COLLEGE OF RESOURCE DEVELOPMENT UNIVERSITY OF RHODE ISLAND KINGSTON, R. I. 02881	Accession No. K940 Date Received 7-28-80

Veterinarian	Address	Phone
A. George		

Owner	Address
Molly Lutcavage	Virginia Institute of Marine Sciences, Gloucester Pt., VA

Ident.	Animal	Breed	Color	Age	Sex	Weight	Prev. Acces.
	Chelonian	C. caretta					K890, K889, K892, K934

Clinical Diagnosis

History and Clinical Summary:

Miscellaneous tissue placed in one jar due to laboratory error, all from Virginia.

Specimen Submitted	Preservation	Condition of Specimen When Received at Lab:
Live Animal ☐ Dead Animal ☐ Tissues ☒	Fresh ☐ Frozen ☐ Fixed ☒	

Biospy Data Exact Location	Size	Duration	Encapsulated	Lymph node involvement
			YES ☐ NO ☐	YES ☐ NO ☐

Autopsy Data	Mode of Euthanasia	Time and Date of Death	Time and Date of Autopsy
Natural Death ☒			

Tissues Submitted:

Findings:

a. Aorta and associated vessels: no significant lesion (NSL)
b. Heart valves: endocarditis - foci of inflammatory cells
c. Trachea: NSL
Salivary gland (serous): NSL; melanin macrophage centers present
d. Intestine: infiltration of lamina propria with mononuclears; post mortem autolysis; severe congestion; no evidence of Spirorchid eggs.
probably acute enteritis but post mortem changes mask lesions.
e. as in a. possible proliferation of serosal surface. post mortem autolysis.
f. Intestine: post mortem autolysis
Esophagus: post mortem autolysis. NSL
g. Liver: passive congestion; post mortem autolysis
Heart: NSL
h. as in a.
Mesentery: post mortem changes

Diagnoses	Classification	
Endocarditis	N4-2c	Tissues saved ☐
Enteritis - acute	P6-2c	Photographs ☐
		Radiographs ☐

Pathologist	Date Prepared	Fee
Anita George		

White – ORIGINATOR Yellow – VETERINARIAN Pink – PATHOLOGIST

Date Submitted

ANIMAL PATHOLOGY RECORD

DEPARTMENT OF ANIMAL PATHOLOGY
COLLEGE OF RESOURCE DEVELOPMENT
UNIVERSITY OF RHODE ISLAND
KINGSTON, R. I. 02881

Accession No. K889

Date Received 6-13-80

Veterinarian: Wolke/George
Address:
Phone:

Owner: Molly Lutcavage
Address: Virginia Institute of Marine Sciences, Gloucester Pt. VA

Ident	Animal	Breed	Color	Age	Sex	Weight	Prev. Acces
Loggerhead turtle		C. caretta		subadult	F?		MT-33-80

Clinical Diagnosis:

History and Clinical Summary:

Found very fresh on Back Bay. NWR Virginia on beach. Leeches on ventral rear flipper. Turtle placed in freezer for 2.5 hours before Molly arrived, but not frozen. In good flesh, appears robust. Small gash (approx. 1.5 inches) on front flipper and a "bite" out of rear flipper (perhaps blue fish bite) CLC 65.5 cm CWC 62.0 cm CLS 56.3 cm CWS 49.8 cm PL 46.0 cm PW 30.0 cm HW 12.0cm

Specimen Submitted: Live Animal ☐ Dead Animal ☐ Tissues ☒

Preservation: Fresh ☐ Frozen ☐ Fixed ☒

Condition of Specimen When Received at Lab: good

Biospy Data Exact Location: | **Size:** | **Duration:** | **Encapsulated:** YES ☐ NO ☐ | **Lymph node involvement:** YES ☐ NO ☐

Autopsy Data Natural Death ☒ | **Mode of Euthanasia:** | **Time and Date of Death:** unknown | **Time and Date of Autopsy:** 6-2-80

Tissues Submitted:

Findings:

Bubbles and red foam flow from mouth. Mouth clear of lesions and obstructions. Pink froth in trachea opening is tenacious. Fluid in peritoneal - pleural cavity. All organs appear normal in shape and color. Lungs full of red fluid. Froth and viscous fluid in all of trachea and in bronchi. Mostly fluid, green and viscous throughout GI tract. Only a few hard crab parts found. Surface of duodenum GI, tract, and colon free of parasites and lesions. Cloaca free of parasites and lesions. Overall body fat substantial, green.

Microscopic findings:

a. Liver: coarse eosinophilic granulocytes (many containing dark brown pigment granules). Granuloma surrounding pigment; focal accumulations of dark brown pigment throughout parenchyma.
b. Spleen: red infarct., zone of hemorrhage, vessels edematous; necrosis. Serial sections did not reveal point of blockage nor an etiologic agent.
c. Heart: NSL
d-1. Heart ventricle: Focal accumulation of mononuclear cells (lymphocytes) probably not significant.
d-2. Heart ventricle: possible degeneration of muscle fibers. Trichrome stain indicates

(OVER)

Diagnoses:
Spleen-infarction, acute
Hepatitis-focal, granulomatous
probable drowning

Classification:
W7-1e
Q2-2a

Tissues saved ☐ Photographs ☐ Radiographs ☐

Pathologist: Anita George | **Date Prepared:** | **Fee:**

White - ORIGINATOR Yellow - VETERINARIAN Pink - PATHOLOGIST

d-2 cont'd.

"degeneration" is connective tissue. PTAH stain is nonconclusive; apparently excessive fibrous tissue between cortical and medullary heart muscles.