Mckenzie Turtles

MORTALITY AND BEHAVIOR OF SEA TURTLES IN THE CHESAPEAKE BAY

SUMMARY REPORT

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INTRODUCTION

Research on the populations of juvenile sea turtles which utilize the Chesapeake Bay as a summer foraging area has been pursued by the Virginia Institute of Marine Science (VIMS) since 1979. The largest part of the funding for our studies has come from National Marine Fisheries Service (NMFS) in the form of student fellowship grants with recent substantial contributions also by the Virginia Game and Inland Fisheries Commission and VIMS. This report is a summary of studies carried out through 1983. It consists of sections analyzing telemetry, conventional tagging, mortalities, fishing conflicts, population description and abundance.

TELEMETRY

Richard Byles' telemetric studies of the movements and behavior of sea turtles in the Chesapeake Bay were initiated in 1981 and continued in 1982 and 1983. For the past three years, over 850 locations have been recorded for fourteen loggerheads and two ridleys on approximately 230 days (Table 1). Contact with individuals has been maintained from one to 75 days and total contact duration for all turtles was 418 days. The development of the underwater sonic telemetry system, the surface radio transmission system and the tracking methods have been discussed in previous reports and the details will not be reiterated here. We have established the following through the telemetry study and other research.

1. PHILOPATRY

Tagged turtles have returned to the Bay annually from southern coastal wintering areas. Loggerhead turtles display a strong tendency to return to the same area each season and, when intentionally displaced, to return to the same area within the season. In 1983, a loggerhead which was tracked in 1981 and recaptured and tracked again in 1982, stranded dead within the Chesapeake Bay. This is the first three-year annual return we've recorded from the Bay (see the tagging section for further recapture information). Restricted site fixity was recorded for several turtles returning annually and being captured in the same nets where they were first tagged by co-operating pound net fishermen. A loggerhead which was telemetered and tracked at the York River mouth for 36 days in 1982, was recaptured in the York in 1983 and tracked for 75 days (Table 1). This turtle was captured in the same pound net each year and exhibited similar movements and occupied the same foraging range during both seasons.

Two loggerheads were captured in pound nets near the mouths of the Rappahannock and the Potomac Rivers in 1983 for the telemetry study and were displaced to the mouth of the York River for release. Each of the turtles returned from the release site to their respective capture sites . Turtle MT-80-83L was released on 8 August 1983 and contact was lost 11 August 1983 due to equipment failure. Contact was re-established near the original capture point at Gwynn Island on 13 September 1983, approximately 40 kilometers from the release site. The second displaced turtle (MT-88-83L) was captured in the Potomac River mouth and released for tracking in the York River on 6 September 1983. Daily contact was maintained with this turtle as it swam more than 75 kilometers in eleven days back to the Potomac River.

Evidence from one specimen (MT-22-81L) which was captured in the York and tracked in 1981 and recaptured in the James River late in the 1982 season shows a multiannual return to a different river system. When this specimen was displaced in 1982 to the York River for tracking, it resumed its prior year's orientation to the York mouth.

2. FORAGING RANGES

The majority of the telemetered turtles were captured, released and tracked in the lower Chesapeake Bay, in the vicinity of the York River. Conclusions concerning the behavior of the York area turtles probably applies to other Chesapeake river systems as well. Loggerheads orient to the mouths of the Rappahannock and the Potomac Rivers as they do to the York and possibly use the James River. However, our data is very sparse for the James region.

All York loggerheads maintained a foraging range which was oriented towards the river mouth, and none ever swam more than two kilometers upriver. The York Spit formed a physical north-eastern boundary to the foraging ranges of all loggerheads captured in the York (Figure 1). The only turtles known to cross the barrier were a ridley (MT-42-83L) and two loggerheads (MT-80-83L and MT-88-83L). The loggerheads were displaced from their Rappahannock and Potomac River capture sites and circumnavigated the barrier to return to their preferred rivers. The southerly range boundaries for York turtles were not as sharply delineated as the northern boundary, but were usually within the river discharge plume and bounded in the south by the gradual shoaling across Poquoson Flats. Composite typical foraging ranges are depicted in Figure 1.

Although variable, the typical pattern was generally less than eight kilometers in the long axis. One loggerhead (MT-16-81L) traveled 27 kilometers away from the York mouth to a mid-Bay location, then returned. An attribute of all York foraging patterns was a northwest apex at the river mouth.

Within each of the three typical foraging ranges, turtles exhibited three general types of movements: 1. long term circular paths which had durations of one tidal cycle to many cycles, (Figure 1, B & C), 2. straight line or elongate oval paths which traversed up and down the river channels coincident with the tidal cycle (Figure 1, A) and 3. stationary positioning at a preferred spot regardless of tidal conditions.

3. RESPIRATORY BEHAVIOR

The ratio of time turtles spent at the surface and below the surface was monitored for six turtles in 1982 and four turtles in 1983. Radio transmitters broadcasting at frequencies from 150.000 to 151.000 kHz were imbedded in floats and attached by short flexible lines to the rearmost marginal bones of each specimen. This positioning insured that the transmitter antenna became aerial with each surfacing and allowed the radio transmission time to approximate closely the time the turtle was visible at or near the surface as would be seen from the air (Figure 2).

Table 2 lists subsurface to surface time ratios and the percentage of time spent at the surface for ten turtles. A minimum of 660 paired observations of dive durations and surface times were obtained during daylight hours (0600 to 2100). The average subsurface to surface time ratio was calculated to aid in our population estimates derived from aerial surveys made in 1982 and 1983(see Aerial Surveys). Turtles MT-63-82L and MT-42-83L were dropped from the analysis. Turtle MT-63-82L was emaciated, sluggish and swam into nets twice; the second encounter was fatal. This turtle spent much more time at the surface than the other turtles studied. The second turtle that was not included was a different species (L. kempi) and exhibited quite different respiratory behavior; it spent nearly four times as long at the surface (19%) than did the loggerheads (5.3%). The remaining 478 observations of loggerheads yielded a mean subsurface to surface ratio of 19.8:1, or 5.3% surface time.

4. NET ENCOUNTERS

All the telemetered turtles encountered pound nets at least once because each specimen was originally retrieved from the head of a net for tracking. Once tracking commenced, only one turtle

(MT-63-82L) was recaptured alive in the head of a net, and it later tangled and drowned in the leader of a different net. Two other turtles, MT-62-82L and MT-61-82L, also drowned in pound net leaders. These three turtles drowned two, seven and one day(s) after release, respectively. The short time between release and drowning for these specimens and the physical and behavioral characteristics of the turtles noted in the laboratory prior to tracking lead us to believe that they may have been sick or in weakened condition. No additional mortalities occurred during the more than 400 days that other specimens were tracked.

The movements of the turtles within their foraging ranges exposed them frequently to pound nets. The majority of loggerheads preferred moving with the tides, towards and away from the river mouth along the river channel or along the edge of the channel. This is unfortunately the location of the majority of pound nets which are placed at the channel edge perpendicular to the channel direction (Figure 1). Consequently, loggerheads typically encountered nets set crosswise to their paths.

Upon encountering a net, turtles usually stopped, even in the presence of strong tidal currents, and proceeded slowly towards either the head end or, less frequently towards the tail end the net. It was obvious the turtle did not just simply swim around the obstacle because the movement to avoid the net always consumed more time than if the swimming speed had been maintained at a level equal to the period of movement that immediately preceded the net encounter. Often, turtles would surface again and again, in one spot next to a given net, or moving parallel to the net. It appeared that the turtles were investigating the area closely before swimming around the net. Crustaceans aggregate on large epibiotic loads that grow on the pound net stakes and horseshoe crabs become concentrated at the bottom of the net. It is not surprising that turtles linger near this food source.

5. SWIMMING BEHAVIOR

Tracked turtles were strongly influenced by the tide. Even so, healthy turtles displayed the ability to remain stationary or swim perpendicular to the tidal direction in all situations. Tidal displacements occurred while turtles were occupying a foraging area, returning to preferred sites or exiting the Bay in the fall. In foraging areas, turtles tended to drift with the tide, probably just over the bottom in search for food. Some turtles were less influenced by tides then others and spent the majority of their time in circumscribed, preferred areas within the larger foraging area.

The displaced turtle MT-88-83L showed a net directional movement of nearly seven kilometers per day. However, within each day, its actual movement had a bi-directional tidal influence. The course doubled back on itself, in a two step forward, one step back manner as the turtle returned to the Potomac.

An unusual event was documented at the start of the fall migration out of the Bay. A loggerhead (MT-91-83L) headed due east from the York Spit to mid-Bay, and maintained it's course against ebb and flood tides for one day. As the next tide started, the turtle stayed on the surface for the entire ebb cycle before resuming the more common practice of only surfacing to breathe. The surface waters of the Bay flow more swiftly out of the Bay on ebb tide than those at depth due to fresh water runoff and this behavior conferred the advantage to the turtle of expending little energy and maximizing movement toward the Bay mouth. Only rarely has basking behavior or prolonged time at the surface been recorded for the telemetered turtles and never to the degree that was recorded for this turtle.

6. MIGRATION

Turtles are usually present in the Bay only when water temperatures are 20 C or above. The absolute temperature, or the rate of change in temperature could be cues to the turtle for the initiation of migration, since both occur with predictability each year (Figure 3). Also coinciding with the fall emigration for the past two years was the onset of the first of the fall northeast storms. These factors could be cues for a shift from foraging to migratory behavior. The relative importance of each has not been ascertained.

The migratory route taken by turtles after leaving the Bay has been determined to be a coastwise, southerly course, most likely within tens of kilometers of shore. Precise locations and continuous tracks of individual turtles have been impossible to record due to adverse conditions prevalent in the Atlantic at the onset of winter. Contact with migrating loggerheads has been maintained south to Cape Hatteras, but no further. Satellite telemetry experiments planned for the fall of 1984 should elucidate the migratory route and the overwintering sites for the Bay population(s) of loggerheads.

7. SPECIES COMPARISON

The first successful telemetry study of a ridley in the Chesapeake Bay was accomplished in 1983. Since it is the rarest of all sea turtles and is near extinction, the data that were obtained are of particular importance.

Ridleys are smaller, more active and agile than loggerheads and differences in food preference reflect this. The predominant food item found in the stomachs of dead, stranded ridleys and in the feces of live captive specimens of Chesapeake ridleys is the blue crab, *Callinectes sapidus*. The predominant food item for the slower moving Chesapeake loggerhead is the horseshoe crab, *Limulus polyphemus*. These food preferences are reflected in habitat preference and behavior of the two species.

The ridley (MT-42-83L) traveled 13 kilometers upon release from the York River to the Mobjack Bay and then abruptly settled down to foraging behavior. In comparison to loggerheads, the ridley frequented much shallower water, and was found nearer to shore over extensive shoal areas of less than five meters in depth. There was no notable orientation to channels and the size of the area covered was even more limited than that of the most restricted loggerhead. The ridley could most often be found among crab pots, undoubtedly feeding on the abundant blue crabs in the area.

The respiratory behavior pattern was similar in the two species but the ridley remained on the surface approximately four times longer than the average loggerhead (Table 2). Another difference noted between the two species was the lower profile maintained by the ridley while at the surface; as opposed to the loggerheads', the ridley's carapace was rarely visible when the turtle surfaced to breathe and the ridley was much more prone to dive when approached.

It is important to consider these differences in habitat and prey item preference between the two species when making management decisions or planning involving the Chesapeake Bay sea turtles. Since there is a great difference in habitat preference and feeding habit, planning should address the individual species rather than sea turtles as a general catagory.

8. SONIC TRANSMITTER

A new sonic transmitter, more powerful than commercially available models, was constructed by Custom Telemetry and Consulting in Athens, Georgia and used with success. The new unit, and its receiving system, are the first steps in the design of a multichannel telemetry system now being adapted for use with sea turtles in the Bay. The major benefit of the new system is the increased range of individual transmitters over the previously used models. Transmitted pulses are now routinely detectable at distances of one to two kilometers from the telemetered turtle and under ideal conditions, ranges of nine to ten kilometers may be obtained. The increased range of the transmitters increases the likelihood of maintaining contact with free-ranging turtles and also aids in the clarity of the signal pulse. The latter is crucial to the methods we will use for multichannel transmission.

AERIAL SURVEYS

Thirteen survey flights were made in 1982 and again in 1983 in the study area (Figure 4). East-west transects were flown as reported in the 1982 annual report. The average length of a four transect survey was 123 linear kilometers in 1982 and 139 kilometers in 1983. Four to five percent of the study area was covered by each survey.

In 1982, 168 loggerheads, one ridley and three leatherbacks were observed during the flights. In 1983, 272 loggerheads, twelve ridleys and one leatherback were observed. Figure 5 is a frequency histogram of the lateral distances of all turtles from the flight path as calculated from perpendicular sighting angles. Ninety percent of all sightings occurred between 50 meters and 300 meters from the path of the plane. We have therefore limited the effective visual strip width to 250 meters on either side of the plane. With this data truncation, and considering only the flights on which turtles were present in the Bay, calculations of the density of loggerheads during the surveys were made. An unadjusted density of 0.21 turtles per kilometer squared was obtained for 1982 and in 1983 the unadjusted density was 0.37 turtles per kilometer squared.

Surfacing times were monitored for radio tagged loggerheads both seasons (see Telemetry) and the average ratio of dive duration to time spent on or near the surface was determined to be 18.9 to 1. In order to account for unseen diving turtles this ratio was multiplied by the number of turtles seen on each flight to yield an estimate of the total number of turtles occurring along the flight path during the study. The results from two flights each occurring in June were excluded from the calculations because we feel that the greater number of turtles seen on these flights were possibly migrating into the Chesapeake Bay. Migrating turtles may exhibit different behavior and activity patterns from those observed in foraging turtles and invalidate the use of the adjustment ratio.

New densities were calculated based on this surmise. For 1982 a new average density of 0.15 turtles per kilometer squared was calculated. The recalculated average density for 1983 was 0.26 turtles per kilometer squared. Use of the adjustment ratio obtained from surfacing behavior yields an estimated density of 2.8 turtles per kilometer squared for 1982 and 4.9 for 1983. The approximate size of the study area is 1550 kilometers squared. Since loggerheads are rarely found in waters less than four meters in depth, the adjusted densities were extrapolated to an area of circa 750 kilometers squared, which corresponds to that portion of the study area enclosed by the four meter contour line. Extrapolating from our average density approximation, we estimate the minimum number of loggerheads utilizing the lower Bay in 1982 to be approximately 2,100 individuals. In 1983, the approximate number of turtles occupying the study area was calculated to be 3,600 turtles. The sixty percent increase between years may be a result of better aerial viewing conditions in 1983 or may reflect true annual variation. No conjectures can be made concerning the inter-annual estimates until several more surveys are made and trends become apparent. Consideration of the negative biases inherent in aerial surveys (glare, observer differences, sea state) will tend to increase the estimate. Decreases in the estimate will arise by excluding areas as non-preferred habitat.

The estimates above do not include the area above New Point Comfort. We consider the estimates to be reasonable for the study area. In order to extrapolate the estimates to include the entire Chesapeake Bay, distribution patterns of loggerheads in the mid and upper Bay need to be determined. Two surveys were flown immediately to the north of the study area and results similar to the study area results were obtained. No information is available for the distribution of loggerheads north of the Potomac River, although turtles are known from the region.

An estimate of the summer standing stock of loggerheads in the Chesapeake Bay has been generated by Lutcavage and Musick (submitted). They estimated circa 3,000 individuals in the Bay in 1981 based on mark-recapture methods. This estimate is of the same order of magnitude as the estimate from the aerial surveys.

One survey was made of the Delaware Bay on 10 August 1983 to determine how many sea turtles may have been using the Delaware as a foraging area. Four transects were flown and no turtles were observed. We conclude that sea turtles were not utilizing the lower Delaware Bay in numbers detectable by aerial observation in August. If turtles were present in the Delaware to the degree that they are present in the Chesapeake Bay, we should have observed approximately twenty turtles on the survey.

TAGGING PROGRAM

In 1983, we added fifty-five loggerheads and eleven ridleys to our population of tagged turtles in the Chesapeake Bay. Since 1980, a total of 210 loggerheads and 24 ridleys have been tagged with numbered steel tags on one or both front flippers. The VIMS tagging program is an ongoing study of the point-to-point movements of sea turtles from the Bay. Volunteer, cooperating pound net fishermen aid us in our tagging program and also provide us with turtles they accidently catch, when requested to do so. The monel tags used are provided by Dr. Archie Carr at the University of Florida and annual reports of tagging effort are sent to Dr. Carr and to NMFS, SE region.

RECAPTURES

As a result of the VIMS tagging program, twenty-three *C. caretta* and three *L. kempi* with numbered tags have been recaptured in the last four years (Table 3). In thirteen instances loggerheads were recaptured in the same year they were tagged. Eleven turtles were annual or multiannual migrants to the Chesapeake Bay. One loggerhead (MT-22-81L) was captured in 1981 and 1982, and recovered dead the third year, in 1983. Another loggerhead, MT-16-81L, was tagged in 1981, then stranded dead two years later. These turtles represent the only multiannual recaptures.

Three ridleys and three loggerheads were long-distance recaptures; tagged in the Bay and recaptured elsewhere or tagged elsewhere and recaptured here. A ridley (AAD109;AAD110) with a carapace length of ~41 cm was tagged near the Canaveral Channel, Florida and washed ashore dead in the Bay near Lynnhaven Inlet, a distance of 1430 kilometers in ten months. A loggerhead (NMFS MS3310) reached the Bay from Port Canaveral, Florida, a distance of 1200 kilometers, in 15 months. MT-17-81L, a ridley, was recaptured alive in Bogue Banks, North Carolina 9 months after its original capture in the York River, 639 kilometers away. Another loggerhead (K804) traveled 552 kilometers to Snead's Ferry, North Carolina, 11 months after capture at Lynnhaven Inlet. Two turtles made extraordinary trips to the Bay. One small, 16.0 cm ridley was a headstart turtle from Homasassa, Florida (tag #G2123). It traveled 2277 kilometers to Hampton

Roads, Virginia where it was captured alive after approximately 14 months, swimming an average of 5.3 kilometers per day. A loggerhead tagged in 1982 (AAB734;AAB735) from Canaveral Channel, Florida was recovered alive only 5 months later in Mathews County, Virginia, a trip covering 1245 kilometers or 8.2 kilometers per day.

Growth can be reported from only four recaptures. MT-16-81L was caught on 11 July 1981 and recaptured and released offshore 10 October 1981. On 25 May 1983 it was found dead. Straight line carapace length (CLS) indicated a 1.5 cm increase over this two year period. MT-156-82L was caught on 16 September 1982 and recaptured in 1983 with a CLS increase of 2.5 cm. The third-year turtle (MT-22-81L) was tagged on 9 September 1981 and had grown 3.2 cm by the time of its recapture, 21 months later. Errors can arise when dealing with growth measurements as shown by a loggerhead, MT-46-80L, caught in 1980 and recaptured in 1981. A loss of 2.5 cm in curved carapace length was recorded. This is probably due to measuring techniques among researchers. Differences in epibiotic loads on the carapace cause errors in curved measurements since a tape measurement includes the epibiota. Another source of error is that stranded dead animals tend to swell because of post mortem decay, causing distortion of the carapace. All our known growth measurements should be treated as tentative until enough specimens have been recaptured to reduce the variation in the data.

Unfortunately, four turtles that were recaptured were released by the public without measurements and after removal of their tags. Also, we observed three loggerheads with tag scars. Turtles lose their tags through corrosion and growth or through removal by people. No data have been collected that reveal the magnitude of the tag loss problem. Therefore, population estimates by mark-recapture techniques are difficult to quantify.

NESTING

Scattered, infrequent loggerhead nesting occurs in Virginia. Weekly aerial surveys of suitable nesting coastline were flown in 1980 and no evidence of nesting was seen (Byles and Musick, 1981, unpublished, Appendix A). Some nesting may have occurred on the Barrier Islands and not been reported, but no major nesting is likely to have occurred. Personnel from Back Bay National Wildlife Refuge have found and protected about one nest each season south of Virginia Beach and Chincoteague National Wildlife Refuge has had the same magnitude of nesting during the study period.

Virginia is only marginally suitable as a sea turtle rookery due to two main factors. There is a lack of suitable habitat (such as sargassum) for the protection and nurture of hatchlings off our coast, and cooler temperatures may prevail during incubation which would drive the sex ratio towards a majority of males (Appendix A).

MORPHOMETRICS

The populations of turtles that use the Bay as a summer foraging area consist of immature specimens, whether loggerheads or ridleys. No adult-sized ridleys have ever been encountered and adult-sized loggerheads are rare, although some were stranded near the Bay mouth and along the Atlantic beaches.

Table 4 lists the overall means of morphometric measures taken by VIMS personnel from live and dead loggerheads for all years. Frequency histograms by five centimeter intervals are given for loggerheads (Figure 6) and ridleys (Figure 7).

Eighty-five percent of the loggerheads we examined fell in the interval between 50 cm and 80 cm straight line carapace length, and these data were clustered tightly about the mean of 67.0 cm (SE = 0.72, N = 255) (Figure 6). The data were weakly skewed towards larger size due to the occassional stranding of adult-sized (~90 cm +) turtles near the Bay mouth and Atlantic beaches. Over 90% of all turtles examined were less than 90 cm in carapace length. The largest live turtle collected in the Bay had a carapace length of 86.0 cm.

The mean straight line carapace length of ridleys we examined was 40.0 cm (SE = 1.329, N = 29) (Figure 7). Seventy-five percent of the ridleys were between 30 and 45 cm.

BLOOD EXAMINATION

Blood was sampled from live turtles when possible and a series of analyses were initiated to determine health or disease state parameters to aid us with rehabilitation and to investigate possible causes of mortalities. These studies are being pursued at present to establish the normal baseline parameters in sea turtles. Appendix C contains the results obtained thus far for the baseline.

Serum gonadotropin levels were determined as an indicator of sex by Dave Owens, Texas A & M University. For 50 live turtles from which blood was sampled, 32 were determined to be female, 14 were male and four were intermediate but probably males, yielding a sex ratio of 1.8 to 1 females to males. The sex ratio of immature loggerhead populations from other southeast areas is 1.6 to 1 (Thane Wibbels, personal communication), which suggests there is no differential migration pattern between the sexes in the immature life stages.

Although the majority of turtles we saw were immature, sex was determined by visual examination of reproductive organs in autopsied individuals. Twenty-six females and fourteen males were identified which yields an overall sex ratio of 1.9 to 1 for turtles examined. This supports the results of the blood analysis.

POUND NET EXAMINATIONS

In 1983 an effort was made to determine the relative number of turtles that were caught in pound net leaders and drowned. Three methods were used to collect the information: aerial, surface and subsurface examination. The aerial survey was to determine the areal and temporal extent of turtles captured in pound nets as well as the ability to spot them from the air. The surface survey was a "ground truth" of the aerial observations and effort was focused on specific areas. The subsurface survey was designed to test the feasibility of the diving method and to determine the number of turtles that were caught below the surface, and that could not be seen with the other two methods.

1. AERIAL EXAMINATION

All pound nets in the Chesapeake Bay were surveyed once a month to determine the number of nets fishing and the locations. On seven flights, from April through October, pound net leaders were examined for dead turtles. Approximately 240 nets were checked closely, and an additional 304 nets were checked at a distance from the plane with binoculars. An average of 78 nets per flight were examined closely or with binoculars. Five turtles entangled in nets were observed from the air during the surveys, which was supported 100% by surface ground truth surveys.

2. SURFACE EXAMINATION

300 net examinations were performed by boat from 22 May 1983 to 16 October 1983. The nets were examined on an opportunistic basis, the frequency, number and locations were dependent largely on surface conditions and weather with the exception of ground truth examinations made in conjunction with overflights. The York River, York Spit and Mobjack Bay received the most attention, in part because of proximity to VIMS and in part due to the greater number of beached carcasses usually found in this area (see Mortalities).

Two ridleys and fourteen loggerheads were found in the leaders or bays of pound nets. Of these, two loggerheads were retrieved alive from leader entanglement, and two loggerheads were retrieved from nets where it was obvious that they drifted into the net with the tide and weren't tangled. All net entanglements were discovered during examinations that occurred from 22 May through 10 June. No turtles were found in the leaders of any nets checked from July through October. This follows the temporal pattern of strandings seen in the Bay since 1979; peak mortalities occur in late May and throughout June (Figure 9).

3. SUBSURFACE EXAMINATION

Ten pound nets were selected for underwater examination with scuba. Dives were made on 6, 7, 8 and 10 June in the York River and York Spit area. Diving could be accomplished only at relatively slack water and was hampered by poor visibility (approximately 10 to 150 cm) and billowing nets. Two divers swam the length of each net's leader, one diver near the bottom and one diver approximately three meters from the top. Divers were linked together by a safety line, in case of entanglement.

Nine nets had no turtles in the leaders, but one net had four loggerheads caught near the surface and two more below the surface. The turtles below the surface were entangled approximately three meters deep, at the point where the stringer top portion of the leader junctured with the mesh lower portion (Figure 8).

MORTALITIES

1. STRANDINGS

We actively solicit sea turtle information from the public each season. Many calls and reports are unconfirmed and haven't been included in the following discussion. Table 5 contains live or dead turtles examined by trained VIMS personnel and dead turtles reported to us by our stranding network. Methods and a discussion of the stranding network were given in the 1982 NMFS report.

Of the total strandings for all years (772), the majority (639) were loggerheads; ridleys made up less than 5% of the total dead turtles. The distribution of strandings by species was similar in all study years.

In all years, the greatest number of strandings occurred in June when turtles first entered the lower Bay (Figure 9). Strandings before May and after November were nearly nonexistent in all study years. The concentration of mortality in the spring may be due in part to the poor physical condition of many turtles resulting from sub-optimal conditions during the winter followed by the arduous coastal migration to the Bay. Evidence supporting a link between mortalities and poor health was revealed by autopsy and carcass examination, however, further work must be done to determine whether a direct causal relationship exists. Blood analyses were begun in 1983 to determine the health state of sea turtles and may provide the link between health and strandings as the study progresses.

The spatial distribution of strandings, like the temporal distribution, was similar for all study years. Strandings were concentrated primarily in zones 3, 6, and 7 (Figure 10 and 11). Factors which may have contributed to the observed stranding pattern include a) local currents, which may have concentrated floating, dead turtles, b) a non-uniform distribution of turtles, c) uneven reporting, and d) differential pressures leading to mortality. The degree of contribution by these four factors to the observed stranding pattern has not been determined.

2. CAUSE OF DEATH

Table 6 lists the causes of death for 250 turtles examined by VIMS personnel since 1979. The largest group is in the undetermined catagory (69%). These turtles either had no marks or other outward signs of the cause of death, or they were too badly decomposed to determine a cause. Nets were directly involved or implicated in 18.6% of the deaths. Implication evidence includes pieces of netting still attached to the carcass, constrictures of the neck or limbs or traces of anti-fouling paint (similar to that found on pound nets) on the carcass.

We had been assuming that many of the undetermined catagory were somehow net related, but have not been able to prove it. This past year our experience with turtles entangled in leaders has made us more skeptical that turtles drowning in pound nets could remain unmarked and drift out of the net to strand. When turtles become tangled, they struggle and generally have very tight constrictions on the extremities that are caught. We have no explanation for the large undetermined category as yet.

Histological examinations were performed by Dr. Richard Wolke, University of Rhode Island, for fifteen turtles in 1983: thirteen loggerheads, one ridley and one leatherback. The heart ventricle, auricle and major vessels, liver, lung, intestine, gonads, kidney, and spleen were the tissues examined. Eleven of the specimens had moderate to advanced post mortem decay which made the cause of death impossible to determine. MT-23-83 and MT-25-83 were diagnosed as having Spirorchidiasis (a parasitic blood fluke infection). Three turtles had evidence of gastroenteritis.

The four turtles above had post mortem decay of their tissues so findings were limited. The histological diagnoses have not revealed the cause of death, but rather a possible weakened condition leading to death. Such has been the case with all post morta examinations of tissues since our research was started; namely that few specimens are suitable for histologic examination and in the cases where results are obtained, a direct link to the cause of death is not found.

3. HYDROCARBON EXAMINATION

We examined tissues from four sea turtles to determine the presence, composition, and concentration of hydrocarbon pollutants found in Chesapeake Bay (Appendix B). Samples of fat and liver were taken from four animals stranded in the Chesapeake Bay and Virginia coastal waters. Three loggerheads and one leatherback turtle were examined. Total concentrations of hydrocarbons per 10.0g of liver ranged from 209.0ppb to 1193.3ppb. Only one fat sample was found to have measurable concentration of pollutants. This sample contained a total hydrocarbon concentration of 1694.0ppb. This sample had the highest concentrations of hydrocarbons for all samples.

Pyrogenic compounds found in sediments were also present in all contaminated turtle samples. Feeding and habitat are primary sources of exposure to these compounds. The results show that compounds that are commonly found in other areas and organisms of the Chesapeake Bay were present in loggerheads and leatherbacks from the Bay and Virginia coastal waters. The results also show high concentration of PCBs. Further studies are needed to determine the magnitude of contamination of sea turtles in Chesapeake Bay and the implications for the health and survival of the turtles.

4. STOMACH CONTENTS

Stomach contents of thirty stranded turtles (27 loggerheads, one ridley, two leatherbacks) were examined in the field in 1983. The loggerheads had mostly horseshoe crab and blue crab parts in their stomachs. Spider crab, rock crab parts and clam bodies were found in some digestive tracts. Quantities of fish bones were found in the stomachs of seven animals leading us to believe they had been feeding in pound nets. The ridley stomach had only blue crab parts in its stomach. Two leatherback stomachs were also examined. Nothing was found in one, but the other had a ketchup plastic wrapper lodged in the intestine. This was not the cause of death.

Stomach contents from thirteen loggerheads were collected for closer examination in the laboratory. Of these, we found three with blue crabs parts, two with horseshoe crab parts, two with spider crab parts, four with fish bones. Clam bodies and seaweed were collected in only a few turtles. One turtle had an operculum from a whelk and sand in its stomach. Sand was common in esophagus of those that stranded on the beaches. There are more analyses on these collections to be completed.

SUMMARY

We are studying the large population of immature sea turtles that migrate to the Chesapeake Bay each summer to forage. Most are loggerheads, however, the rare ridley also uses the Bay in the same manner, but in fewer numbers. Since 1979, we have documented well over 1,000 sightings, incidental captures and strandings of sea turtles. Positive identification has been made for 664 loggerheads, 47 ridleys and eight leatherbacks, most of which were stranded dead animals.

Loggerheads and ridleys reside and forage in the Chesapeake Bay during the warm months. They swim to the Bay as the water reaches 20 C, which usually occurs in late May. Both species have been shown to travel from wintering sites as far away as Florida, and to leave the Chesapeake in the autumn (again as temperatures reach 20 C), and travel at least as far south as Cape Hatteras, North Carolina. No evidence has been found of turtles wintering in Virginia waters.

Loggerheads foraging in the Bay oriented towards river mouths and frequented the channels and channel edges of the rivers. Their movements generally had a strong tidal component, although they were able to maintain position against all tidal flows. Foraging ranges of telemetered turtles were typically

five to ten kilometers in length and confined by the width of river channels. However, the foraging behavior encompassed a continuum from stationary, preferred spots to 30 kilometer long, multitidal cycles. Additionally, a strong tendency to return to preferred foraging ranges in specific rivers was shown by displaced turtles within the season. Annual returns to the same river were documented for some turtles but not all. Loggerheads foraged in water 4 to 20 meters deep.

The ridley telemetered in 1983 maintained a smaller foraging range than the loggerheads. It usually moved horizontally only ten to one hundred meters with the tide and stayed in much shallower water, from one to three meters deep. The ridley's foraging area was limited to the shallow water along marsh edges and to the seagrass beds, which are frequented by its major prey item, the blue crab.

The foraging behavior of the loggerheads brought the turtles into contact with staked pound nets along channel edges. Many net encounters by telemetered turtles revealed that they often swam next to and around nets in all tidal conditions without entanglement or capture. Several turtles in poor or emaciated condition were unable to avoid net entanglement, and drowned.

Incidental capture of turtles alive or dead in pound nets was dependent in part on the position of the net. Nets set near to shore in areas of moderate tidal currents were likely to catch turtles alive and rarely had dead turtles tangled in the leaders or bays. Nets set along channel edges in areas of strong tidal currents and especially deep water nets near large scale, physical features like the York Spit were likely to catch and drown turtles. We believe that nets in areas of strong tidal currents and especially where currents change rapidly or are flowing in multiple directions at different depths are more likely to drown turtles.

The type of net also figured in incidental mortalities. Larger mesh nets (12 to 16 inch stretch mesh) were more likely to tangle and drown turtles than small mesh (6 to 10 inch stretch). Nets with vertical stringers from the top line to about three meters down from the top seemed particularily prone to capture and drown turtles in areas of strong tides. The diving study suggested that there was no large group of drowned turtles undetected under the surface.

Patterns of respiratory behavior investigated by radio telemetry were used to generate a factor which was applied to aerial survey densities to account for unseen, diving turtles. Loggerheads spent an average of 5.3% of their time at the surface during daylight hours. That meant we only saw 5.3% of the population of turtles, the percentage at the surface during any flight. The survey densities were adjusted to include the 94.7% turtles below the surface.

We estimated that there were 2,100 loggerheads in the study area in 1982 and 3,600 in 1983. We consider these estimates conservative and representative of the lower Bay. However, we hesitate to extrapolate these estimates to include the rest of the Chesapeake until more is discovered about the distribution patterns of turtles in the central and northern portions of the Bay. The sixty percent increase in density from 1982 to 1983 may be a true increase, or it may be the result of better survey conditions in 1983.

Migration patterns or pathways have been difficult to determine. Migration takes place when the rising or falling temperatures reach 20 C. Other cues such as photoperiod or fall storms coincide with the changing temperature, but the importance of each cue has not been determined.

We have established that turtles migrate south of Cape Hatteras each winter, but no information was obtained as to how far south they travelled or whether they hibernated or remained active during the cold months. We have more information for turtles migrating north to the Bay in the spring: several tag records from as distant as Florida and the Gulf of Mexico have been recorded.

Nesting of sea turtles on the Virginia coasts during the study period was limited. Ridleys, of course, nest only on the Gulf shores of Mexico. The occasional loggerhead nests oviposited on our shores are probably at the limits of the breeding range of the species. The large stock of loggerheads which frequent the Bay each summer do not originate from Virginia beaches.

Whether the foraging loggerheads which enter the Bay each summer constitute one population, or are comprised of discrete populations in a feeding aggreagation has not been determined. There is no proven method of aging sea turtles, and this prevents us from determining survivorship curves, recruitment, and the impact of mortalities on the population(s). Our inability to determine parent stocks or even migration routes of Bay turtles has made it impossible to fully assess the impact of events in the Chesapeake Bay on the numbers of sea turtles worldwide.

We have found that the loggerheads and ridleys entering the Bay each year are immature. The size classes of each species are narrowly limited. Eighty-five percent of the loggerheads we have seen were between 50 cm and 80 cm. Seventy-five percent of the ridleys were between 30 cm and 45 cm.

The sex ratio of loggerheads in the Bay were skewed towards females in an approximate 1.8 to 1 ratio. This is similar to the sex ratio of other immature loggerhead populations in the southeast United States.

The documented loggerhead mortalities average 150 turtles per year, and each year the greatest numbers are in June. The number of mortalities comprises approximately 5 - 10% of the population which we estimate are using the lower Bay each summer. We have not identified what portion of the total mortalities the known deaths represent, but actual mortalities are greater than the numbers we examine each year.

The impact of mortalities on the ridley population is more difficult to assess since the numbers using the Bay have not been determined. However, due to the severe decimation of the nesting population, any mortalities are important and protection must be afforded ridleys wherever they are found. We have documented thirty dead ridleys in the Bay since 1979, and have examined seventeen live specimens.

Investigations of mortality causes have been hampered because the advanced decomposition of most strandings, and because most carcasses we examined revealed no evidence to pinpoint the cause of death. In approximately 70% of the mortalities, the cause of death could not be determined. Pound net related causes accounted for ~19% of the mortalities, with all other causes accounting for the remaining 11%. The pound net fishery is responsible for a minimum of 50 loggerhead deaths each year and the figure could be higher if some of the undetermined catagory are actually pound net related.

Intitial studies of the tissues of some stranded turtles revealed elevated quantities of PCB's and hydrocarbon pollutants similar to those found in Bay sediments and benthic organisms. Ingestion is the likely source of these compounds in sea turtles.

RECOMMENDATIONS

1. Our estimates of the percent time turtles spend on the surface are based on the behavior of summer foraging residents. Additional research on surfacing behavior must be conducted through tracking experiments on migrating turtles along the coast. This data can then be applied to the large aerial survey data base (accrued by the BLM CETAP program and NMFS programs) to produce more accurate regional estimates of turtle abundance.

2. Our estimates of subsurface pound net mortality are based on only a small sample size because of the difficult diving conditions in the Chesapeake Bay. Additional SCUBA surveys of pound nets should be conducted in June to achieve more accurate estimates of subsurface turtle mortality.

3. Additional comparisons should be made of mortality rates in pound nets with an upper portion of the leader composed of stringers versus nets with leaders entirely composed of twelve or sixteen inch mesh.

4. Studies should be continued on the relative health of turtles entering Chesapeake Bay in the spring and the potential vulnerability of "sick" turtles to pound net capture.

5. Preliminary data suggest that pound nets with stringer-type leaders and located in deep water where strong currents occur may be the principal source of pound net turtle mortalities in early June. Time of year, area, net configuration and the turtle's physical condition all contribute as important variables in sea turtle mortality in pound nets. We plan to continue and expand our consultation with cooperating commercial pound net fishermen to arrive at a series of recommendations to phase out certain mesh types in the lower Bay to reduce sea turtle mortality.

6. Aerial surveys in the Chesapeake Bay should be continued to monitor density fluctuations and refine the estimations of

population size. Additional surveys of the central and upper portions of the Bay are necessary to estimate the numbers of turtles utilizing the entire estuary.

7. The numbers and causes of mortalities should be monitored as we have done in the past with the help of the existing stranding network. Carcass salvage should be maintained for the information that can be provided (bones for aging studies, stomach contents, possible cause of death, tissue samples, etc.).

8. Environmental impact statements, dredge and fill permits, and other legal documents should be studied with care where possible. Impacts on sea turtles or their habitats will occur in the Bay.

Table 1

TELEMETERED TURTLES 1981-1983

TURTLE	SPECIES	TAG NOS	WT (kg)	CLS (cm)	RELEASE	LAST CONTACT	DAYS TRACKED
MT-10-81L	Lk	K2128,K2129	9.1	41.0	11VI81	11VI81	1
MT-16-81L	Cc	G1013,G1015	36.0	62.3	17VII81	8IX81	54
MT-22-81L	Cc	K778,G1017	43.0	66.0	9IX81	11X81	33
MT-64-82L	Cc	K2701,K2702	33.0	60.7	12VII82	12VII82	1
MT-62-82L	Cc	G1018,G1019	56.0	75.4	15VII82	21VII82	7
MT-63-82L	Cc	K2703,K2704	25.0	57.0	27VII82	30VII82	2
MT-61-82L	Cc	K2705,K2706	25.0	55.0	2VIII82	2VIII82	1
MT-65-82L	Cc	K2707,K2708	28.0	59.5	4VIII82	24VIII82	21
MT-156-82L	Cc	K2176,K2177	40.5	62.0	16XI82	21X82	36
MT-163-82L	Cc	K778,G1017	0.0	69.0	7X82	11XI82	36*
MT-161-82L	Cc	K2185,K2186	0.0	75.0	19X82	11XI82	24
MT-42-83L	Lk	K3028,K3030	15.7	51.2	7VII83	24VIII83	48
MT-78-83L	Cc	K2751,K2752	37.0	64.5	29VII83	12X83	75**
MT-80-83L	Cc	K3043,K3044	61.5	75.0	5VIII83	23IX83	50/18***
MT-88-83L	Cc	K3047,K3048	68.0	77.2	6IX83	18IX83	13
MT-91-83L	Cc	K3098,K2008	25.0	55.4	9X83	22X83	14
MT-105-83L	Cc	K3076,K3077	~80	79.3	18X83	18X83	1
MT-168-83L	Cc	K2715,K2779	47.0	71.8	7XI83	7XI83	1

* Tracked previously for 33 days in 1981 (MT-22-81L)
** Also tracked for 36 days in 1982 (MT-156-82L)
*** Lost contact for 32 days

Table 2

TURTLE SURFACE/DIVE TIMES FOR 1982 & 1983
DAYLIGHT HOURS ONLY

TURTLE	CLS (cm)	WEIGHT (kg)	SUBSURFACE/ SURFACE RATIO	% SURFACE	# OBSERVATIONS
MT-62-82L	75.4	56.0	26.3	3.8%	38
*MT-63-82L	57.0	25.0	8.9	11.2%	49
MT-61-82L	55.0	24.0	19.2	5.2%	10
MT-65-82L	59.5	28.0	12.0	8.3%	103
MT-156-82L	62.0	40.5	23.2	4.3%	118
MT-163-82L	69.0	-	21.6	4.6%	31
*MT-42-83L	51.2	15.7	5.3	18.9%	133
MT-80-83L	75.0	61.5	17.2	5.8%	41
MT-88-83L	77.2	68.0	18.7	5.3%	90
MT-91-83L	55.4	25.0	19.7	5.1%	47

* Dropped from analysis

Table 3

TAGGED TURTLE RECAPTURES
1979 - 1983

SPECIES	MT NUMBER TAG NUMBERS	CLS (cm)	TAGGED/RELEASED DATE/LOCATION	RECAPTURE DATE/LOCATION	CONDITION	MULTIPLE RECAPTURES DATE/LOCATION	COMMENTS
Lk	G2123	16.0	9V79/Homasassa, FL	1VII80/Chisholm Creek, York Co., VA	live		headstart turtle
Cc	K490	64.0	28VI80/Potomac River	/Potomac River	live	X80/Potomac River	live
Cc	K728		20VIII80/Potomac River	30X80/Lynnhaven, VA	live		
Cc	K474		12VII80/Cherry Point, Mathews Co., VA	20VIII80/Potomac River	live	X80/Potomac River	live
Cc	K439	69.0	30VI80/Potomac River	/Potomac River	live	X80/Potomac River	live
Cc	K467	51.0	4VI80/Cherry Point, Mathews Co., VA	12VIII80/Potomac River	live	X80/Potomac River	live
Cc	K487	69.9	24VI80/Potomac River	10VI81/Cherry Point, Mathews Co., VA	dead		
Cc	NMFS MS3310		18III80/Port Canaveral, FL	10VI81/	live		
Cc	MT-46-80L G1010;G1012	71.1 (CLC)	30VII80/York River	8VIII80/Rudee Inlet, VA Beach, VA	live	5VI81/York River	live
Cc	K727		7VIII80/Potomac River	27VI82/Haven Beach, Mathews Co., VA	dead		MT-50-82
Lk	AAD109;AAD110		4II81/FL	25VIII81/Lynnhaven, VA	dead		
Cc	K595		24VI81/York River	15VII81/York River	live		
Lk	MT-17-81L K2141;K2142	40.8	28VII81/York River	29IV82/Bogue Banks, NC	live		released minus tags
Cc	K2003	66.0	14IX81/Cherry Point Mathews Co., VA	7VI82/Milford Haven, Mathews Co., VA	live		released minus tags
Cc	K804		12VI81/Lynnhaven, VA	19V82/Newriver Inlet, Sneed's Ferry, NC	live		released minus tags

Table 3 (cont.)

TAGGED TURTLE RECAPTURES
1979 - 1983

SPECIES	MT NUMBER TAG NUMBERS	CLS (cm)	TAGGED/RELEASED DATE/LOCATION	RECAPTURE DATE/LOCATION	CONDITION	MULTIPLE RECAPTURES DATE/LOCATION	COMMENTS
Cc	MT-22-81L K778;G1017	66.0	9IX81/York River	25IX82/Hampton Roads Middle Grounds Hampton, VA	live	29VI83/Buckroe Beach	dead - MT-79-83; Radio-tacked in '81 & '82 (MT-163-82L)
Cc	MT-16-81L G1013;G1015	62.3	11VII81/York River	10X81/3 miles east of Cape Henry, VA	live	25V83/Buckroe Beach, Hampton, VA	dead - MT-12-83
Cc	AAB734;AAB735		3II82/Canaveral Channel, FL	14VII82/Cherry Point, Mathews Co., VA	live		released minus tags; MT-168-82SF
Cc	US Nat. Res. 0577			6VII82/Lynnhaven Inlet VA Beach, VA	dead		MT-167-82SF
Cc	K2094		V82/Buckroe Hampton, VA	31V82/York River	dead		MT-10-82
Cc	K2187		20IX82/Potomac River	1VII83/Potomac River	live		
Cc	MT-156-82L K2176;K2177	62.0	16IX82/York River	22VI83/York River	live		MT-78-83L; retagged K2751;K2752
Cc	MT-64-83L K2767;K2768	63.0	26VII83/York River	9VIII83/York River	dead		
Cc	K2153		21V83/Buckroe Hampton, VA	lateVI83/Potomac River	live		
Cc	K2790		VI83/Buckroe Hampton, VA	5VII83/Cape Henry, VA	live		
Cc	GA3174;GA3119			31VII83/Sand Shoals Smith Island Chesapeake, VA	live		

Table 4

LOGGERHEAD MORPHOMETRIC MEANS

ALL VIMS EXAMINED LIVE & DEAD
1979-1983
(CM)

MEASUREMENT	MEAN	RANGE	STANDARD ERROR	N
Straight Carapace Length	67.0	43.2-108.2	0.72	255
Straight Carapace Width	55.4	36.8-81.0	0.52	241
Curved Carapace Length	71.4	37.0-118.0	0.79	215
Curved Carapace Width	67.2	35.2-100.1	0.72	208
Head Length	15.4	10.0-25.9	0.17	177
Head Width	13.1	7.5-23.4	0.15	234
Plastron Length	50.5	30.6-78.0	0.62	176
Plastron Width	34.9	23.1-58.4	0.50	124

Table 5

VIMS OR STRANDING NETWORK EXAMINED TURTLES

	VIMS EXAMINED				STRANDING		
YEAR	LIVE		DEAD		NETWORK		TOTALS
1983	28 Cc	+	89 Cc	+	42 Cc	=	159 Cc
	9 Lk	+	5 Lk	+	0 Lk	=	14 Lk
	0 Dc	+	2 Dc	+	0 Dc	-	2 Dc
	0 Un	+	0 Un	+	5 Un	=	5 Un
	37	+	96	+	47	=	180
1982	15 Cc	+	63 Cc	+	50 Cc	=	128 Cc
	4 Lk	+	0 Lk	+	2 Lk	=	6 Lk
	0 Dc	+	2 Dc	+	0 Dc	=	2 Dc
	0 Un	+	0 Un	+	17 Un	=	17 Un
	19	+	65	+	69	=	153
1981	4 Cc	+	16 Cc	+	47 Cc	=	67 Cc
	3 Lk	+	4 Lk	+	3 Lk	=	10 Lk
	0 Dc	+	0 Dc	+	0 Dc	=	0 Dc
	0 Un	+	0 Un	+	6 Un	=	6 Un
	7	+	20	+	56	=	83
1980	7 Cc	+	64 Cc	+	125 Cc	=	196 Cc
	1 Lk	+	5 Lk	+	4 Lk	=	10 Lk
	0 Dc	+	2 Dc	+	1 Dc	=	3 Dc
	0 Un	+	0 Un	+	6 Un	=	6 Un
	8	+	71	+	136	=	215
1979	2 Cc	+	62 Cc	+	60 Cc	=	124 Cc
	0 Lk	+	6 Lk	+	1 Lk	=	7 Lk
	0 Dc	+	1 Dc	+	0 Dc	=	1 Dc
	0 Un	+	0 Un	+	9 Un	=	9 Un
	2	+	69	+	70		141
TOTALS	73	+	321	+	378	=	772

Cc = *Caretta caretta*
Lk = *Lepidochelys kempi*
Dc = *Dermochelys coriacea*
Un = Unknown

Table 6

CAUSE OF DEATH
VIMS EXAMINED TURTLES

Undetermined	197	69.1%
Net Related	53	18.6%
Shark Related	1	0.4%
Prop Damage	21	7.4%
Idiot-Induced (intentional)	9	3.2%
Other Fishing Gear	4	1.4%
TOTAL	285	100.1%

COMPOSITE FORAGING RANGES

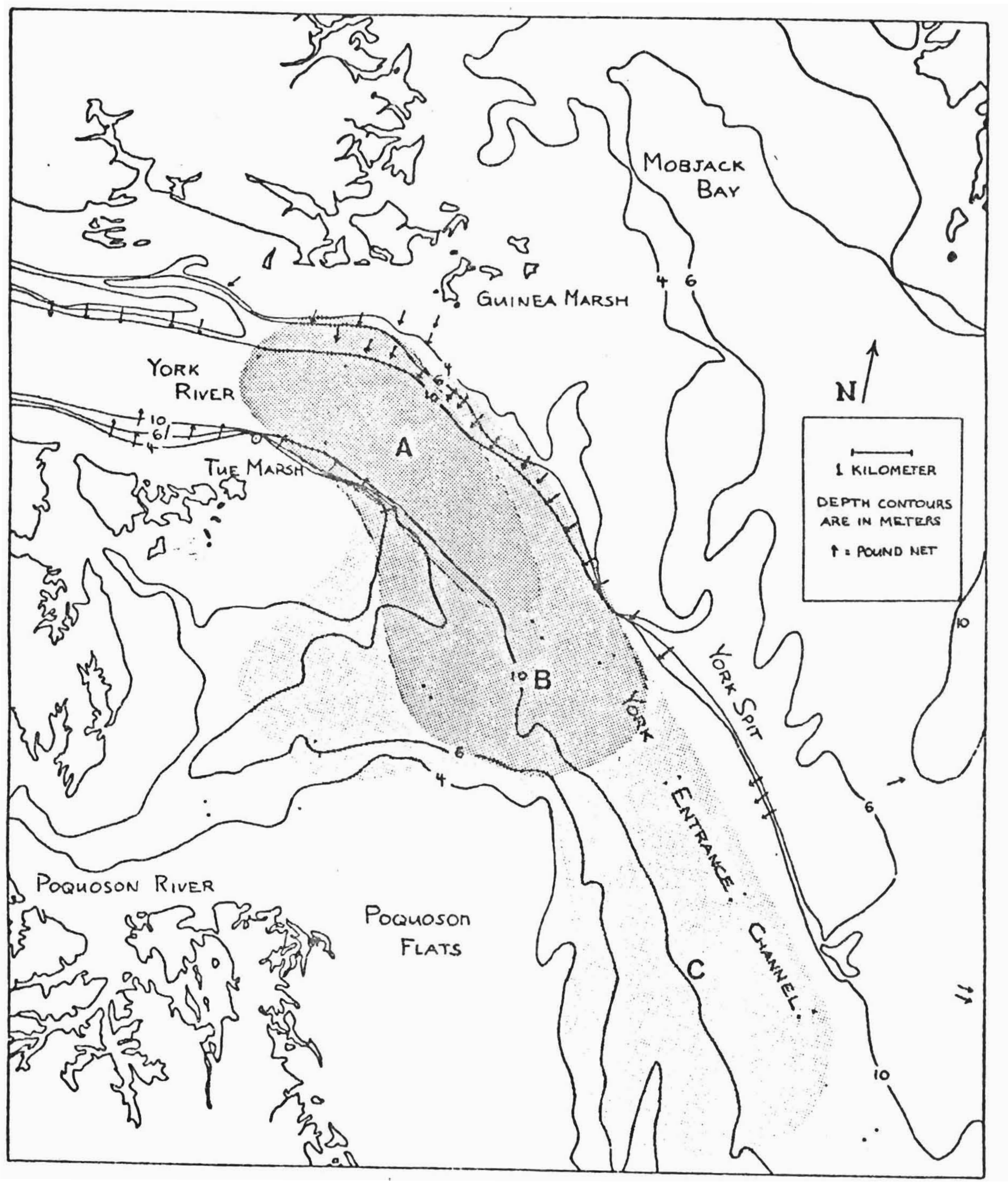
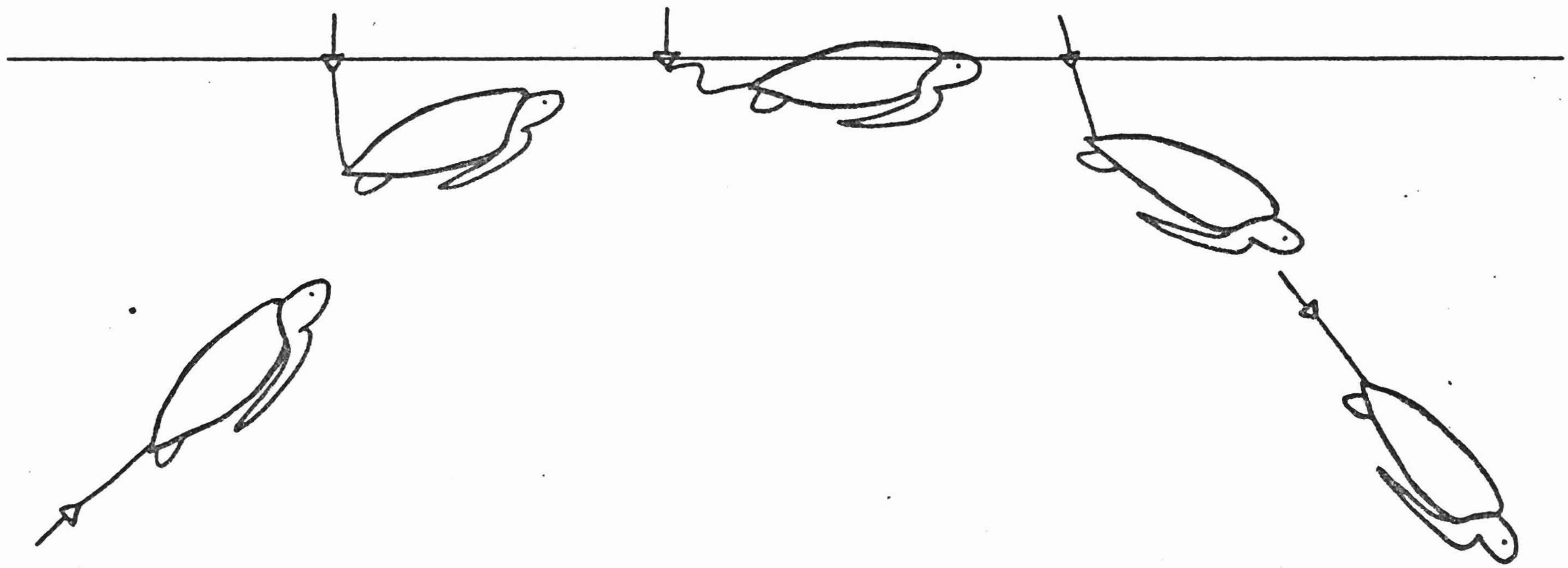


Figure 1

RADIO TRANSMITTER DEPLOYMENT
FOR SURFACE TIME DETERMINATION



Figure

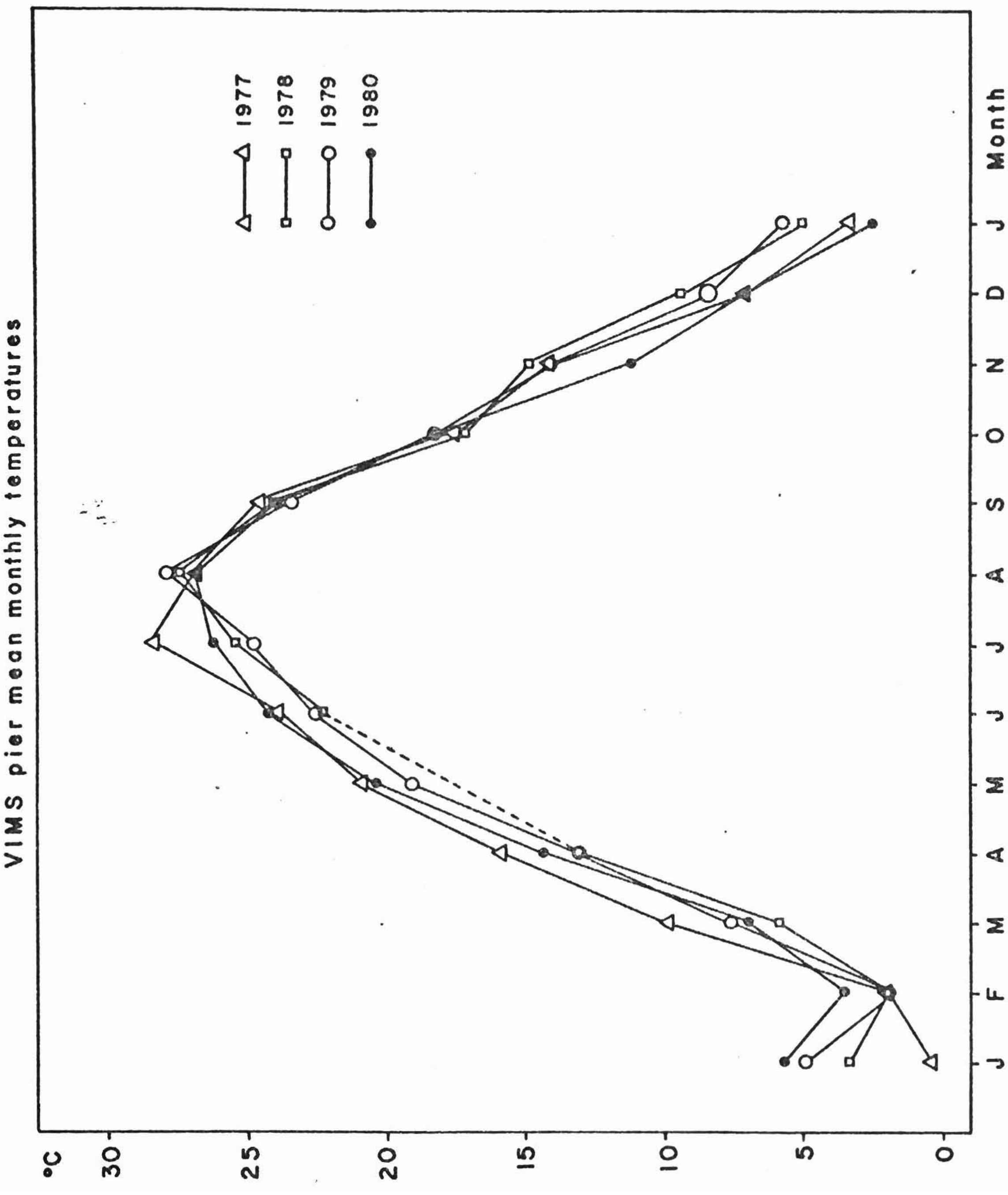
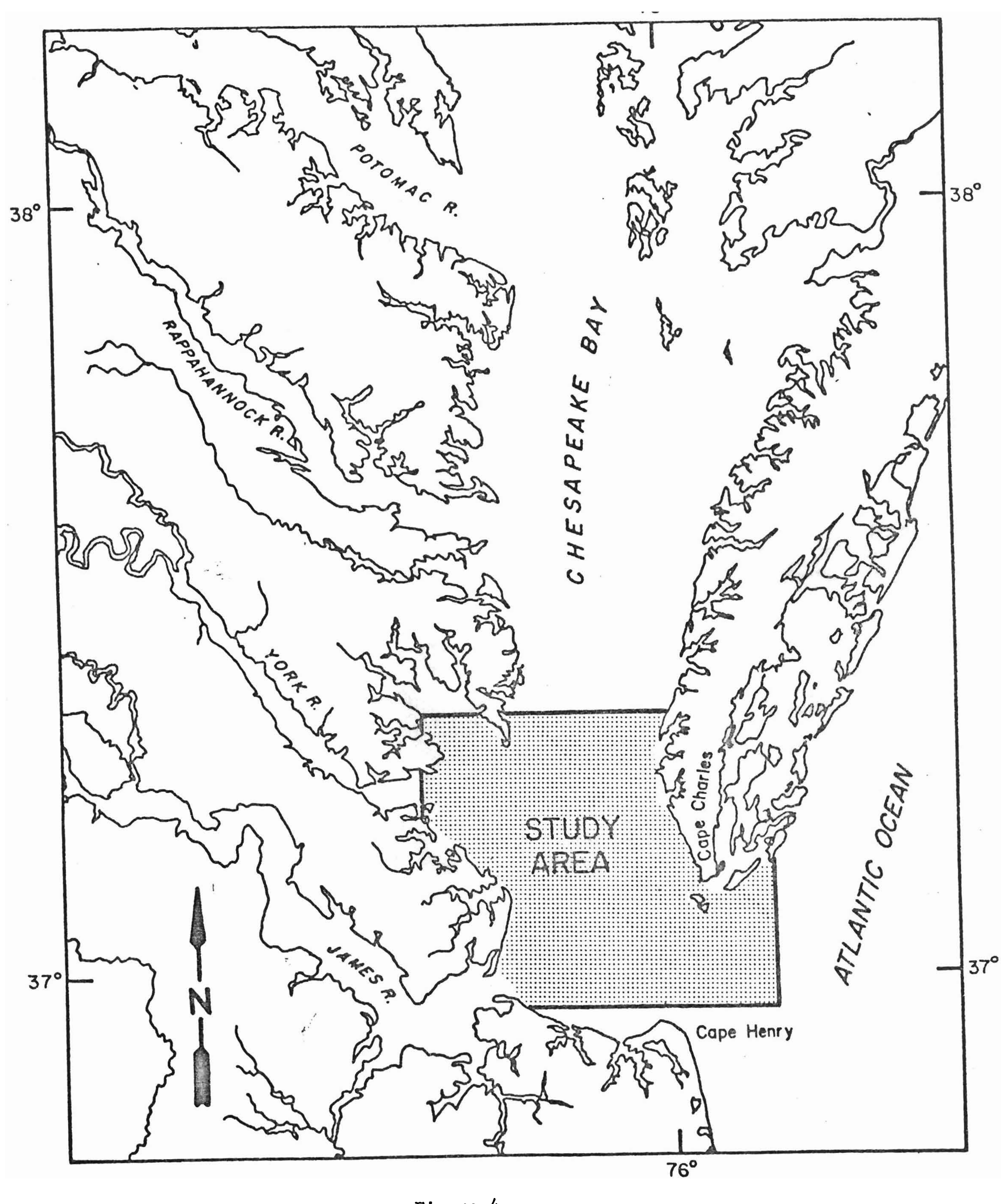

VIMS pier mean monthly temperatures
°C
30
25
20
15
10
5
0
J
F
M
A
M
J
J
A
S
O
N
D
J
Month
1977
1978
1979
1980

Figure 3



POTOMAC R.
38°
38°
RAPPAHANNOCK R.
CHESAPEAKE BAY
YORK R.
Cape Charles
STUDY AREA
ATLANTIC OCEAN
N
JAMES R.
37°
37°
Cape Henry
76°

Figure 4

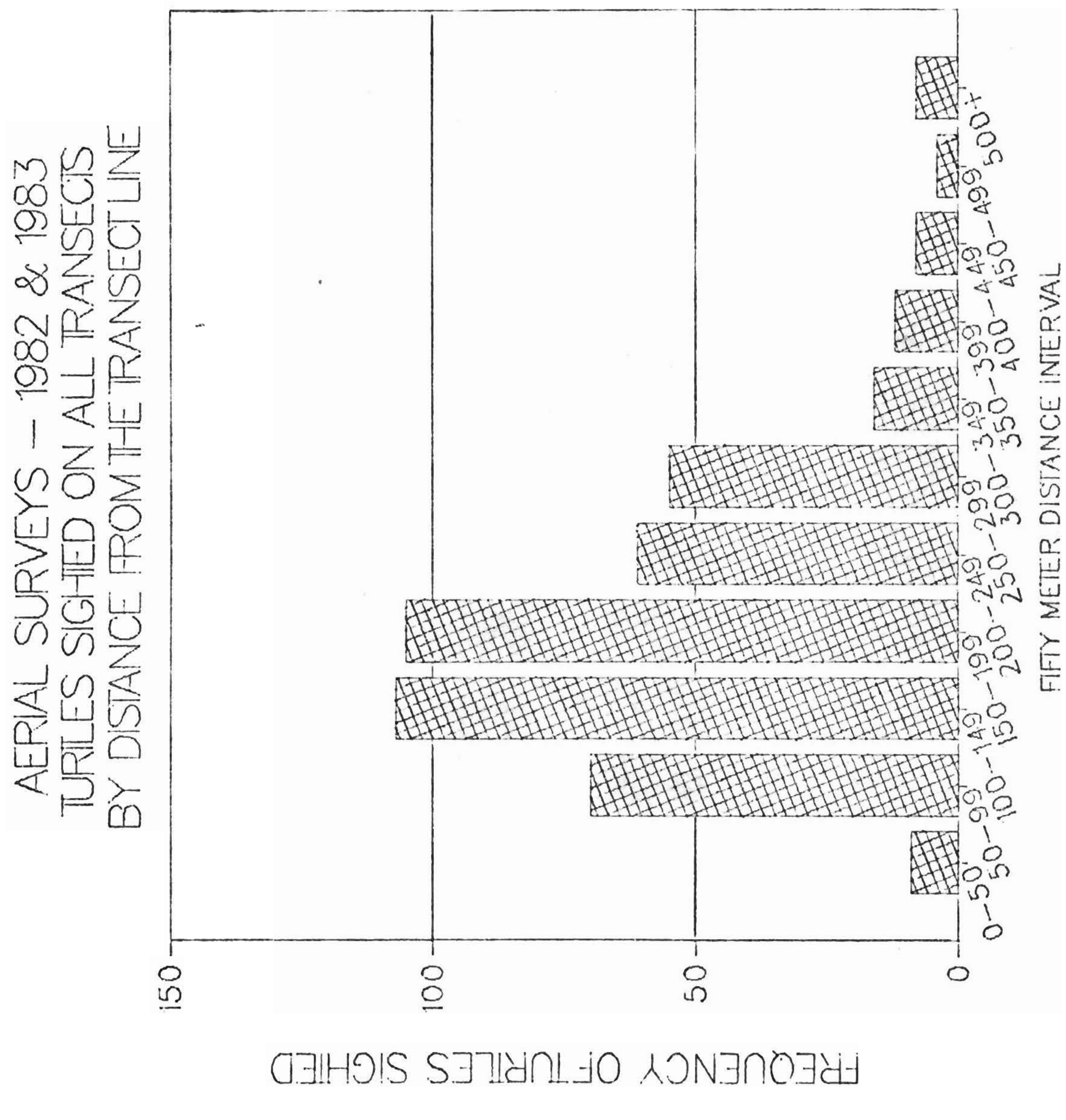

AERIAL SURVEYS — 1982 & 1983
TURTLES SIGHTED ON ALL TRANSECTS
BY DISTANCE FROM THE TRANSECT LINE
FREQUENCY OF TURTLES SIGHTED
150
100
50
0
0–50
50–99
100–149
150–199
200–249
250–299
300–349
350–399
400–449
450–499
500+
FIFTY METER DISTANCE INTERVAL

Figure 5

SIZE CLASSES
VIMS EXAMINED CARETTA BY CLS
1979 — 1983 LIVE AND DEAD

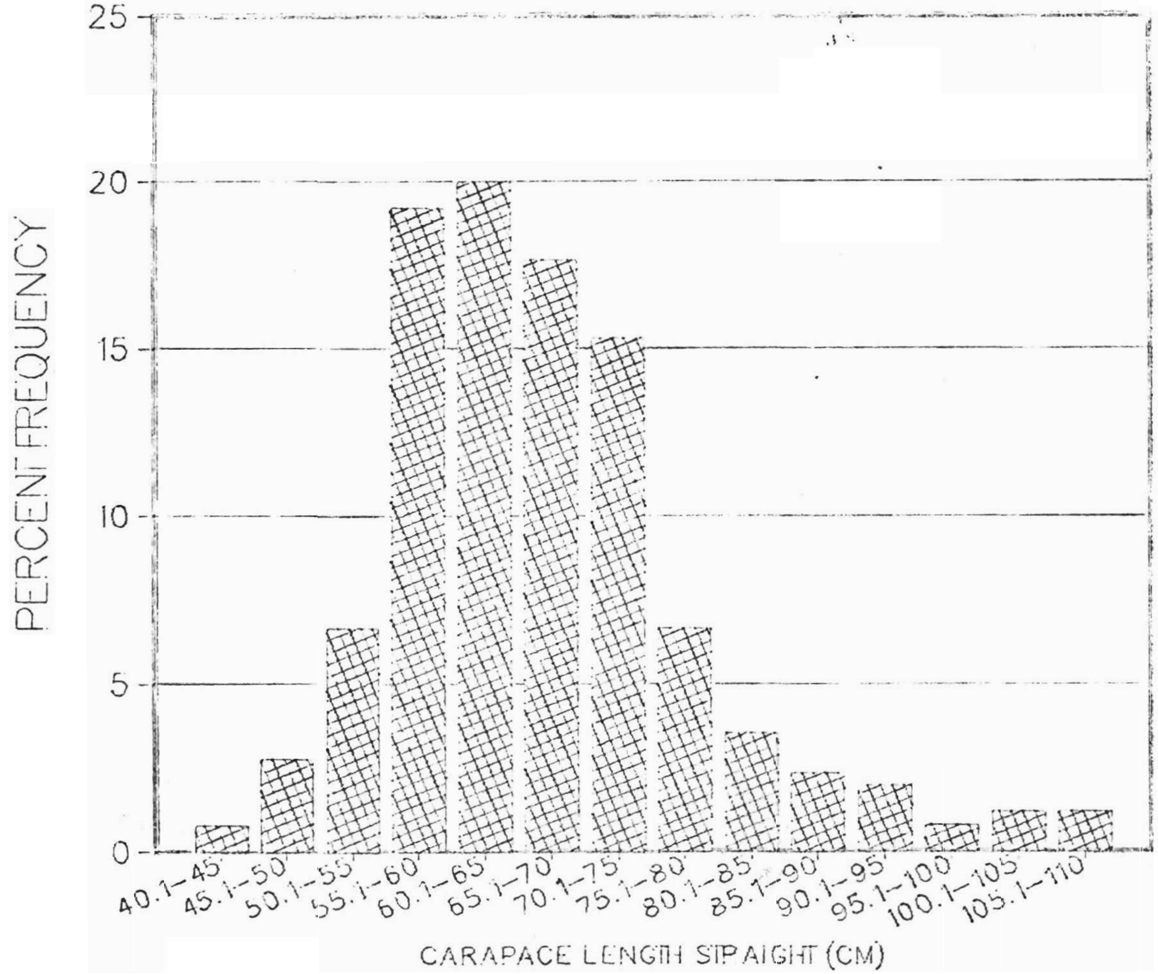
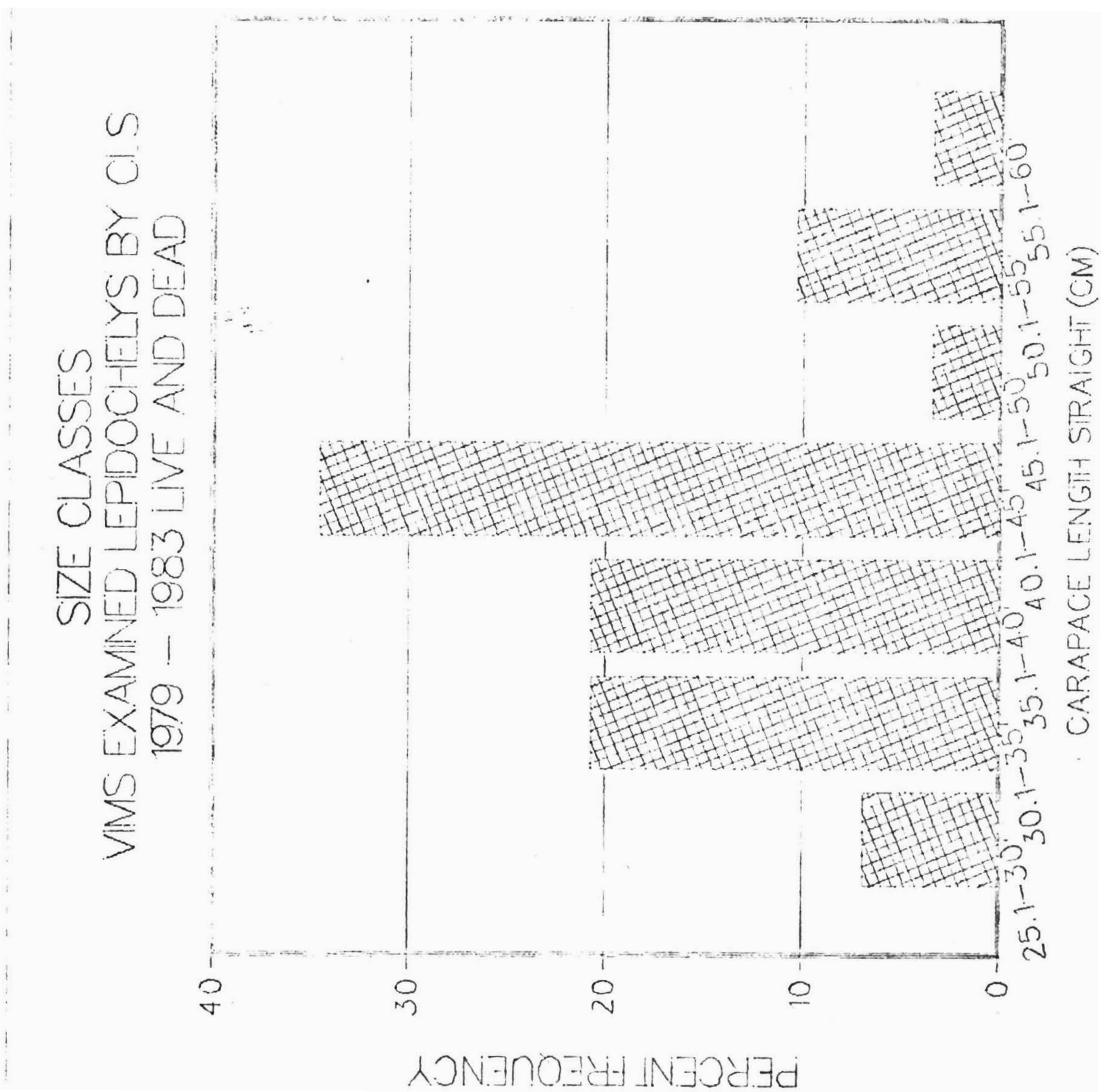


Figure 6



SIZE CLASSES
VIMS EXAMINED LEPIDOCHELYS BY CLS
1979 — 1983 LIVE AND DEAD
PERCENT FREQUENCY
0
10
20
30
40
25.1–30
30.1–35
35.1–40
40.1–45
45.1–50
50.1–55
55.1–60
CARAPACE LENGTH STRAIGHT (CM)

Figure 7

STRINGER POUND NET LEADER

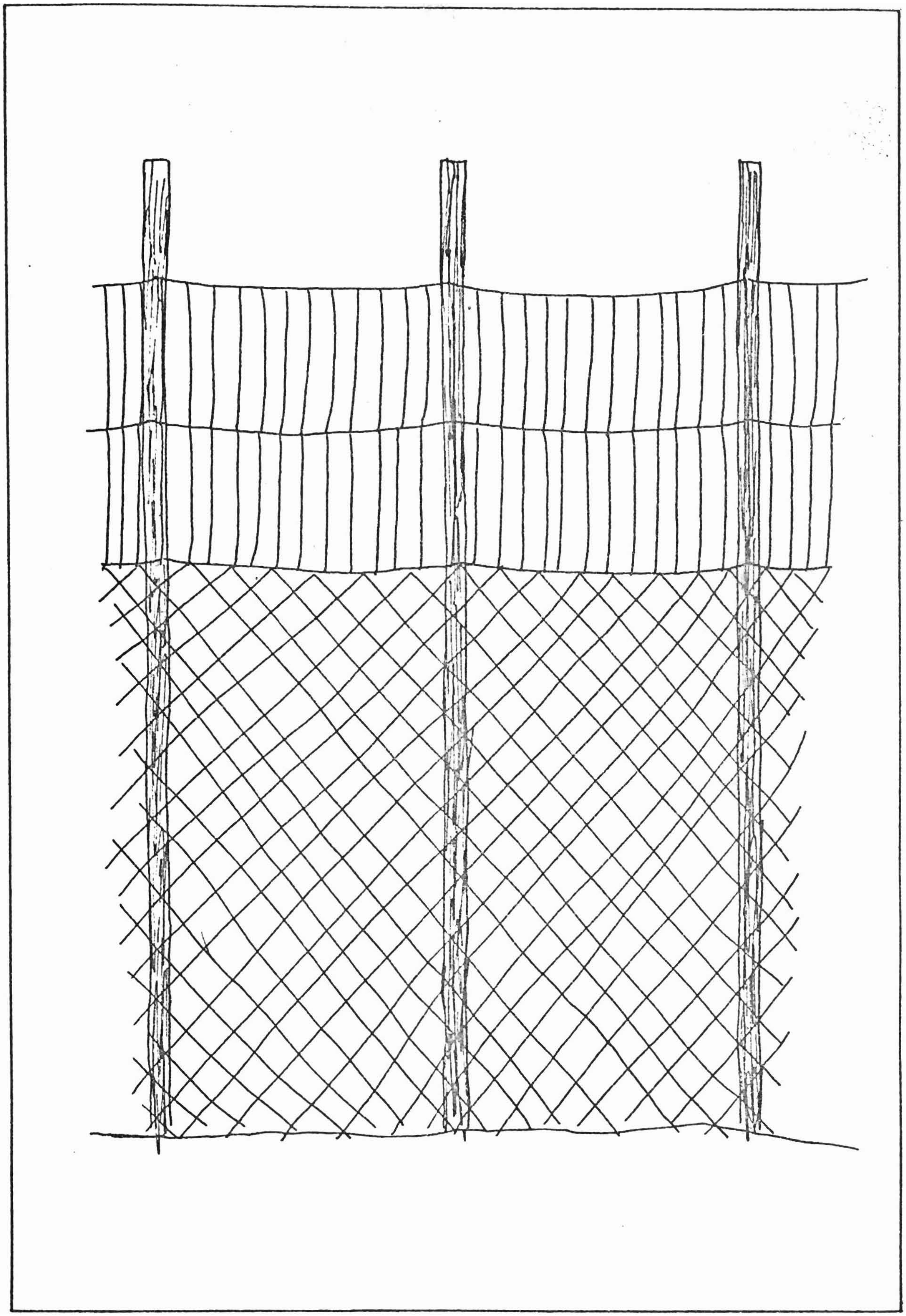


Figure 8

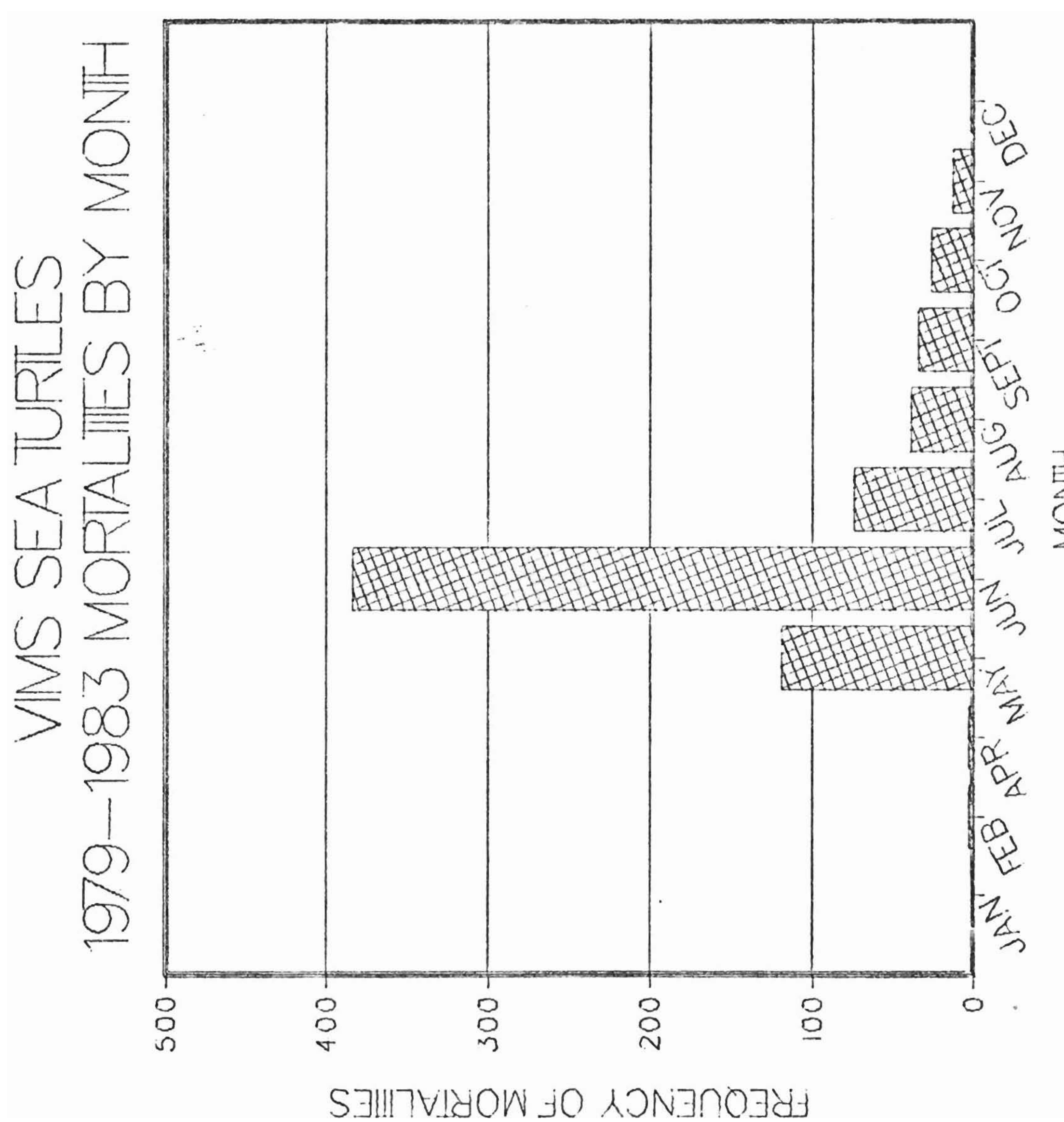
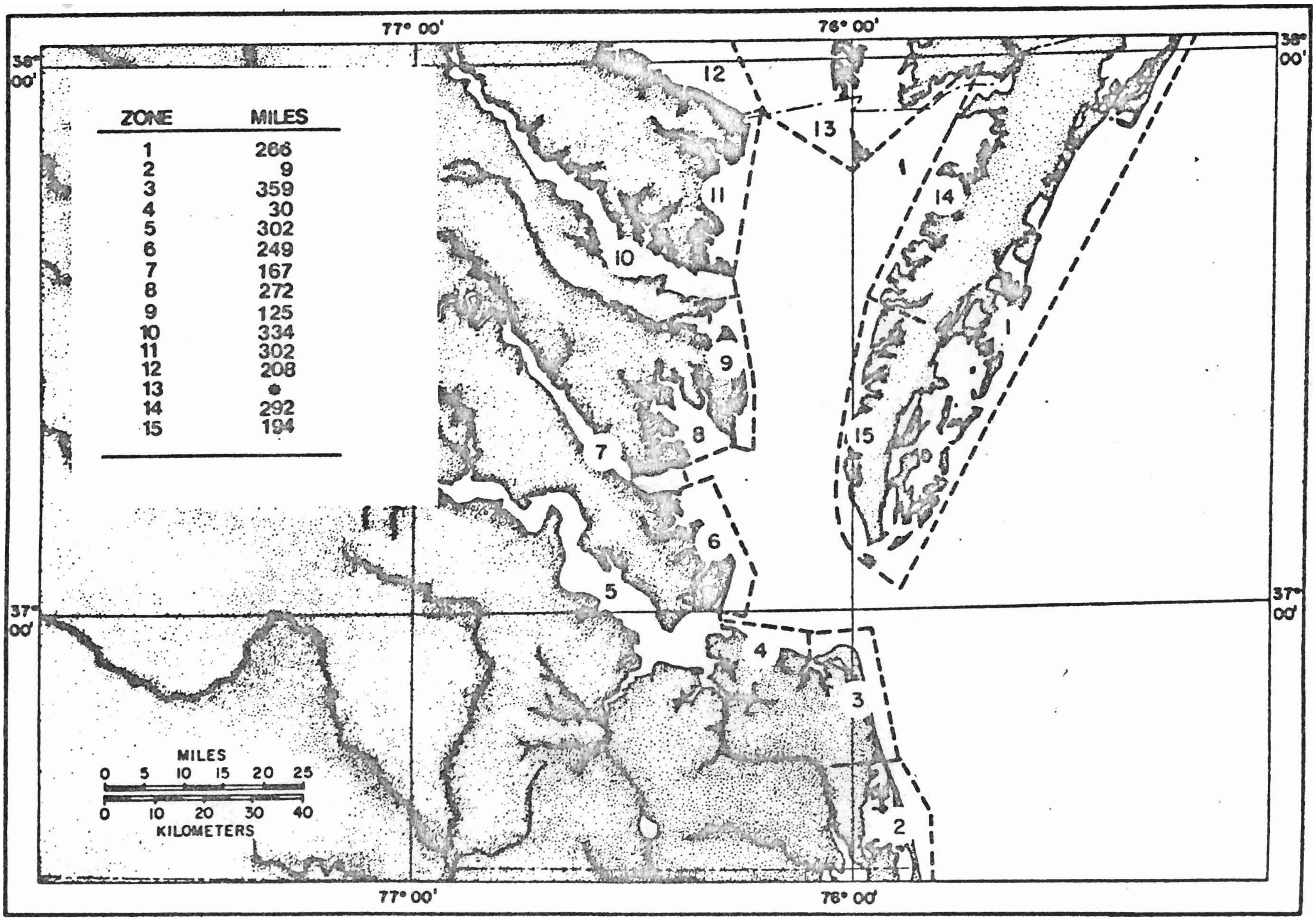

VIMS SEA TURTLES
1979—1983 MORTALITIES BY MONTH
FREQUENCY OF MORTALITIES
500
400
300
200
100
0
JAN
FEB
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
MONTH

Figure 9

CHESAPEAKE BAY STRANDING ZONES



Figu 10

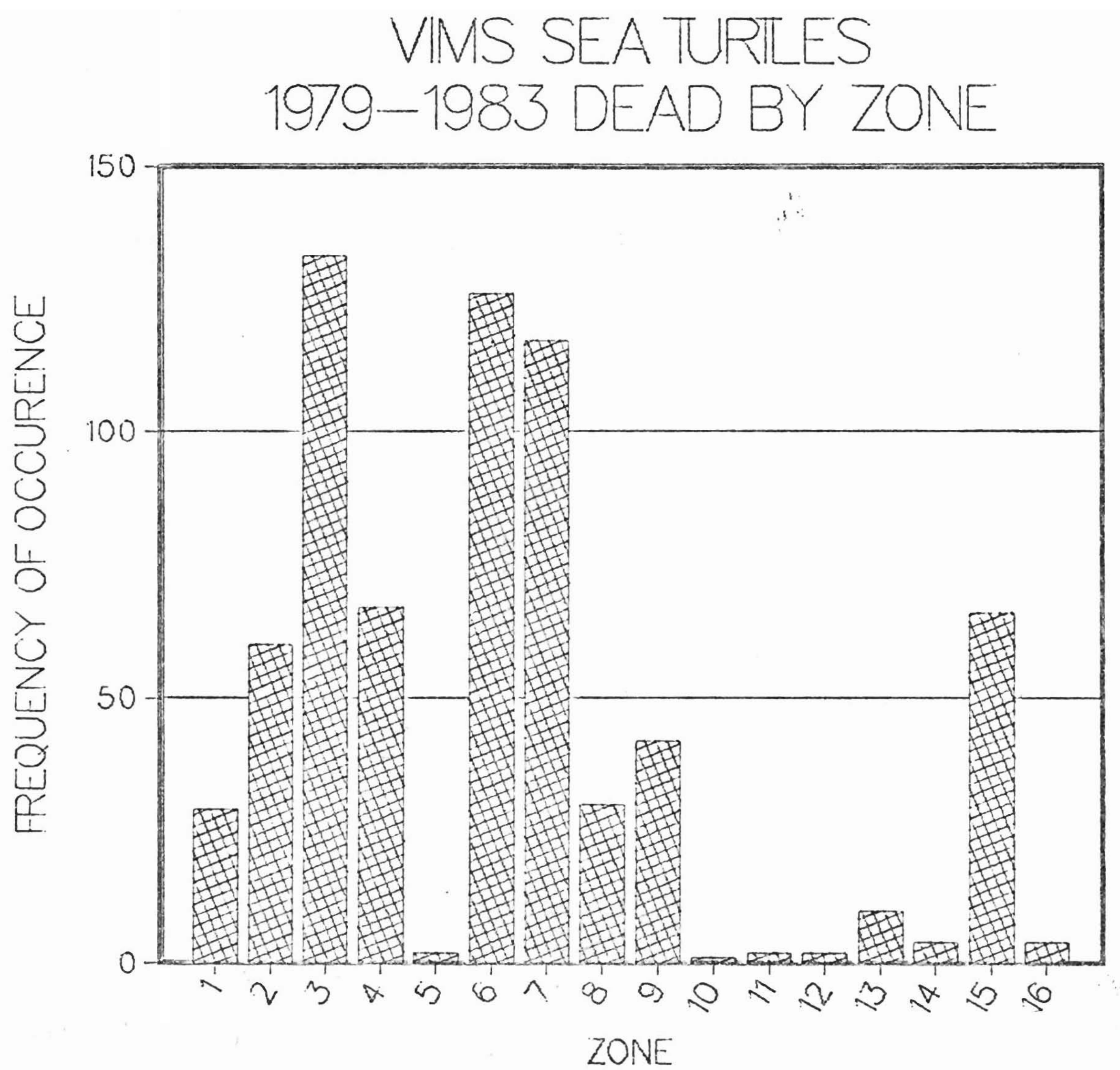

VIMS SEA TURTLES
1979—1983 DEAD BY ZONE
150
100
50
0
FREQUENCY OF OCCURENCE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
ZONE

Figure 11

Anonymous, 1992. Interactions between sea turtles and the summer flounder trawl fishery, November, 1991 - February, 1992. U.S. Dep. Commer. NOAA Technical Memorandum NMFS-SEFSC-307, 58 p.

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Burke, V.J., E.A. Standora and S.J. Morreale. 1989. Environmental factors and seasonal occurrence of sea turtles in Long island, New York. In: Eckert, S.A., K.L. Eckert and T.H. Richardson (Compilers). 1989. Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Technical Memorandum NMFS-SEFC-232, pp 21-23.

Burke, V.J., S.J. Morreale and E.A. Standora. 1990(a). Comparisons of Diet and Growth of Kemp's ridley and loggerhead turtles from the northeastern U.S. In: Richardson, T.H., J.I. Richardson, and M.Donnelly (Compilers). 1990. Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFC-278. p 135

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Turtles - McKenzie

Appendix A

Nesting of Loggerhead Sea Turtles, *Caretta caretta*, in Virginia

Final Report Submitted to
the Environmental Protection Agency
and the City of Danville, Virginia

By

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1 May 1981

INTRODUCTION

In May of 1980, we initiated a project to evaluate the nesting use of Virginia's Atlantic coastal beaches by the loggerhead sea turtle, *Caretta caretta*.

The loggerhead is considered an endangered species by the Commonwealth of Virginia and the species is on the federal threatened list.

Funds for the study were provided by a fellowship stipend from the City of Danville, Virginia through the Environmental Protection Agency.

The loggerhead is the most common nesting marine turtle in the United States and the southeast coast is one of only four major loggerhead nesting areas remaining in the world (L.M. Ehrhart, personal communication). The species is the most commonly occurring sea turtle of the four species that enter Virginia's nearshore waters and the Chesapeake Bay during warm weather. The Chesapeake Bay and adjacent marine waters serve as a major summer feeding area for subadult loggerheads (M. Lutcavage, unpublished Master's Thesis, VIMS, 1981).

Carr (1952, p. 390) described the U.S. breeding range of *Caretta* as the southern coast and "formerly from Virginia to Florida and the Gulf states" and Ernst & Barbour (1972, p. 233) state that although it formerly nested in Virginia, today's breeding range "probably is restricted to points south of Cape Lookout, North Carolina." However, on several occasions nesting by loggerheads has been reported on the beaches of the Barrier Islands of the Delmarva Peninsula and on or near the Back Bay National Wildlife Refuge (NWR). In spite of the paucity of verified records (see Appendix I), we believed the actual incidence of nesting might be much greater due to several factors enumerated below.

1. Nearly all of Virginia's Barrier Islands are uninhabited with extremely limited access. The majority of the Barrier coast is under stewardship of the Nature Conservancy which intends the perpetual preservation of the ecosystem (Hennessey, 1976), controls access to the islands, and patrols only infrequently to keep unauthorized persons off the lands, all of which are only accessible by boat. Recent and current nesting may not have been observed and therefore could not be reported.

2. The Back Bay NWR is also remote and uninhabited and not regularily patrolled by Fish and Wildlife Personnel. Although there is more public access to this section of beach, unnoticed or unreported nesting may have occurred.

3. Concentrations of adult sized loggerheads are found in Virginia's coastal waters during summer months. They are particularily abundant in the tidal channels and other waters around the Barrier Islands. Caldwell, Carr and Ogren (1959) note that male and female loggerheads congregate for mating near a nesting beach during the reproductive season and the

reports of adult size sea turtles in our area may be circumstantial evidence that suggests nesting activities.

4. In 1969, the U.S. Fish and Wildlife Service initiated a program of transplanting *Caretta* eggs from nests laid at the Cape Romain (South Carolina) NWR to Chincoteague, Back Bay and Pea Island NWR's. According to Rick Poetter, assistant manager of the Back Bay NWR, from 1969 through 1979 over 14,500 hatchlings were released on North Carolina's and Virginia's beaches. The purpose of the transplantation program was to attempt a northward extension of the breeding range of the Atlantic loggerhead to coastal NWR's in Virginia and North Carolina where nesting colonies could be "reestablished" on protected beaches (unpublished U.S.F.W.S. Progress Report No. 11, October 31, 1979).

As the survivors of these efforts reached maturity, it was assumed they would return to beaches where they first crawled into the ocean as hatchlings and lay their eggs.

DESCRIPTION OF STUDY AREA

1. The Eastern Shore

The Eastern Shore of Virginia is the southernmost portion of the Delmarva Peninsula bounded on the north by the State of Maryland, on the west and south by the Chesapeake Bay and on the east by the Atlantic Ocean. Low barrier islands backed by extensive tidal marshlands and lagoon systems separate the mainland of the Peninsula from the Atlantic Ocean. The thirteen islands which compose the outermost barrier system are interrupted by twelve major tidal inlets (see Map 1).

Unbroken island coastal lengths range from approximately 2.7 kilometers for Myrtle Island to approximately 13 kilometers for Parramore Island. The total length of Atlantic shoreline composed by Virginia's Barrier Islands is approximately 82 kilometers.

These barrier Islands vary from low sand overwash areas and eroding old marshlands to well defined sandy beaches backed by stable dune ridges and maritime forests. All of the islands grade into extensive tidal marshes and upland islands to the west.

The generally narrow beaches consist of fine to coarse siliceous and carbonate sands with varying amounts of shell fragments. They range from well sorted to not well sorted sands. Hennessey (1976) describes the higher and older frontal dunes as excessively drained soils of the Newhan series (fine sand) vegetated by herbaceous plants interspaced with open areas of slight vegetation marked by blowing sand. Typically behind the frontal dunes, flatter areas of Corolla fine sands, Corolla fine sand overwashes or complexes of soil types are found. These soils support a wide variety of herbaceous and woody plants.

This is a high energy shoreline with erosion and sand transport altering the island beach configuration markedly from year to year and season to season.

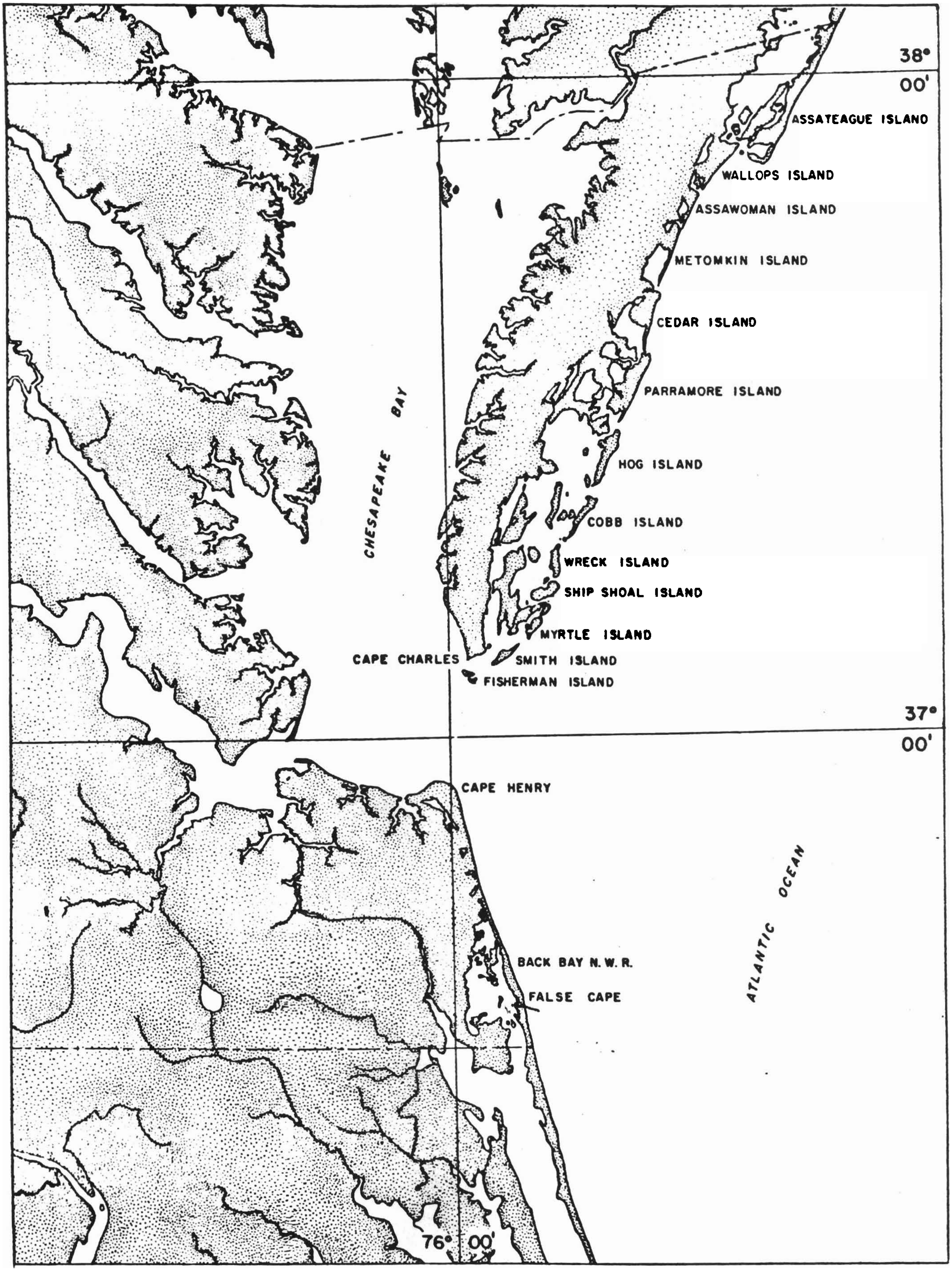
2. Cape Henry and South

South of the Chesapeake Bay mouth, Virginia's 43 kilometer Atlantic coast is typically a low barrier beach in the southern half; bounded by the North Carolina state line to the south and Back Bay waters and marshes (a northward continuation of Currituck Sound) to the west. The northern half of the region is low mainland beach bounded by the Bay mouth at Cape Henry.

The beach south of the Bay mouth is wider, more stable and has a higher, continuous dune with fewer overwash areas than the Eastern Shore beaches. The extensively developed Virginia Beach area has a serious erosion problem that requires tons of sand be trucked in to replace sand lost to erosion.

Soil, sand, and beach types are similar to those of the Barrier Islands described in 1. above.

Map 1


38°
00'
ASSATEAGUE ISLAND
WALLOPS ISLAND
ASSAWOMAN ISLAND
METOMKIN ISLAND
CEDAR ISLAND
PARRAMORE ISLAND
CHESAPEAKE BAY
HOG ISLAND
COBB ISLAND
WRECK ISLAND
SHIP SHOAL ISLAND
MYRTLE ISLAND
CAPE CHARLES
SMITH ISLAND
FISHERMAN ISLAND
37°
00'
CAPE HENRY
ATLANTIC OCEAN
BACK BAY N. W. R.
FALSE CAPE
76° 00'

MATERIALS AND METHODS

The survey of the suitable Virginia nesting beaches was made weekly by aircraft flying at 45 to 90 meters in altitude except in areas of human activity where a 150 meter minimum distance was maintained. Air speed was kept as low as conditions and safety permitted--generally around 75 knots. One observer and the pilot were the minimum crew with added observers when possible to aid in overwater and coastal nearshore sightings of waterborn turtles.

The VIMS aircraft, a single-engined, high-winged de Haviland Beaver was used for most of the flights. The plane is designed as a military observer craft and is ideally suited for low-level aerial surveys. Due to budgetary and availability problems, various Cessna 150 and 170 class planes were rented for some of the earlier flights.

The methodology followed guide lines established in planning meetings held by the National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (FWS) and the sea turtle recovery team. The purpose of the meetings was to discuss and plan aerial survey methodology, techniques and details for the 1980 nesting season in the Southeastern U.S. Methods outlined in a NMFS, SE Fisheries Center, February 5, 1980 memo by Fred Berry and Nancy Thompson were adopted and used by sea turtle researchers in the SE Region. The basic methods outlined in the above memo were utilized in the present study.

The Virginia coast from Chincoteague Island to False Cape was examined at weekly intervals from 15 May 1980 to 19 August 1980 for a total of fifteen flights.

RESULTS

1. Sea Turtle Observations

No turtle tracks that resulted in a nest were observed during the weekly flights. One non-nesting track was noted on south Parramore Island, the 24th of May, flight Number 2. This was a small (approximately 50 cm wide), wandering track.

One documented loggerhead nesting occurred which was witnessed by the public on a heavily used portion of Sandbridge Beach on the night of the 25th of July. The tracks were immediately obliterated by curious onlookers. US FWS employees from Back Bay NWR carefully exhumed the nest within 12 hours of deposition and reburied the 104 eggs in two nearly equal numerical parts side by side in a protected area of the refuge beach for incubation. The clutch was split in order to use protective wire enclosures already in hand. Ninety eggs hatched out on 29 September and 1 October, 1980 for an extremely good hatch of 86.5%.

Live, waterborn sea turtles were seen on seven of the survey flights and are listed in Table 1. Many live specimens were probably missed as a result of closely monitoring the beach and not the adjacent waters. The stranded, dead turtles observed on the beaches are recorded in Table II.

2. Ancillary Observations

On 9 June a saddleback dolphin, *Delphinus delphis*, was observed dead on the Hog Island beach. The specimen was washed off the beach by the tide before positive identification could be made. On 7 July, an adult dwarf sperm whale *Kogia simus* was observed and examined on a sandbar in Chincoteague Inlet. Identification was later confirmed by the Smithsonian Institute.

Table I

Live Waterborn Loggerheads - 1980

Date	Location	Comments
9 June	N. Bay Bridge Tunnel	2, heading into Bay
	Bay - Wolftrap Light	1, heading north
	Bay - New Point Comfort	1 < 25 cm, heading NNE
17 June	Kitty Hawk Pier, N.C.	1 heading north
	Dam Neck area	3 heading north
	Rudee Inlet (offshore)	1, heading north
1 July	Currituck Co., N.C.	1, heading north
	Bay - 3km SE of Grandview	1, heading UpBay
7 July	Bay - SW of Fisherman's Island	2, 40-50cm, heading UpBay
	1.6km E of Trestle "B" CBBT	1, direction not noted
	Corrolla Lighthouse, N.C. 300m offshore	1 large, heading north
	" " " " " " "	1 60-75cm, heading offshore
	N.C. State Line, 300m offshore	1 large, not active
	3km N of Cape Henry and 1.5km E of Thimble Shoals Channel	1, heading towards Bay
	Just W of Trestle "B" CBBT	1 ~ 75cm, heading north
	Bay - 10km NW Tunnel CBBT	1 ~ 60cm, heading east
	Bay - <1km E of Grandview	1 ~ 45cm, heading UpBay
15 July	0.5km S of Fisherman's Island	1 large, heading south
1 Aug.	Currituck Co., N.C., >1.5km offshore	4, direction not noted
5 Aug.	Bay - 3km NW of Tunnel CBBT	1, direction not noted
19 Aug.	Wachapreague Inlet	1, heading east

(CBBT = Chesapeake Bay Bridge Tunnel)

Table II

Stranded Dead Loggerheads - 1980

Date	Location	Comments*
24 May	Fisherman's Island	1 bloated
30 May	Cobb Island	1 large Loggerhead
	N. Hog Island	1 small Loggerhead
9 June	Currituck Co., N.C.	2 Loggerheads, near Lighthouse
	Back Bay NWR	1 Loggerhead
	Cape Henry	1 at Lighthouse
	Fisherman's Island	2
	Ship Shoal Island	1 old, belly-up
	Hog Island	1 old loggerhead
	Parramore Island	1 buried by sand
12 June	Currituck Co., N.C.	1
17 June	N. Hog Island	1
	False Cape	1 Loggerhead
	N.C. border	1 large, belly-up
	Rudee Inlet	2 Loggerheads
24 June	Currituck Co., N.C.	1
7 July	Chincoteague Inlet	1 Loggerhead, rear crushed, 1.2 m, on sandbar
	Wallops Island	1 Loggerhead ~ 1 m

*Positive identifications are noted as "Loggerheads".

DISCUSSION

Sea turtles exhibit an ecological strategy seen in many migratory animals--that of returning to a favorable area to reproduce. Carr (1967a) and most sea turtle researchers suspect that reproductive females return to the beach where they were hatched (natal beach) in order to lay eggs. Philopatry (in this case the seasonal return to the same beach) in sea turtles is known in green turtles (Carr and Carr 1972, Carr 1975, Carr, Carr and Meylan 1978), ridleys (Márquez, et al. 1976, Zwinenberg 1977), leatherbacks (Pritchard 1976) and loggerheads (Hughes 1974, Ehrhart 1980).

Fitch and Fitch (1967) contend the egg stage in oviparous reptiles is the least tolerant to variations in environmental conditions. Therefore, the location of loggerhead nesting beaches is seemingly dictated by proper environmental conditions for adequate nesting and the subsequent successful incubation and hatch of the eggs. However, the hatchlings also must survive to maturity and reproduce viable offspring in order to perpetuate the species. The homing instinct serves as a mechanism to return the turtles to a beach that already has proved to be a successful incubation and hatching environment. This behavior has evolved in part because sea turtles have parental care investments in their offspring limited only to a temporal and spatial selection of nesting areas.

Environmental conditions on many of Virginia's beaches should be suitable for the successful nesting and hatching of loggerhead turtles:

1. The isolation and lack of human activity of the majority of Virginia's coastline would be beneficial for maintenance of a chelonery (sea turtle "rookery"; after Hirth 1980). Loggerheads pause often and look around when crawling from the surf to elevated sections of the beach to lay their eggs. During this time lights, sudden blocking of the moonlight or starlight and close-by movement can cause the turtle to return to the sea without nesting.

Lights in developed areas not only disturb the adult females but also affect the sea finding sense of hatchlings. In their crucial first hours of freedom, the principal mechanism of orientation is based on a positive phototaxis which will lead them toward the sea with its lighter horizon (Mrosovsky 1978). A case was described by Philibosian (1976) where hatchling hawksbill turtles wandered onto a brightly lit baseball field attracted by the flood lights. Mortimer (1979) reported the charred bodies of 500 hatchlings in an unattended bonfire on Ascension Island and another 100 that were crushed when attracted to a brightly lit hut where a dance was in progress. Hatchlings lured from a direct run to the sea by house or street lights could suffer higher mortality due to predation and desiccation, thereby reducing the viability of the colony.

2. The beach types of the Eastern Shore and the Back Bay NWR area are quite similar to types found in the major loggerhead cheloneries in Florida, Georgia and South Carolina

(see description of study area). Caldwell (1959) stated that aerial reconnaissance of beaches from the Atlantic Coast of Florida to North Carolina indicated that nesting turtles preferred beaches backed by high dunes or vegetation. He also found that loggerheads nesting in Cape Romain, South Carolina preferred 25 to 40 foot wide, sloping beach with a continuous outer dune. The shoreline of Virginia south of Sandbridge nearly always match these criteria and most of the large Barrier Islands have major sections fitting these criteria.

Sandy beaches are necessary for the excavation of the nest cavity. Stancyk and Ross in 1978 reported results of an attempt to correlate the amount of nesting activity of green turtles to sand characteristics on various beaches at Ascension Island. They felt they had encompassed the complete range of beach types and found the only significant reduction in nesting occurred in areas of human disturbance. Since the sand types from Virginia to Florida are much the same, differing mainly in organic content in certain areas, we feel this parameter is not detrimental to nesting in Virginia. The evidence of successful nesting presented in Number 4 below supports this conclusion.

3. Temperature is probably the most important factor limiting the ranges of reptiles. Thermal tolerance has been correlated with geographic distribution of many reptiles (e.g. Fitch 1964, Fitch and Fitch 1967, Bustard 1969, Vinegar 1973). Licht and Moberly (1965) proposed that effects on embryonic

development by temperature ranges other than optimal were factors influencing the distribution of lizards. Poikilothermous reptiles need to insure their eggs are in areas with temperatures most conductive for metabolism during incubation. The enzymes controlling metabolism and development will function best at optimum temperatures which are externally defined for these ectotherms.

Temperatures for suitable Virginia beaches have not been sampled at the depth of sand that a natural nest would be found. Temperatures have been monitored in natural and artificially incubated loggerhead nests in Florida (McGehee, unpublished Master's Thesis, Univ. of Central Fla., 1979). The average sand temperature at nest depth on the beach one meter lateral to a nest was 27.8°C with a range from 27° to 29°C. An optimal temperature of 27°C was found for eggs incubated artificially at 20°, 24°, 27°, 30°, 32°, 35° and 38°C. Although we have no temperatures to compare directly, our contention is that the temperatures on Virginia's beaches are sufficient to hatch loggerhead nests as evidenced by the successful nest described in Number 4 below.

4. Primary evidence that Virginia's shores can adequately produce healthy hatchlings is shown by the one nest that was encountered this summer, transplanted to Back Bay NWR and successfully incubated and hatched under nearly natural conditions. Hatchling appearance occurred after 66 and 68 days of incubation.

Of the 104 eggs laid and then transplanted, 90 hatchlings were produced yielding a hatching success of 86.5%.

Caldwell (1959) tells of lengths of incubation for loggerhead eggs in natural nests at Cape Romain, S.C. from 49 to 62 days. Blanck and Sawyer (1981) state the mean incubation time for transplanted loggerhead nests at Ossabaw Island, GA. is 60 $\pm$ 10.2 days. The incubation time of 66-68 days for the Back Bay nest is near the natural time and within the range of observations of transplanted nests. The good hatching percentage achieved in this nest shows us that turtle eggs can get the balance of environmental conditions necessary for success on a Virginia beach.

In lieu of the evidence in favor of loggerhead nesting in Virginia, why isn't there an established chelonery here? Possibilities are the production of male-only clutches under minimum acceptable incubation temperatures, the lack of suitable refugia for the hatchling turtles when they leave the beaches, and the race against falling autumn temperatures during the first few months of life of the hatchlings.

Incubation temperature is known to affect the sex ratio of fresh water turtles (Pieau 1971, Yntema 1979) and *Caretta caretta* (Yntema and Mrosovsky 1979). The last authors found that eggs incubated 26° and 28°C produced all males, 30°C temperatures yielded an approximate 50-50 sex ratio and 32° and 34°C incubation gave all females. These findings resulted from laboratory incubation at controlled and even temperatures.

Temperatures under field conditions are neither controlled nor even, fluctuating slightly with diurnal period (although remarkably constant) and even more with climatic changes over the incubation period. The effects on sex ratio by fluctuating temperatures in natural nests or possible synergistic effects of temperature and other environmental parameters during incubation have not yet been elucidated. Nonetheless, cooler temperatures here at the northern end of the breeding range could be producing clutches of predominately male hatchlings and few or no females to return at maturity and lay their eggs on these shores.

When sea turtle hatchlings leave the nest and swim out to sea, they must run a gamut of predators including ghost crabs, sea gulls, pelagic birds, sharks, and many predatory fishes. For neonate loggerheads, the first year is spent at or near the surface. They have virtually no buoyancy control the first month and tend to pop up like corks when they dive according to Milsom (1975). He noted the ability to dive developed rapidly but at two to four months they had only limited control of buoyancy and full control did not develop until around eleven months of age. Presumably, the early diving ability is adaptive for both aerial predator avoidance and feeding while the neonates are "confined" to the surface.

Hatchlings have shown what has become known as "swimming-frenzy" (Carr 1967a); once they enter the water, hatchlings swim continuously for at least 24 hours (Frick 1976). Carr (1967b) says it is not known when some other navigation process may replace the tendency to swim away from the beach. He also notes that food and shelter will only be found in *Sargassum* rafts or debris during this pelagic phase. The *Sargassum* community is diverse and rich (Weis 1968, Fine 1970) in food items available to neonate sea turtles. Hatchling sea turtles have been reported in association with *Sargassum* rafts by Carr 1967a, Smith 1968, Caldwell 1969, and Witham 1974. Frick (1976) followed green turtle hatchlings from the beach and found that they tended to move directly from shore keeping on a straight course even when out of sight of land. Two of the samples she tracked encountered *Sargassum* and stopped to rest or explore. She suggested "the fundamental adaptive reason for the juvenile travel-drive may be, as has been suggested (by Carr, 1967 a&b), to reach longshore currents in which *Sargassum* rafts serve as a refuge and feeding place." Loggerhead hatchlings were tracked by Fletemeyer (1978) and found to stop in floating *Sargassum*. Four day old loggerheads he released near a weedline swam directly to the rafts and did not leave them during two hours of observation. Carr and Meylan (1980) found three green turtle hatchlings in only ten minutes of observation in well consolidated *Sargassum* rafts in a shear line 40 km off the coast of Panama. Carr states "the more or less consolidated alignment of rafts along inshore shears increased the probability that a hatchling will find refuge in the weed."

A problem for sea turtle hatchlings leaving Virginia's beaches is that there are no well developed rafts of *Sargassum* nearshore and the consolidation of such rafts along inshore shears is nonexistent. Other than occasional windblown patches and spotty, widely dispersed small clumps in the summer, *Sargassum* is not found off the coast of Virginia except near and in the Gulf Stream. Although the shortest route to the Gulf Stream from Virginia is southwesterly and is approximately 160 km from the southern border, the average position of the inner margin of the Stream is approximately 220 km due east of southern Virginia and 370 km due east in the north (Harrison et al. 1967). A hatchling would have a great distance of open ocean to cover before reaching suitable shelter and the longer he is thus exposed, the more likely he would fall to a predator.

Water temperatures just off Virginia fall from summer highs of 26°C or 27°C in August to below 20°C by mid-October, 15°C by November and below 10°C in winter. Declining air temperatures are much colder than water temperatures during the fall. Hatchlings that did encounter suitable *Sargassum* refugia drifting in the mid-Atlantic Bight would find shelter from predators but would be trapped by falling temperatures. Exposed portions of floating *Sargassum* die in air temperatures below 18°C, causing the plant mass to rotate with the heavier dead portions assuming deeper positions in the water and thus exposing living portions to the air (Parr, 1939). The cycle continues until sufficient quantities of the plant have succumbed to overcome the buoyancy of the living portions and the mass then sinks. This then would leave hatchling sea turtles associated with the *Sargassum* refugeless and exposed to predators and water temperatures rapidly dropping to levels that will immobilize the turtles and eventually kill them (Schwartz, 1978).

CONCLUSIONS

Loggerhead sea turtles are a regular and common component of Virginia's migratory fauna. Although conditions exist that can support successful nesting on the coast, the surveys have shown there is no major nesting activity on our beaches. Occasional nesting occurs but we are beyond the periphery of the normal breeding range. We conclude that this may be due to a combination of less than optimal temperatures during and after incubation and the lack of suitable refugia for neonatal hatchling protection.

SUMMARY

Loggerheads are common in Virginia's waters in the summers and occasional nests have been reported. Aerial examinations of suitable nesting beaches from May to August, 1981 revealed no nests made by sea turtles. Although loggerheads nest further north than any other sea turtle species, Virginia apparently is beyond the normal breeding range.

Evidence favorable for successful nesting in Virginia are:

1. The isolation and lack of human activity on the majority of the State's coastline;
2. Beach profiles and sand types similar to those found on beaches of the major cheloneries in the southeastern U.S.;
3. Temperatures favorable for successful incubation and hatching;
4. Evidence of a very successful nest at the Back Bay NWR which produced 90 hatchlings from 104 eggs buried.

Probable reasons that a chelonery has not become established here are:

1. Possible production of predominantly male hatchlings by less than optimal incubation temperatures;
2. The lack of suitable refugia (*Sargassum*) for neonate turtles in Virginia's nearshore and offshore waters;

3. Temperatures in the fall and early winter that can kill any *Sargassum* and hatchlings occuring in the mid-Atlantic Bight.

Virginia does not have a nesting population and those loggerheads nesting here should be considered extra-limital to the breeding range.

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APPENDIX I

Historical Nesting Records

Records of Sea Turtle Nesting Activities

for the Virginia Atlantic Coast

I. Cape Henry and South

20 June 1970 - A nest of 132 loggerhead eggs was found at the south ramp of Back Bay NWR. The female turtle was estimated to weigh 400 pounds.

30 June 1970 - A nest of 87 loggerhead eggs was found at Sandbridge and transferred to Back Bay NWR. No hatching occurred.

June 1971 - Two loggerheads came ashore at Back Bay NWR but returned without nesting.

10 July 1971 - A loggerhead estimated at 250 pounds came ashore to nest but was scared off by vehicle headlights before completing the egg chamber.

26 July 1971 - A loggerhead was seen nesting at Virginia Beach. A clutch of 119 was transferred to Back Bay NWR. When no signs of hatching were seen, the nest was exhumed and all the eggs had been stolen.

15 August 1971 - A sea turtle estimated at 400 pounds came ashore, crawled to the dune line but was scared by a bystander with a flashlight and returned without nesting.

24 August 1972 - One loggerhead nest was examined south of Back Bay NWR (J. A. Musick, unpublished data).

11 August 1973 - A dead loggerhead hatchling was found at Sandbridge by a VIMS scientist (VIMS museum # RKD-37).

ca. 1 July 1979 - Turtle tracks were encountered at Back Bay NWR that did not result in a nest.

21 July 1979 - A nest of 131 loggerhead eggs 1 mile north of the southern Back Bay NWR boundary was exhumed and transferred to a protected location by FWS.

2 August 1979 - A nest of 147 loggerhead eggs was encountered near the southern Back Bay NWR boundary, exhumed and transferred to a protected location.

Late Summer, 1979 - A track was discovered in Sandbridge that did not result in a nest. Exact location and date not recorded.

25 July 1980 - A nest of 104 loggerhead eggs was exhumed and transferred from Sandbridge to Back Bay NWR.

II. Eastern Shore

Early 1920-'s - Recollections made by Granville Hogg, a Smith Island resident, of turtles as large as three feet in length that crawled out of the ocean in the summer to lay eggs on the beach. He also saw hatchlings crawl to the sea.

21 July 1974 - Nest at S. tip Assateague I. 115 eggs moved - all developed but died before pipping the eggs.

8 May 1975 - Tracks were encountered by a Botanist and two U.S.S.C.S. soil scientists. The tracks went inland from the beach surf line. Nesting unknown.

21 June 1975 - Nest on north beach Assateague I. Left in place. Tides flooded the nest and all the eggs rotted.

21 July 1975 - Nest on north beach Assateague I. Checked 10-8, dug up 11-5. Only 8 living, 4 badly deformed.

24 July 1975 - 3 crawls reported on Wallops I. nesting not known.

22 April 1976 - Virginia Marine Resources Commission pilot Jeff Walker noticed turtle tracks from the air on the Barrier Islands. Tracks weren't confirmed by foot.

29 July 1977 - Nest @ S. tip Assateague I moved to hatchery. Cool rains in August. Moved 110 inside (34 bad). Hatched 83 under 150 w bulb.

18 June 1979 - A loggerhead nest was discovered on North Parramore near Coast Guard Station. It is thought to have been dug up by predators later.

June 1979 - False crawl @ MD-VA line.

~ July 1979 - Nest at Wallops I. High tides inundated. Moved 2 days later 129 eggs - no hatch.

Appendix B

Hydrocarbon Analysis of Sea Turtles

1983

Sarah Bellmund

Introduction

The loggerhead (*Caretta caretta*) and the leatherback (*Dermochelys coriacia*) turtles are regular summer visitors to Virginia waters. The loggerhead is commonly found foraging in the Chesapeake Bay and Virginia coastal waters during summer months (Lutcavage,1981). The leatherback turtle feeds near the Bay mouth and is seen in Virginia coastal waters during the summer. Migration patterns for leatherbacks along the Mid-Atlantic coasts are not known.

Polychlorinated hydrocarbons, polychlorinated biphenyls (PCBs), and polynuclear aromatic hydrocarbons (PAHs) have been reported from sea turtles (Thompson *et al*.,1974; McKim and Johnson,1983; and Hall *et al*.,1983). Thompson *et al*. (1974) reported PCBs and p,p' DDE from South Atlantic green (*Chelonia mydas*) turtle eggs. PCBs were reported from postyearling loggerhead and green turtles found along the east coast of Florida (McKim and Johnson,1983). Petroleum hydrocarbons, consisting of normal chain hydrocarbons and PAHs, were found in loggerhead (*C. caretta*) and Kemps ridley (*Lepidochelys kempi*) sea turtles stranded in Laguna Madre and believed to have been affected by the IXTOC I oil spill in the Gulf of Mexico (Hall *et al*., 1983). Aromatic hydrocarbons, PAHs, chlorinated pesticides, and a large combination of PCBs are well documented in Chesapeake Bay sediments and benthic biota (Bieri *et al*.,1981).

Exposure of sea turtles to hydrocarbons occurs through habitat exposure and ingestion while feeding. The loggerhead feeds extensively on benthic arthropods found in the Bay. The primary food of the loggerhead is the horseshoe crab (Limulus polyphemus), however they are also known to feed on the blue crab (Callinectes sapidus), the spider crabs (Libinia sp.), and the cancer crabs (Cancer sp.) (Lutcavage, 1982). The blue crab concentrates a variety of hydrocarbons including pesticides, PAHs, and PCBs (Hale,1983). Typical hydrocarbon pollutants found in sediments have also been reported in the horseshoe crab (Smith et al.,1979). The presence of hydrocarbon pollutants in the habitat and food of the loggerhead should lead to measurable accumulation within tissues.

The leatherback feeds primarily in the water column on the jellyfish and other coelenterates found there (Pritchard, 1967). Its habitat and feeding behavior should result in less exposure to hydrocarbon pollutants than occurs in the benthic feeding loggerhead. This study was initiated to investigate the possibility of sea turtles ingesting and retaining pollutants found in Chesapeake Bay.

METHODS AND MATERIALS

Sample collection

Samples of liver and fat from three stranded dead loggerheads and one leatherback (Table 1) were removed with solvent washed instruments. Each sample was then placed in a solvent washed jar or wrapped in solvent rinsed aluminum foil. Samples were frozen until preparation for extraction.

Sample preparation

Samples were thawed, chopped, and homogenized. The samples were then poured into solvent-washed stainless steel trays and freeze dried. After freeze drying, subsamples of 10.0g liver and 2.0g fat were removed after freeze drying for extraction. Liver samples were crushed and placed in glass thimbles for Soxhlet extraction. Samples were refluxed for 24 hours with methylene chloride (CH2Cl2) using a Soxhlet apparatus. A sand blank was run concurrently using the same refluxing procedures as in the liver extraction. Fat samples were incompletely dried using the freeze drying technique. Due to refluxing problems with incompletely dried samples, fat samples were extracted by mechanical dissolution in methylene chloride (CH2Cl2). The fat-methylene chloride mixture was then centrifuged to remove any undissolved connective tissue. All samples were concentrated to 6-12ml using rotary evaporation, after extraction.

Sample clean-up

Samples were taken after rotary evaporation and injected on a gel permeation column (GPC; Autoprep Model 1001; Analytical Bio Chemistry Laboratories, Inc.). Columns were packed with Biobead

S-X8 resin and samples were eluted with CH2Cl2. The clean up step removes large biomolecules and complex lipids though molecular exclusion from the column packing beads. Each sample was subsequently injected into a 5.4ml injection loop. Samples were collected from the GPC in two fractions, G1 (0-130ml) contained large biomolecules and was later discarded, G2 (130-220ml) contained hydrocarbons, PCBs, PAHs, and some biogenic compounds.

All G2 fractions were concentrated using rotary evaporation, transfered with CH2Cl2 rinses to volumetric test tubes, and concentrated to 0.2ml under a gentle nitrogen (N2) stream in a warm water bath. These samples were examined using gas chromatography and found to contain a large amount of interfering biogenic material. Silica gel chromatography was employed as a second clean-up step to remove the interfering compounds. Silica gel was slurried in hexane and packed in a 1.0cm diameter column to a height of 17.5cm and overlayed with 1cm solvent extracted sand. The column was washed with ~20ml hexane and drained to the top of the bed. The samples were increased to 1.0ml in hexane and added to the top of the column. Three solvents were used to elute three fractions. These fractions were; F1 (20ml of hexane) containing aliphatic hydrocarbons, F2 (30ml of 80:20 hexane:CH2Cl2) containing aromatics and major pollutants, and F3 (30ml methanol) containing polar compounds and lipids. All fractions were examined for the presence of pollutants using gas capillary chromatography. Fraction 2, containing the major pollutants, was examined in further detail using gas capillary chromatography and mass spectral analysis.

Gas Chromatographic Analysis

Gas chromatography performed on all samples used either a Varian 3700 or modified Varian 2740 gas chromatograph. Instruments were equipped with approximately 27m glass capillary columns constructed at VIMS, deactivated with silanol groups,and coated with SE-52 according to the method of Grob and Grob (1979) and Godefroot et al. (1980). The carrier gas used was helium at a flow of 3ml/minute. Temperature programing extended from 75C to 300C at 6C/minute. Detection was by flame ionization (FID). Injections were made in the splitless mode and the splitter was opened after the solvent front passed through the column. The temperature programming was started at this point. Samples were co-injected with 20ng of 1,1 Binapthyl as an internal standard. Data was recorded and analysed using a Hewlett Packard 3354B data system.

Gas Chromatography-Mass Spectrometry (GC-MS)

GC-MS was used for identification of compound peaks after the methods of Bieri et al. (1982). The GC-MS system used consisted of a Varian 2700 GC, with a capillary column coupled to the mass spectrometer. The mass spectrometer was a DuPont 21-492B magnetic sector mass spectrometer, scanning once every 2.3 seconds with an electron ionization energy of 70 electron volts.

RESULTS

Gas chromatography and mass spectral analysis revealed low levels of polynuclear aromatic hydrocarbons (PAH) and polychlorinated biphenyls (PCB) in four of the eight samples examined. Table 2 presents total concentrations and identifiable compound concentrations for samples with concentrations above detection limits. Samples with measurable contamination exhibited unresolved envelopes characteristic of weathered hydrocarbon pollution (Bieri _et al._, 1982). Figures 1 and 2 show reconstructed chromatograms obtained from turtles 1 and 4, respectively. These samples also contained the major pyrogenic compounds found in contaminated Chesapeake Bay sediments (Bieri _et al._,1982). Major pyrogenic compounds easily separable from biogenic compounds include pyrene, chrysene, flouranthene, and phenanthene. Samples not listed in table 2 did not have detectable levels of hydrocarbons or PAHs. The detection limits were 1 part per billion (ppb) for the system used. Fat from turtle 1 was not examined in this analysis.

Total concentrations of hydrocarbons per 10.0g of liver ranged from 209.0ppb to 1193.3ppb. Only one fat sample was found to have measurable concentrations of pollutants. This sample contained a total hydrocarbon concentration of 1694.0ppb. This sample had the highest concentrations of hydrocarbons for all samples.

Mass spectral analysis was performed on samples 1a and 3b for verification of compound composition. Mass spectral analysis for qualitative verification of contaminant composition revealed high concentrations of PCBs. Mass spectrometry also confirmed the presence of the compounds listed in table 2.

DISCUSSION/CONCLUSIONS

This study was a preliminary analysis to look for the occurrence of hydrocarbon pollutants in sea turtles from Virginia waters. Samples were selected primarily for lack of decomposition. The samples chosen represent animals found both inside and outside of Chesapeake Bay. The results of the analysis seem to reflect expected concentrations derived from normal habitat exposure. The results, however, represent only a small sample size and extrapolations to larger populations should wait until a larger sample size is run.

Sample selections were limited to animals with little decomposition, stranding in the latter part of the summer of 1982 when samples were collected. Turtles 1, 2, and 3 were taken from the Virginia Beach/Back Bay coastline. Turtle 4 was radio-tracked in the York river mouth for eight days prior to its death. This turtle was originally taken in a pound net, removed to VIMS, released, and then followed via telemetry for six days before entangling and drowning in a net. Turtle 4 can be assumed to be a temporary resident in the Bay and its associated rivers. This turtle showed the highest level of total hydrocarbons per sample. Turtle 3 was removed to VIMS after washing ashore injured at Dam Neck Naval Air Station and held at VIMS until its death two months later. This turtles condition was poor and its fat reserves were severely diminished. The period it was held prior to death may have been sufficient time for depuration to occur. This turtle, which had time to depurate prior to death, showed no detectable levels of hydrocarbons in both tissues sampled. Turtle 2, the leatherback turtle, stranded dead at Back Bay National Wildlife Refuge on the Virginia coast. Animals of this species known in the Bay are small and generally rare (Lutcavage, 1981; Musick, 1979). The leatherback turtle liver was found to have a higher than expected total hydrocarbon content, however this sample contained a large amount of biogenic material which may have interfered with the analysis. Fat was not collected from turtle 1, however its liver showed the second highest hydrocarbon concentration for all samples. The prior history for turtle 1 is unknown, so, although it was found outside of the Bay, no assumptions can be made about its behavior or feeding.

Behavior and habitat preference are important factors in the exposure of sea turtles to pollutants. Feeding habits of sea turtles bring them into contact with sediments and sediment laden organisms (Lutcavage,1981; Musick,1979). Two prey species of the loggerhead and Kemps ridley are known to contain pollutants of the same classes found in polluted sediments in the Bay. Hale (1983) reports the presence of alkyl substituted aromatic hydrocarbons, unsubstituted aromatic hydrocarbons, heterosubstituted aromatic hydrocarbons, PCBs, and DDT metabolites in various concentrations at the ppb level in the blue crab (Callinectes sapidus). Smith (1981) found the horseshoe crab (Limulus polyphemus) to have measurable concentrations of the standard sediment hydrocarbon pollutants phenanthrene, flouranthene, and chrysene in tissues taken from animals found in clean sediments in Virginia waters on the continental shelf. This xenobiotic burden is similar to that found in loggerhead sea turtles of the Chesapeake Bay, so that feeding may be a route of exposure to these compounds.

The major pyrogenic compounds found in sediments were also present in all contaminated turtle samples (Bieri et al., 1982). Necropsies of other stranded loggerhead turtles in this area often reveal sand and sediments in the digestive tract. This is believed to occur during feeding and would lead to direct exposure to contaminated sediments. This would result in a second route of exposure during feeding in loggerheads.

Routes of exposure for the leatherback are unknown, with the possible exception of pollutants partitioned in the water column. Not enough information is known about leatherback behavior to make any further speculations about exposure. It is likely, however, that many of the compounds found in the leatherback were of a biogenic origin.

The detection of PCBs in these turtles by mass spectroscopy is significant considering the relatively low response of these compounds on flame ionization detectors. PCB detection is usually performed with an electron capture detector (Hale,1983).

Response factors of highly chlorinated compounds are significantly lower in an FID than those of non-chlorinated hydrocarbons. Calculations in this work assume that response factors of detected peaks are similar to that of the 1,1' Binaphthyl co-injected standard. The concentration of PCBs is therefore severely underestimated by GC analysis.

The intent of this analysis was to look qualitatively for possible pollutants that are commonly found in the sediments and organisms of the Chesapeake Bay. The results show that these compounds are present in average specimens from the Bay and Virginia coastal waters. They also show an unsuspectedly high concentration of PCBs. Further qualitative and quantitative analysis for the presence and composition of hydrocarbons, PAHs, PCBs, and pesticides should be done on larger sample numbers and all species, particularly the Kemps ridley (*Lepidochelys kempi*), found in the Chesapeake Bay.

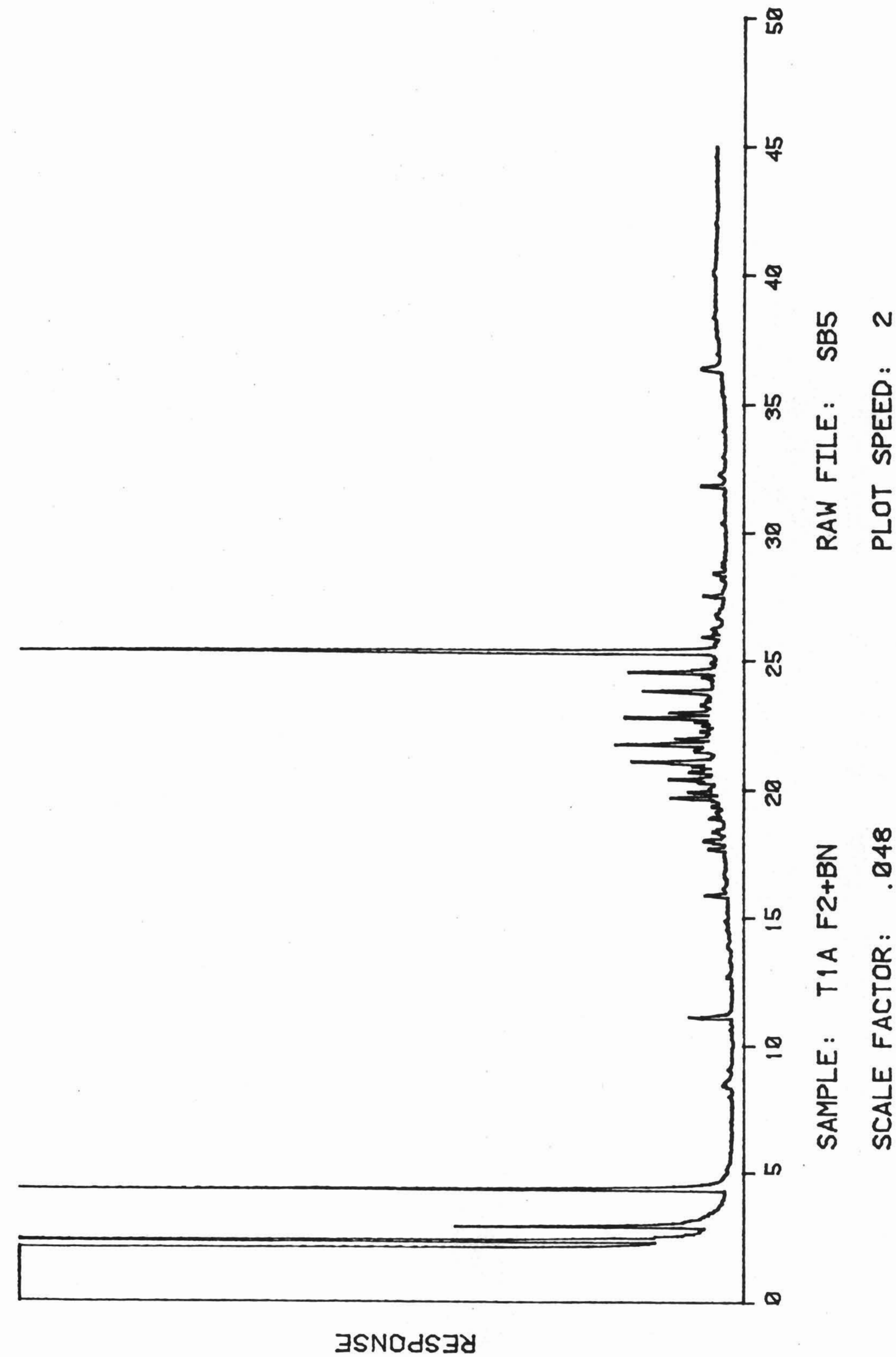
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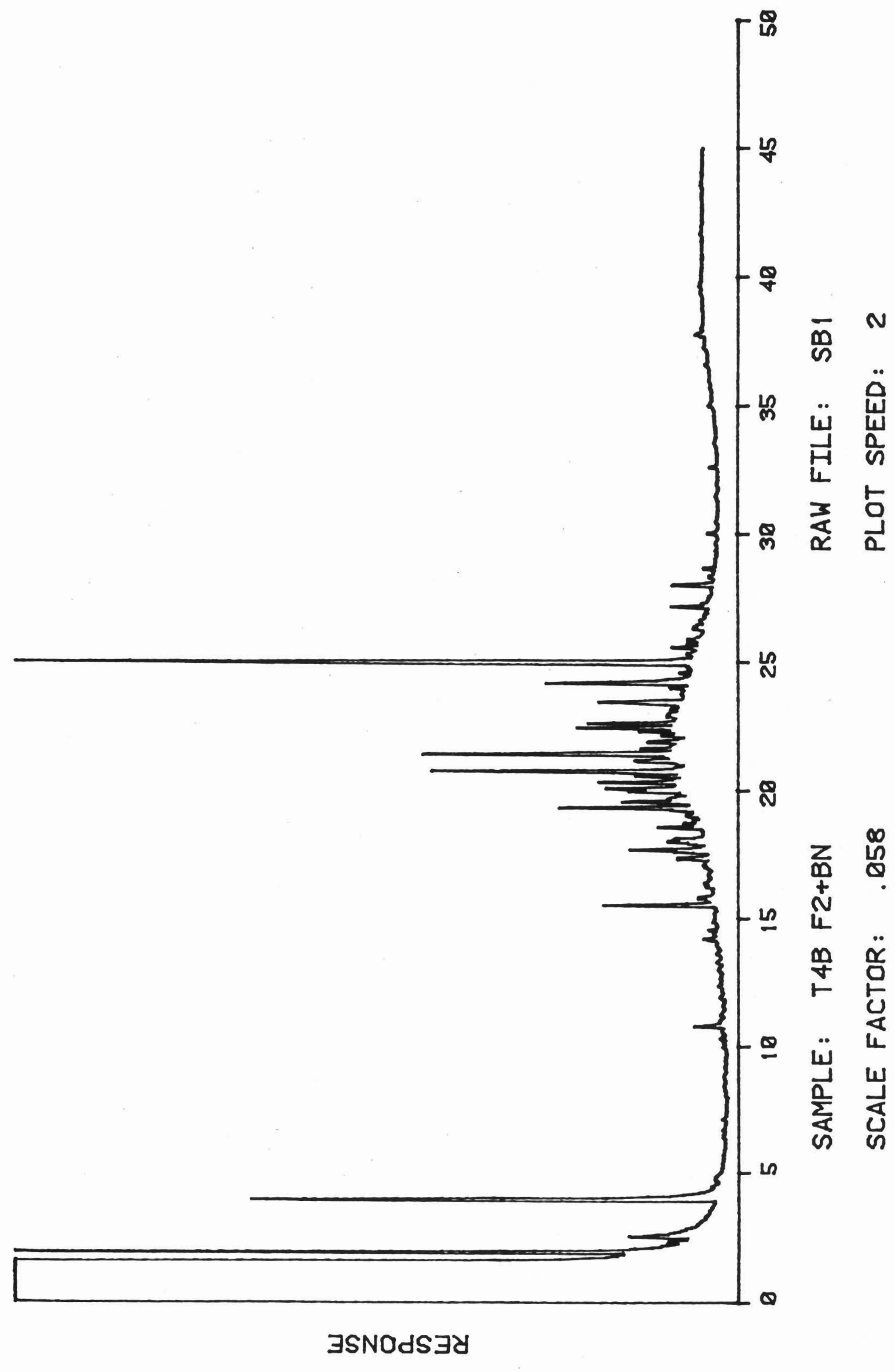
Figure 1



RESPONSE
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SAMPLE: T4B F2+BN
SCALE FACTOR: .058
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PLOT SPEED: 2

Figure 2

Table 1

Turtles Examined for Hydrocarbons

MT No.	Turtle No.	Species	Date	CLS (cm)	Weight (kg)	Location
MT-154-82L	1	Cc+	24IX82	64.8	32	Dam Neck Naval Air-station, VA Beach, VA
MT- 56-82	2	Dc++	26VII82	143*	-	Back Bay National Wildlife Refuge, VA
MT-162-82	3	Cc	7X82	75.6**	-	VA Beach, VA
MT- 62-82L	4	Cc	21VII82	75.4	56	Stranded; pound net, York River

\- not taken
* approximate measurement
** curved measurement

\+ *Caretta caretta*
++ *Dermochelys coriacea*

Table 2

Toxicant Concentration in Tissues

Liver

Turtle	Total Concentration (ppb)	Compounds (ppb) phenanthrene	pyrene	fluoranthene
1	209.0	4.2	4.3	4.9
2	1093.6	5.3	7.4	9.0
4	1193.3	4.7	2.3	2.4

Fat

Turtle	Total Concentration (ppb)	phenanthrene	pyrene	fluoranthene
4	1694.0	74.8	248.6	27.7

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Appendix C

Serum Normal Values

Determined For

Chesapeake Bay Juvenile Sea Turtles

Albumin g/dl

	VIMS *C. caretta*	VIMS *L. kempi*	*Gopherus polyphemus* *
n	56	9	17
$\bar{x}$	0.95	1.04	1.52
s	0.39	0.54	0.139
range	0.3-1.8	0.7-2.5	0.5-2.6

Glucose mg/dl

	VIMS *C. caretta*	VIMS *L. kempi*	*Gopherus polyphemus*	*Gopherus agassizi* **
n	46	9	16	-
$\bar{x}$	158.55	116.5	74.5	-
s	88.0	73.26	4.52	-
range	12.6-325.6	19.3-231.1	55.0-128.0	30-150

BUN (Blood Urea Nitrogen) mg/dl

	VIMS *C. caretta*	VIMS *L. kempi*	*Gopherus polyphemus*	*Gopherus agassizi*
n	43	9	17	-
$\bar{x}$	66.69	82.25	30.12	-
s	20.29	25.11	8.68	-
range	32.5-98.8	39.4-96.7	1.0-130.0	1-30

Creatinine mg/dl

	VIMS *C. caretta*	VIMS *L. kempi*	*Gopherus polyphemus*	*Gopherus agassizi*
n	29	3	17	-
$\bar{x}$	0.51	0.5	0.28	-
s	0.27	0.16	0.021	-
range	0.2-1.6	0.3-0.7	0.1-0.4	0.1-0.4

* Taylor & Jacobson, 1982

** Rosskopf & Woerpel, 1982

Glutamic oxaloacetic transaminase (GOT) K-A units

	VIMS *C. caretta*	VIMS *L. kempi*	*Gopherus polyphemus*	*Gopherus agassizi*
n	13	2	17	-
$\bar{x}$	109.8	76.8	135.8	-
s	34.5	20.9	19.92	-
range	54.1-182.3	55.9-97.7	57.0-392.0	10-100

Glutamic pyruvic tranaminase (GPT) K-A units

	VIMS *C. caretta*	VIMS *L. kempi*	*Gopherus polyphemus*
n	23	1	13
$\bar{x}$	52.6	29.9	14.8
s	16.28		4.64
range	29.4-76.6		2.0-57.0

Lactate dehydrogenase (LD-H) K-A units

	VIMS *C. caretta*	VIMS *L. kempi*	*Gopherus polyphemus*	*Gopherus agassizi*
n	33	6	17	-
$\bar{x}$	58.55	443.65	272,81	-
s	44.1	250.33	52.01	-
range	10.1-183.4	181.9-768.5	17.8-909.0	25-250

Inorganic Phosphorus mg/dl

	VIMS *C. caretta*	VIMS *L. kempi*	*Gopherus polyphemus*
n	31	4	17
$\bar{x}$	7.1	7.6	2.07
s	1.6	0.87	0.16
range	4.6-9.4	6.8-9.1	1.0-3.1

Calcium mg/dl

	VIMS *C. caretta*	VIMS *L. kempi*	*Gopherus polyphemus*	*Gopherus agassizi*
n	45	10	10	-
$\bar{x}$	6.33	7.25	11.77	-
s	1.08	2.53	0.60	-
range	4.4-8.8	2.8-11.8	9.7-14.4	9.0-17.0