EVALUATION OF MACROHABITAT UTILIZATION BY LOGGERHEAD SEA TURTLES IN DELAWARE ESTUARY USING SONIC AND SATELLITE TRACKING TECHNIQUES

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June 1997

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SECTION 1.0
SUMMARY AND CONCLUSIONS

This evaluation was prepared by Public Service Electric and Gas Company (PSE&G) for submittal to the U.S. Nuclear Regulatory Commission and the National Marine Fisheries Service (NMFS) to document PSE&G's efforts addressing Item No. 7 in the Incidental Take Statement found in the Section 7 Consultation for the Salem Generating Station and to support PSE&G's request to delete this requirement from the Incidental Take Statement.

PSE&G's Salem Generating Station (Unit Nos. 1 and 2) is located on the southern end of Artificial Island in Lower Alloways Creek Township, Salem County, New Jersey. The station is situated on the eastern shore of the Delaware River estuary.

Artificial Island is located approximately 2 miles (3.2 kilometers) upstream of the head of Delaware Bay and approximately 50 miles (80 kilometers) upstream of the mouth of the Bay. Freshwater flow in the estuary averages 23,352 cubic feet per second (661 cubic meters per second) and tidal flows average 399,710 cubic feet per second (11,320 cubic meters per second). The salinity ranges from zero parts per thousand (ppt) to a maximum of 20 ppt. Water temperature in the river in the vicinity of the Artificial Island varies from 32°F (0°C) to 86°F (30°C).

Sonic and satellite transmitters were used by PSE&G from 1992 to 1996 to track the movements of loggerhead sea turtles in the Delaware Estuary. These turtles were animals which had been incidentally captured at the Salem Generating Station, equipped with sonic and satellite transmitters, and released back into the bay downstream of the station. The movements of these turtles relative to Salem Generating Station were of interest to PSE&G and NMFS in determining whether or not there was any evidence that the station was an attractant to these animals. Additionally, NMFS was interested in obtaining information on the habitat utilization by these turtles in the Delaware Estuary. The sonic equipment used by PSE&G in this study was manufactured by Sonotronics, Inc. and the satellite equipment by Telonics, Inc. The Argos global satellite-based location and data collection system was used to track the signals from the Telonic's transmitters attached to sea turtles.

Seven loggerhead sea turtles were tracked by PSE&G using satellite and/or sonic tracking equipment. In order to characterize the habitat usage by these turtles, the Delaware Estuary was partitioned into four general macrohabitats: New Jersey shallow inshore areas, Delaware shallow inshore areas, the

shipping channel, and the tributary streams. The sonic and satellite results were apportioned to these different macrohabitat types and percent occurrence based on estimated minutes spent in each area were tabulated.

Sonic tracking data was collected for up to 48-hours following the release of the tagged animal. Based on sonic data, it appears that these loggerheads spent the bulk of the time following their release in shallow shoreline areas adjacent in New Jersey or mid-river in the vicinity of the shipping channel. One turtle was observed to have crossed the river and spend time adjacent to the Delaware River shoreline and in the Appoquinimink River prior to returning to the shipping channel.

Satellite tracking data was collected from two tagged animals which were tracked for seven and twenty-two days respectively. Based on satellite data from these two loggerheads the majority of their time was spent in shallow Delaware shoreline areas and lesser time in New Jersey shoreline areas and the shipping channel. Usage of the Appoquinimink and Mahon Rivers in Delaware and marsh areas near Egg Island Point in New Jersey was also observed for short periods of time.

Based on these data it was concluded that the loggerhead sea turtles tracked by PSE&G using sonic and satellite tracking techniques used the full range of macrohabitats available in the Delaware Estuary near Salem Generating Station. These macrohabitats include: shallow shoreline areas adjacent to both New Jersey and Delaware, the shipping channel, and, tidal tributary streams and marshes. These data also provided no evidence that the turtles tracked by sonic and satellite techniques were attracted to the Salem Generating Station following their release.

SECTION 2.0
INTRODUCTION

2.1 PURPOSE

This report is being submitted to the U.S. Nuclear Regulatory Commission (NRC) and National Marine Fisheries Service (NMFS) by Public Service Electric and Gas Company (PSE&G): 1) to provide results of their sonic/satellite tracking studies to date; 2) to provide insight into the movements and habitat utilization of loggerhead sea turtles in the Delaware Estuary relative to Salem Generating Station; and, 3) to support PSE&G's request that NMFS reevaluate and delete the continuance of Item No. 7 from the Endangered Species Act, Section 7 Consultation dated 5/14/93, Biological Opinion, Incidental Take Statement. Item No. 7 of the Incidental Take Statement requires that PSE&G multi-tag sea turtles incidentally taken with sonic and satellite transmitters and monitor their movements. The sonic signal is required to be monitored for 48 hours following release and again two weeks later. The satellite signal is required to be monitored from the time of the turtles release until the signal stops. The intent in gathering these data is to provide an understanding of the habitat utilization in Delaware Estuary by sea turtles.

2.2 CHRONOLOGY OF EVENTS LEADING UP TO SONIC/SATELLITE TRACKING PROGRAM

The issue of sea turtle strandings at Salem Generating Station was initially addressed in 1979 and 1980 when two sea turtles were collected on the circulating water intake trash racks at Salem Generating Station. The matter was discussed jointly by PSE&G, NRC, NMFS, U.S. Environmental Protection Agency (USEPA) and New Jersey Department of Environmental Protection (NJDEP) during October 1981 (informal Section 7 review). It was concluded from this discussion that the two specimens collected from the intake were probably dead before they appeared on the trash racks and that the intake structure did not have a role in their deaths. A procedure for PSE&G to report future occurrences of sea turtles to NMFS and NRC was established at this meeting.

In the years following, PSE&G kept both NMFS and NRC apprised of the collection of threatened and endangered sea turtles at Salem Generating Station. In 1985 and again in 1987 and 1988, a number of turtles were collected from the trash racks which were either alive or showed no evidence of previous trauma. This was considered by NMFS to reflect new information concerning the effects of the Salem circulating water intake system which was not considered in the 1981 informal consultation.

Rather than initiating a new review, NMFS requested the reinitiating of the 1980 formal consultation which pertained to the endangered, shortnose sturgeon (Acipenser brevirostrum) at Salem and Hope Creek Generating Stations. This request was made pursuant to 50 CFR 401.16 of the ESA Interagency Cooperation regulations.

Toward the end of September 1988, PSE&G received a letter from NRC (J. C. Stone, 1988) advising them of NMFS request and requesting a proposed schedule for preparation of a "biological assessment" and an outline of the material to be included in the document. This information was submitted to NRC in October 1988 (S. E. Miltenberger, 1988) and was discussed in a meeting with NRC on November 22, 1988. Following this meeting, NRC approved PSE&G's request to prepare the "biological assessment" with the understanding that several additional items be included in the document (J. C. Stone, 1988). PSE&G submitted this "biological assessment" to the NRC in July 1989 (PSE&G, 1989; S. E. Miltenberger, 1989).

On January 2, 1991, the National Marine Fisheries Service (NMFS) issued a Biological Opinion in accordance with Section (b)(4) of the Endangered Species Act. The Nuclear Regulatory Commission (NRC) transmitted this Biological Opinion to PSE&G on April 11, 1991 (W. R. Butler, 1991). Included in the Biological Opinion were an Incidental Take Statement and Conservation Recommendations. The conservation recommendations included items suggested by the NMFS to potentially reduce the incidental take of sea turtles at the Salem and Hope Creek Generating Stations. Incidental Take Statement items were required to be completed by PSE&G.

On July 1, 1991, PSE&G submitted a proposal to the NRC and NMFS to address these Conservation Recommendations (S. E. Miltenberger, 1991). PSE&G proposed to determine the feasibility of developing a program suggested in Item 1 and conduct examinations of Items 2 through 5.

After deciding the feasibility of a tracking program, which addressed Item I of the Section 7 Conservation Recommendations, PSE&G submitted a proposal to the NRC and NMFS on March 16, 1992, which outlined a study to observe sea turtle movements throughout the Delaware Bay and River (S. E. Miltenberger, 1992).

On June 2, 1992, a meeting was held between PSE&G, NMFS and the NRC to discuss the proposed program. The NRC concurred with the proposed programs in a letter dated April 17, 1992 (J. C. Stone, 1992).

PSE&G submitted a report addressing the January 1991 Conservation Recommendations on December 23, 1993 (PSE&G, 1993). This report addressed the Conservation Recommendations from a review of existing data, literature, research, and studies. PSE&G collected extensive papers, attended pertinent meetings and conferences, and evaluated extensive options for this report.

During the summer of 1992, PSE&G also began a habitat utilization study of turtles incidentally taken at the Salem Circulating Water Intake Structure. This study included the use of satellite and sonic transmitters to monitor the turtles' movements throughout the Delaware Estuary after capture. This report presents the results of the sonic and satellite data gathered by PSE&G from 1992 through 1996.

SECTION 3.0
SITE DESCRIPTION

3.1 LOCATION

PSE&G's Salem Generating Station is located on the southern end of Artificial Island in Lower Alloways Creek Township, Salem County, New Jersey. The facility is located 15 miles (24 kilometers) south of Wilmington, Delaware, 30 miles (48 kilometers) southwest of Philadelphia, Pennsylvania, and 7 miles (11 kilometers) southwest of Salem, New Jersey (Figure 3-1).

Artificial Island is actually a peninsula connected to the mainland of New Jersey by a strip of marshland and extends approximately one third of the way across the Delaware River Figure 3-2). During the early 1900's, Artificial Island was a natural sand bar. At that time, the U.S. Army Corps of Engineers installed a retaining wall of oak pilings at the southern tip of the sand bar. A few years after the retaining wall was constructed, additional pilings were installed and the area was used for storing fill that was dredged from the Delaware River. The sand bar evolved into an island and finally into the peninsula it is today.

Artificial Island encompasses approximately 1,482 acres (600 hectares) (Figure 3-2). Topographically, it is flat with an average elevation of 8.8 feet (2.7 meters) above mean sea level and a maximum elevation of 18 feet (5.5 meters) above mean sea level. The 740 acre (300 hectare) PSE&G site is located on the southernmost 25 percent of the peninsula and is divided into Salem Generating Station (220 acres of 89 hectares), Hope Creek Generating Station (153 acres or 62 hectares), and uncommitted land (367 acres or 148 hectares). The undeveloped areas of the island are owned by the U.S. Government and characterized by diked dredge spoil disposal impoundments used by the U.S. Army Corps of Engineers and tidal salt marsh.

3.2 MORPHOLOGY AND BATHYMETRY

Salem Generating Station is situated on the eastern shore (New Jersey) of the lower portion of the Delaware River Estuary. The Delaware River estuary is 132 miles (211 kilometers) long and extends from Capes May and Henlopen to Trenton, New Jersey. This region of the estuary is referred to as Delaware Bay and is 48 miles (77 kilometers) long and extends from the Capes to a line between stone markers located at Liston Point, Delaware and Hope Creek, New Jersey (Polis et al., 1973). The estuary varies in width from 11 miles (18 kilometers) at the Capes; to 27 miles (43 kilometers) at its widest point (near Miah Maull Shoal); to 1,000

feet (0.3 kilometers) at Trenton, New Jersey. Water depth in the bay is less than 30 feet (9.1 meters) deep in 80 percent of the bay and is less than 10 feet (3 meters) deep in much of the tidal river area. A navigation channel passes from deep water inside the entrance of the bay to Trenton, New Jersey. Authorized depth of the channel is 40 feet (12.1 meters) below mean sea level up to Philadelphia and then 25 feet (7.6 meters) below mean sea level to Trenton.

Artificial Island is located approximately 2 miles (3.2 kilometers) upstream of the hypothetical line demarking the head of Delaware Bay. The tidal river in this area narrows upstream of Artificial Island and makes a bend of nearly 60 degrees. Both the narrowing and bend are accentuated by the presence of Artificial Island. The width of the Delaware River Estuary is approximately 2.5 miles. Furthermore, more than half of the typical river width in this area is relatively shallow, less than 18 feet (5.5 meters), while the deeper part, including the dredged shipping channel has depths of up to 40 feet (12.2 meters).

3.3 HYDROLOGY

The largest tributaries of the Delaware Estuary are the Schuylkill River in Pennsylvania, the Christina River in Delaware, and the Assunpink, Crosswicks, Rancocas and Salem Rivers, and Big Timber, Hope and Alloways Creeks in New Jersey (PSE&G, 1984). The head of the Delaware Estuary is at Trenton, New Jersey, about 81 miles (130 kilometers) upstream of Artificial Island (Figure 3-1). The Chesapeake and Delaware Canal, which connects the Delaware River with Chesapeake Bay, is located approximately 7 miles (11.3 kilometers) north of Artificial Island.

Of the total freshwater flow into the Delaware Estuary, an annual average of 23,352 cubic feet per second (661 cubic meters per second) is contributed by the Delaware River at Trenton; 12 percent (2,715 cfs or 76.9 cubic meters per second) by the Schuylkill River; and, the remaining 38 percent by all other tributaries (USGS, 1981a; USGS, 1981b).

Tidal flow as measured near the Delaware Memorial Bridge, 20 miles above Artificial Island, was measured at 399,710 cfs (11,320 cubic meters per second)(USGS, 1966). Tidal flow of this magnitude is 17 times as great as the total average freshwater flow rate into the estuary. Proceeding toward the mouth of the estuary, tidal flow increasingly dominates freshwater downstream flow; proceeding upstream from the Delaware Memorial Bridge, the ratio of tidal flow to net downstream flow becomes smaller as tidal influence decreases.

Tides in the Delaware estuary are semidiurnal, with a period of 12.42 hours (Polis, D. F. et al., 1973). The mean tidal range averages 4.3 feet (1.3 meters) at the mouth of the estuary; 5.9 feet (1.8 meters) at Artificial Island; and, 6.7 feet (2 meters) at Trenton, New Jersey. These ranges are influenced by heavy precipitation, storm surges and wave action. Tidal ranges as high as 14.1 feet (4.3 meters) have been observed at Artificial Island during periods of extreme flood and ebb conditions.

Current speed and direction throughout the Delaware Estuary are dominated by the tide. Surface tidal currents generally are directed along the longitudinal axis of the estuary except in nearshore areas of the river bends and coves. At maximum ebbing or flooding tide, local currents at any point within the estuary may reach speeds of 3.3 to 4.3 feet per second (1.0 to 1.3 meters per second) (R. F. Weston, Inc., 1982).

The average river velocity adjacent to the site is 1.2 feet per second (0.4 meters per second) with typical ebb and flood maximums of 3.2 and 2.5 feet per second (1 and 1.3 meter per second)(U.S. Commerce Department, 1982). Near field current velocities, within 100-feet of the intakes, are strongly influenced by tidal currents except for directly in front of the intakes (R. F. Weston, Inc., 1982). Average current velocities within the circulating water system (CWS) and service water system (SWS) withdrawal zones were observed to be 1.1, 0.9, 0.8 and 0.7 feet per second (0.33, 0.27, 0.24 and 0.21 meters per second) respectively during ebb, low slack, flood and high slack tides. The greatest variation in velocities were observed during high slack tide which ranged from 0.2 to 2.0 feet per second (0.06 and 0.61 meters per second).

Velocity measurements at the face of the CWS intake show higher velocities near the surface and generally decrease at mid-depths. Velocities at some mid-depths of the intake and near the bottom were at or near zero feet per second. The average velocity for the water column is approximately 1 foot per second (design velocity)(R. F. Weston, Inc., 1982). Velocity measurements at the face of the SWS intake (below the curtain wall) averaged 0.3 feet per second (0.1 meters per second).

The morphometric and bathymetric features of the river in the area of Artificial Island affect near field circulation patterns near the generating stations (R. F. Weston, Inc., 1982). The bend in the river produces a persistent flow (averaged over several tidal periods) of near surface water away from the inside of the bend (i.e. away from Artificial Island, towards the west shore), with a compensating deep flow toward the inside (i.e., the New Jersey side) of the bend. Such flows generally tend to

work to keep stream channels on the outside of bends, since sediment is carried with the bottom current toward the shore at the inside, as well as being deposited by slower inside forces.

In addition, two artificial structures on the east shore (Figure 3-3), Hope Creek jetty and Sunken Ship Cover, also appear to influence the near-field current pattern, contributing to current deflection and shoreline drag. The resultant complex circulation results in changing sedimentation and erosion patterns. Reedy Island Breakwater is located near midriver but has little influence on current patterns near Artificial Island.

3.4 SALINITY

Salinity in the Delaware estuary varies from freshwater (typically defined as less than 1 part per thousand) at Trenton to typical ocean water concentrations of about 32 parts per thousand (ppt) on the continental shelf off the mouth of the Bay. Salinity at any particular location in the estuary is dependent on the amount of freshwater discharge from upstream and the extent of saltwater intrusion from downstream. Variables such as tidal phase, basin morphology, and meteorological conditions affect salinity (Polis, D. F. et al., 1973; PSE&G, 1984). High freshwater discharge conditions typical of spring runoff normally result in downstream displacement of the saltfront to about river kilometer 89 and increased vertical salinity stratification. During low freshwater flow conditions in late summer and fall, the saltfront normally extends to about river kilometer 120 and the system is well mixed vertically.

At Artificial Island, salinity typically ranges from near zero during periods of high river flow (December through March) to 10 or 12 part per thousand (ppt) during periods of low river runoff (summer and fall). A maximum of 20 ppt has been recorded at Artificial Island. Salinity around Artificial Island and a short distance upstream from it is essentially homogeneous vertically, with variations at any given point are limited generally to 1 part per thousand between surface and bottom. Some variation is observed across the estuary due in part to Coriolis forces, which tend to displace lower salinity water toward the western (Delaware) side which results in replacement by water of greater than average salinities on the east (New Jersey) shoreline. Thus, there is a relatively homogeneous salinity distribution until a point is reached in the lower Delaware Bay where the tidal velocities are low enough to permit a degree of vertical stratification to develop. In the lower bay, downstream of Artificial Island, there is an extensive amount of stratification brought about by the combination of salinity gradients and meteorological conditions.

3.5 TEMPERATURE

Water temperature in the Delaware Estuary is also determined by the flow characteristics of the entire drainage area. Temperature patterns in the estuary are determined by the thermal characteristics of the Delaware River, its tributaries, and the coastal ocean waters. Temperatures of the sources are altered by air temperature, humidity, wind, insolation, cloud cover, and tidal mixing.

Temperature of the Delaware River at Trenton, which constitutes the major freshwater input to the estuary, varies annually from 0 degrees Centigrade in mid-winter to over 30 degrees Centigrade in summer (Polis, D. F., et al. 1973; PSE&G, 1984). Periods of rapid temperature change occur in spring and fall. Atlantic Ocean water that enters the estuary exhibits a less extreme annual range of temperature. Minimum mean temperatures of approximately 6 degrees Centigrade usually occurs in February or March; a maximum of approximately 24 degrees Centigrade in August (Polis et al., 1973). Thus, the large volume of shelf water that enters the Bay on each tidal cycle and mixes with the fresher water tends to moderate the temperatures of the lower Bay.

Water temperatures in the Delaware River near Artificial Island ranges from near zero degrees Centigrade in winter to about 30 degrees Centigrade in summer (PSE&G, 1984). Ice forms in the winter along the shoreline of the estuary, but is broken up by tidal action. Due to shipping, the Delaware River has not been entirely covered by ice near the site in recent years. In early spring, ice from the upper Delaware River floats past the site to Delaware Bay.

3.6 AQUATIC LIFE IN THE DELAWARE SYSTEM

The wide variety of habitats in the Delaware system support hundreds of species of aquatic life. The entire array of species occupying these habitats could be considered to function as one large biological community (Figure 3-4). However, it is also common practice to examine major subdivisions and biological categories of species. These major subdivisions are defined by habitat zones and by the functional role of biotic categories of species within the total community. For example, few species can survive the full range of salinity (0.1 to 32 parts per thousand) that occurs in the Delaware system and in other estuaries. Thus, freshwater organisms that are carried downriver into brackish water regions perish, as do marine organisms that are transported into less saline regions. The freshwater and marine organisms which perish as a result of transport to unfavorable salinities contribute to the detrital portion of the food supply in the brackish water zone. Thus, it is reasonable to divide the

biological community which occupies the Delaware system into the following components: tidal fresh water, brackish water, and marine.

Similarly, the organisms which occupy the relatively fixed-in-place tidal marshes in the littoral zone along both shores of the Delaware system rely much more on the extremely productive marsh vegetation for habitat and food than do the species which occupy the pelagic zone (Figure 3-5). It is reasonable, therefore, for the purpose of environmental assessments to consider those as interactive subcompartments of the total community.

Finally, within those physically distinguished compartments, it is customary to distinguish categories of species based on their food web function, such as the primary producers (phytoplankton and vascular plants) and consumers categories, which include: primary consumers (herbivores), secondary consumers (predators on the herbivores), top predators (which consume smaller animals), and the decomposers (bacteria and fungi) of plant and animal remains (detritus).

Salem's cooling water intake structure on the southwest corner of Artificial Island withdraws water from the pelagic brackish water zone of the Delaware system. Because of their relative locations, many components of the biological community have little to no involvement with Salem's cooling water intake structure, and, therefore, are biological categories with low potential for impact that do not need to be addressed further in determining the effects of Salem on the aquatic community. The categories which do not occur at Salem include (1) the obligate freshwater species which occupy the tidal fresh waters of the system; (2) the obligate marine species which occupy the high salinity zones in the lower Delaware Bay and Atlantic Ocean; (3) the plant and animal populations which occupy the mudflats and tidal marshes in the littoral zone along both shores of Delaware Bay; and (4) the species which live in or attached to the bottom outside of the immediate location of Salem. Thus, the majority of species present in the Delaware system do not occur in the vicinity of Salem at all.

What remains to be addressed, then, are those relatively few species which are able to tolerate, and include within their geographical distribution for part or all of their life cycles, the pelagic, brackish water zone at Salem. These species include (1) some species that reside in the Estuary for most or all of their life cycle (for example, scud and white perch); (2) others that migrate seasonally between the Ocean and upstream freshwater portions of the system (for example, blueback herring); and (3) certain marine species with distribution ranges for one or more

life stages that extend into this brackish water zone (for example, weakfish and sea turtles).

3.6.1 GENERALIZED SEA TURTLE LIFE HISTORY

Sea turtles spend most of their lives in an aquatic environment and males of many species may never leave the water (Hopkins and Richardson, 1984; Nelson, 1988). The recognized life stages for these turtles are egg, hatchling, juvenile/subadult, and adult (Hirth, 1971). A generalized sea turtle life cycle is presented in Figure 3-6.

Reproductive cycles in adults of all species involve some degree of migration in which the animals return to nest at the same beach year after year (Hopkins and Richardson, 1984). Nesting generally begins about the middle of April and continues into September (Hopkins and Richardson, 1984; Nelson, 1988). Mating and copulation occur just off the nesting beach and it is theorized that sperm from one nesting season may be stored by the female and thus fertilize a later seasons eggs (Booth and Peters, 1972; Simon et. al., 1975). A nesting female moved shoreward by the surf lands on the beach, and if suitable crawls to a point above the high water mark (Ross et al, 1989). She then proceeds to excavate a shallow body pit by twisting her body in the sand. After digging the body pit, she proceeds to excavate an egg chamber using her rear flipper (Ross et al, 1989). Clutch size, egg size, and egg shape is species specific (Nelson, 1988) Incubation periods for loggerheads and green turtles average 55 days but range from 45 to 65 days depending on local conditions (Nelson, 1988).

Hatchlings emerge from the nest at night, breaking the egg shell and digging their way out of the nest (Ross et al, 1989). They find their way across the beach to the surf by orienting to light reflecting off the breaking surf (Hopkins and Richardson, 1984). Once in the surf, hatchlings exhibit behavior known as "swim frenzy," during which they swim in a straight line for many hours (Carr, 1986). Once into the waters off the nesting beach, hatchlings enter a period known as the "lost year." it is not known where this time is spent, what habitat this age prefers, or mortality rates during this period. It is currently believed the period encompassed by the "lost years" may actually turn out to be several years. Various hypotheses have been put forth about the "lost year." One is that the hatchlings may become associated with floating sargassum raft offshore. These rafts provide shelter and are dispersed randomly by the currents (Carr, 1986). Another hypothesis is that the "lost year" of some species may be spent in a salt marsh/estuarine system (Garmon, 1981).

The functional ecology of sea turtles in the marine and/or estuarine ecosystem is varied. The loggerhead is primarily carnivorous and has jaws well-adapted to crushing mollusks and crustaceans and grazing on encrusted organisms attached to reefs, pilings and wrecks; the Kemp's ridley is omnivorous and feeds on swimming crabs and crustaceans; the green turtle is a herbivore and grazes on marine grasses and algae; and, the leatherback is a specialized feeder preying primarily upon jellyfish. Until recently, sea turtle populations were large and subsequently played a significant role in the marine ecosystem. This role has been greatly reduced in most locations as a result of declining turtle populations. These population declines are a result of natural factors such as disease and predation, habitat loss, commercial overutilization, and inadequate regulatory mechanisms for their protection. This has led to several species being in danger of or threatened with extinction.

However, due to changes in habitat use during different life history stages and seasons, sea turtle populations are difficult to census (Meylan, 1982). Because of these problems estimates of population numbers have been derived from various indices such as numbers of nesting females, numbers of hatchlings per kilometer of nesting beach and number of subadult carcasses (strandings) washed ashore (Hopkins and Richardson, 1984).

Six of the seven extant species of sea turtles are protected under the federal Endangered Species Act. Three of the turtles, Kemp's ridley, hawksbill and leatherback, were listed as endangered. The Florida nesting population of green turtle and Mexican west coast population of olive ridley are also endangered. All of the remaining populations of green turtle, olive ridley and loggerhead are threatened. The only unlisted species is the locally protected Australian flatback turtle (Hopkins and Richardson, 1984). Three species of sea turtles, loggerheads, Kemp's ridleys and green sea turtles, occur in the Delaware estuary near the Salem and Hope Creek Generating Stations. Leatherbacks do occur in coastal New Jersey and Delaware and the mouth of Delaware Bay.

3.6.1.1 LOGGERHEAD (*Caretta caretta*)

Description

The adult loggerhead turtle has a slightly elongated, heart-shaped carapace that tapers towards the posterior and has a broad triangular head (Pritchard et al., 1983). Loggerheads normally weigh up to 450 pounds (200 kilograms) and attain a carapace length (straight line) up to 48 inches (120 centimeters)(Pritchard et al., 1983). Their general coloration is reddish-brown dorsally and cream-yellow ventrally (Hopkins and

Richardson, 1984). Morphologically, the loggerhead is distinguishable from other sea turtle species by the following characteristics: 1) a hard shell; 2) two pairs of scutes on the front of the head, 3) five pairs of lateral scales on the carapace; 4) plastron with three pairs of enlarged scutes connecting the carapace; 5) two claws on each flipper; and, 6) reddish-brown coloration (Nelson, 1988; Dodd, 1988; Wolke and George, 1981).

Loggerhead hatchlings are brown above with light margins below and have five pairs of lateral scales (Pritchard et al., 1983)

Distribution

Loggerhead turtles are circumglobal, inhabiting continental shelves, bays, lagoons, and estuaries in the temperate, subtropical and tropical waters of the Atlantic, Pacific and Indian Oceans (Dodd, 1988; Mager, 1985).

In the western Atlantic ocean, loggerhead turtles occur from Argentina northward to Nova Scotia including the Gulf of Mexico and the Caribbean Sea (Dodd, 1988; Mager, 1985; Nelson, 1988). Sporadic nesting is reported throughout the tropical and warmer temperate range of distribution, but the most important nesting areas are the Atlantic coast of Florida, Georgia and South Carolina (Hopkins and Richardson, 1984). The Florida nesting population of loggerheads has been estimated to be the second largest in the world (Ross, 1982).

The foraging range of the loggerhead sea turtle extends throughout the warm waters of the U.S. continental shelf (Shoop et al., 1981). On a seasonal basis, loggerhead turtles are common as far north as the Canadian portions of the Gulf of Maine (Lazell, 1980), but during cooler months of the year, distributions shift to the south (Shoop et al., 1981). Loggerheads frequently forage around coral reefs, rocky places and old boat wrecks; they commonly enter bays, lagoons and estuaries (Dodd, 1988). Aerial surveys of loggerhead turtles at sea indicate that they are most common in waters less than 50-meters in depth (Fritts et. al., 1983), but they occur pelagically as well (Carr, 1986).

Food

Loggerheads are primarily carnivorous (Mortimer, 1982). They eat a variety of benthic organisms including sea pens, mollusks, crabs, shrimp, jellyfish, sea urchins, sponges, squids, and fishes (Nelson, 1988; Plotkin et. al., 1993). Adult loggerheads have been observed feeding in reef and hard bottom areas (Mortimer, 1982). In the seagrass lagoons of Mosquito Lagoon,

Florida, subadult loggerheads fed almost exclusively on horseshoe crab (Dodd, 1988). Loggerheads may also eat animals discarded by commercial trawlers (Shoop and Ruckdeschel, 1982). This benthic feeding characteristic may contribute to the capture of these turtles in trawls.

Nesting

The nesting season of the loggerhead is confined to the warmer months of the year in the temperate zones of the northern hemisphere. In south Florida nesting may occur from April through September but usually peaks in late June and July (Dodd, 1988; Florida Power & Light Company, 1990).

Loggerhead females generally nest every other year or every third year (Hopkins and Richardson, 1984). When a loggerhead nests, it usually will lay 2 to 3 clutches of eggs per season and will lay 35 to 180 eggs per clutch (Hopkins and Richardson, 1984). The eggs hatch in 46 to 65 days and hatchling emerge 2 or 3 days later (Hopkins and Richardson, 1984).

Hatchling loggerheads are a little less than 2 inches (5 centimeters) in length when they emerge from the nest (Hopkins and Richardson, 1984; Florida Power & Light Company, 1990). They emerge from the nest as a group at night, orient themselves seaward and rapidly move towards the water (Hopkins and Richardson, 1984). Many hatchlings fall prey to sea birds and other predators following emergence. Those hatchlings that reach the water quickly move offshore and exist pelagically (Carr, 1986).

Population Size

Loggerhead sea turtles are the most common sea turtle in the coastal waters of the United States. Based on numbers of nesting females, numbers of hatchlings per kilometer of nesting beach and number of subadult carcasses (strandings) washed ashore, the total number of mature loggerhead females in the southeastern United States have been estimated to be from 35,375 to 72,520 (Hopkins and Richardson, 1984; Gordon, 1983).

Adult and sub-adult (shell length greater than 60 centimeters) population estimates have also been based on aerial surveys of pelagic animals observed by NMFS during 1982 to 1984.
Based on these studies the current estimated number of adult and sub-adult loggerhead sea turtles from Cape Hatteras, North Carolina to Key West, Florida is 387,594 (NMFS, 1987). This number was arrived at by taking the number of observed turtles and converting it to a population abundance estimate using

information on the amount of time loggerheads typically spend at the surface.

Some sea turtles which die at sea wash ashore and are found stranded. NMFS, Sea Turtle Stranding and Salvage Network collects stranded sea turtles along both the Atlantic and Gulf Coasts (Teas, 1994). In 1993, 980 loggerhead turtles were reported by the network. The largest portion was collected from the southeast Atlantic Coast (573 turtles) followed by the northeast Atlantic Coast (219 turtles) and Gulf Coast (190 turtles).

Based on these data, it is evident that a large population of loggerhead sea turtles does exist in the southeast Atlantic and Gulf of Mexico. Various populations estimates suggest that the number of adult and sub-adult turtles is probably in the hundreds of thousands in the southeastern United States alone. This plus the fact that other populations of loggerheads occur in many other parts of the world suggest that although this species needs to be conserved it is not in any immediate danger of becoming endangered. However, the continued development of coastal foraging areas and offshore commercial trawling are still having a negative impact on population numbers as evidenced by declining nesting trends in the southeast United States (NMFS and USFWS, 1991)

3.6.1.2 KEMPS RIDLEY (*Lepidochelys kempii*)

Description

The adult Kemp's ridley has a circular-shaped carapace and a medium sized pointed head (Pritchard et al., 1983). Ridleys normally weigh up to 90 pounds (42 kilograms) and attain a carapace length (straight line) up to 27 inches (70 centimeters)(Pritchard et al., 1983). Their general coloration is olive-green dorsally and yellow ventrally (Hopkins and Richardson, 1984). Morphologically, the Kemp's ridley is distinguishable from other sea turtle species by the following characteristics: 1) a hard shell; 2) two pairs of scutes on the front of the head, 3) five pairs of lateral scutes on the carapace; 4) plastron with four pairs of scutes, with pores, connecting the carapace; 5) one claw on each front flipper and two on each back flipper; and, 6) olive-green coloration (Pritchard et al., 1983; Pritchard and Marquez, 1973).

Kemp's ridley hatchlings are dark grey-black above and white below (Pritchard et al., 1983, Pritchard and Marquez, 1973).

Distribution

Kemp's ridley turtles inhabit sheltered coastal areas and frequent larger estuaries, bays and lagoons in the temperate, subtropical and tropical waters of the Atlantic Ocean and Gulf of Mexico (Mager, 1985).

The foraging range of adult Kemp's ridley sea turtle appears to be restricted to the Gulf of Mexico. However, juveniles and subadult occur throughout the warm coastal waters of the U.S. Atlantic coast (Hopkins and Richardson, 1984; Pritchard and Marquez, 1973; Ross et al, 1989). On a seasonal basis ridleys are common as far north as the Canadian portions of the Gulf of Maine (Lazell, 1980), but during cooler months of the year, they shift to the south (Morreale et al., 1988).

Food

Kemp's ridleys appear to be opportunistic feeders ingesting items incidentally (Shaver, 1991). The feeding habits are not well understood, but appear to change with size. Hirth (1971) suggested hatchlings appear to be carnivorous and gradually change to herbivores. The turtle size and biological factors such as water depth, water temperature and available food items are causes for dietary changes (Shaver, 1991; Ogren, 1989). relationships

Nesting

Kemp's ridley nesting is mainly restricted to a stretch of beach near Rancho Nuevo, Tamaulipas, Mexico (Pritchard and Marquez, 1973; Hopkins and Richardson, 1984). Occasional nesting has been reported in Padre Island, Texas and Veracruz, Mexico (Mager, 1985).

The nesting season of the Kemp's ridley is confined to the warmer months of the year primarily from April through July.
Kemp's ridley females generally nest every other year or every third year (Pritchard et al., 1983). They will lay 2 to 3 clutches of eggs per season and will lay 50 to 185 eggs per clutch (Hopkins and Richardson, 1984). The eggs hatch in 45 to 70 days and hatchling emerge 2 or 3 days later (Hopkins and Richardson, 1984).

Hatchling ridleys are a little less than 2 inches (4.2 centimeters) in length when they emerge from the nest (Hopkins and Richardson, 1984). They emerge from the nest as a group at night, orient themselves seaward and rapidly move towards the water (Hopkins and Richardson, 1984). Following emergence, many

hatchlings fall prey to sea birds, raccoons and crabs. Those hatchlings that reach the water quickly move offshore. Their existence after emerging is not well understood but is probably pelagic (Carr, 1986).

Population Size

Kemp's ridley sea turtles are the most endangered of the sea turtle species. There is only a single known colony of this species, almost all of which nest near Rancho Nuevo, Tamaulipas, Mexico. An estimated 40,000 females nested on a single day in 1947, but since 1978 the number rarely reached 200 females on a single day. Estimates can be made of the female reproductive population by calculating the average number of nests per female per season (Marquez et al., 1982). Using this technique the estimated population estimate for breeding females would be 770.

Population estimates of immatures, males and solitary nesters is hard to develop because of the lack of data. Increased juvenile re-captures have been noticed in long-term tagging studies in the northeast Gulf of Mexico (USFWS and NMFS, 1992).

Kemp's ridleys also die at sea and wash ashore. NMFS, Sea Turtle Stranding and Salvage Network collects stranded sea turtles along both the Atlantic and Gulf Coasts (Teas, 1994). Based on 1993 data, 365 ridleys were report by the network. The largest portion was collected for the Gulf Coast (222 turtles) and mostly the western portion of the Gulf. Nearly equal numbers of ridleys were reported from the northeast and southeast Atlantic Coasts (62 and 81 turtles respectively).

Because of uncertainties with population estimates and human threats, the Kemp's ridley continues to be the most endangered sea turtle.

3.6.2 SEA TURTLE OCCURRENCE AND DISTRIBUTION IN THE DELAWARE RIVER ESTUARY

The use of near-shore and estuarine waters of the eastern United States by sea turtles is well documented (Lazell, 1980; Lutcavage & Musick, 1985; Bellmund et al, 1987; Keinath et al., 1987; Morreale et al., 1992; Burke et.al. 1993). Records of sea turtle occurrences in the Delaware River Estuary were compiled by PSE&G (PSE&G, 1989). However, these data merely document the occurrence of turtles at PSE&G's Salem Generating Station and at other locations in the estuary based on information from various sources such as Delaware Department of Natural Resources and Environmental Control and the Marine Mammal Stranding Center. No information has been obtained on habitat utilization in the Delaware River Estuary by sea turtles.

Five species of sea turtles have been reported from Delaware Bay and coastal New Jersey and Delaware. These sea turtle species are: loggerhead (Caretta caretta), Kemp's ridely (Lepidochelys kempii), green turtle (Chelonia mydas), leatherback (Dermochelys coriacea), and hawksbill (Eretomochelys imbricata). Three of these sea turtle species, Kemp's ridley, hawksbill and leatherback, are listed as endangered and two, the loggerhead and green turtle are listed as threatened. The loggerhead and Kemp's ridley are distributed throughout the Bay. The leatherback, green and hawksbill sea turtles occur primarily in the coastal areas of New Jersey and Delaware and around the mouth of the Bay.

Sea turtles have been observed and incidentally captured at Salem Generating Station and during field sampling associated with the station since 1977. A total of 92 sea turtles have been reported since 1979. The majority of these, 88, have been collected from the stations' circulating water intake trash racks. Of the 88 turtles from the intake, 62 (70.5 percent) were loggerhead sea turtles, 24 (27.3 percent) were Kemp's ridleys and, 2 (2.2 percent) were green turtles (Table 3-1).

Loggerheads were the more common of the three species captured from the CWS intake. The loggerheads captured ranged in length (straight-line carapace) from 29 to 70.1 centimeters. The number of loggerheads captured annually since 1980 ranged from zero to 23 (mean = 3.9). Forty-two of the 62 loggerheads captured were alive. Among the 20 dead turtles, 4 were considered fresh dead and had either collapsed lungs or internal infections or damage which may have contributed to their death. The other 16 were either moderately or severely decomposed. Necropsies available for these turtles showed evidence of boat propeller damage and internal infections.

Kemp's ridley sea turtles were less common than loggerheads. The Kemp's captured ranged in length from 17 to 32.5 centimeters. Annually, the number of Kemp's ridleys captured since 1980 ranged from zero to 6 (mean = 1.5). Fifteen of the 24 Kemp's ridleys were alive and released back into the wild. Among the 9 dead turtles, 4 were considered fresh dead and had collapsed lungs. The other 5 dead were either moderately or severely decomposed. Two of these animal showed evidence of boat propeller damage.

In 1994, the U. S. Army Corps of Engineers (USACOE) encountered sea turtles in the bay in conjunction with hopper dredging activities in the shipping canal (Reine & Dickerson, 1994). During this dredging, the USACOE performed protective relocation and assessment of sea turtle abundance. Through the use of trawls, they captured and relocated eight (8) loggerhead sea turtles that were encountered below Artificial Island in the

various ranges of the shipping channel. Seven (7) of these turtles were captured within the Liston Range of the Delaware Bay, which is located just south of Artificial Island. The size range of the turtles encountered included one adult (greater than 82.5 centimeters and seven juveniles (Frazer, 1983). The straight carapace length (SCL) of the adult was recorded as 88.0 centimeters, while the juveniles' SCL ranged from 46.4 to 55.4 centimeters. These size classes of loggerheads are consistent to the size classes encountered at the Salem Generating Station.

Strandings of sea turtles have also been reported by Delaware Division of Natural Resources and Environmental Control (DEDNREC) for the Delaware Bay and Atlantic Ocean. Since 1991, Delaware has reported over ninety strandings. Of these, forty (40) were within the Delaware Bay ranging from Bombay Hook to Lewes, Delaware. As shown in Table 3-2, loggerheads involved thirty-three (33) reports, Kemp's ridleys with three (3) reports, leatherbacks with three (3) reports and one (1) unknown.

Figure 3-7 summarizes the size class distribution for loggerheads in the Delaware Bay, from PSE&G, USACOE, and DEDNREC. It must be noted that most of the length information from DEDNREC is represented in curved carapace length. The majority of carapace length distribution ranges between 40 to 80 centimeters, representing both small and large juvenile class of loggerheads (Frazer, 1983).

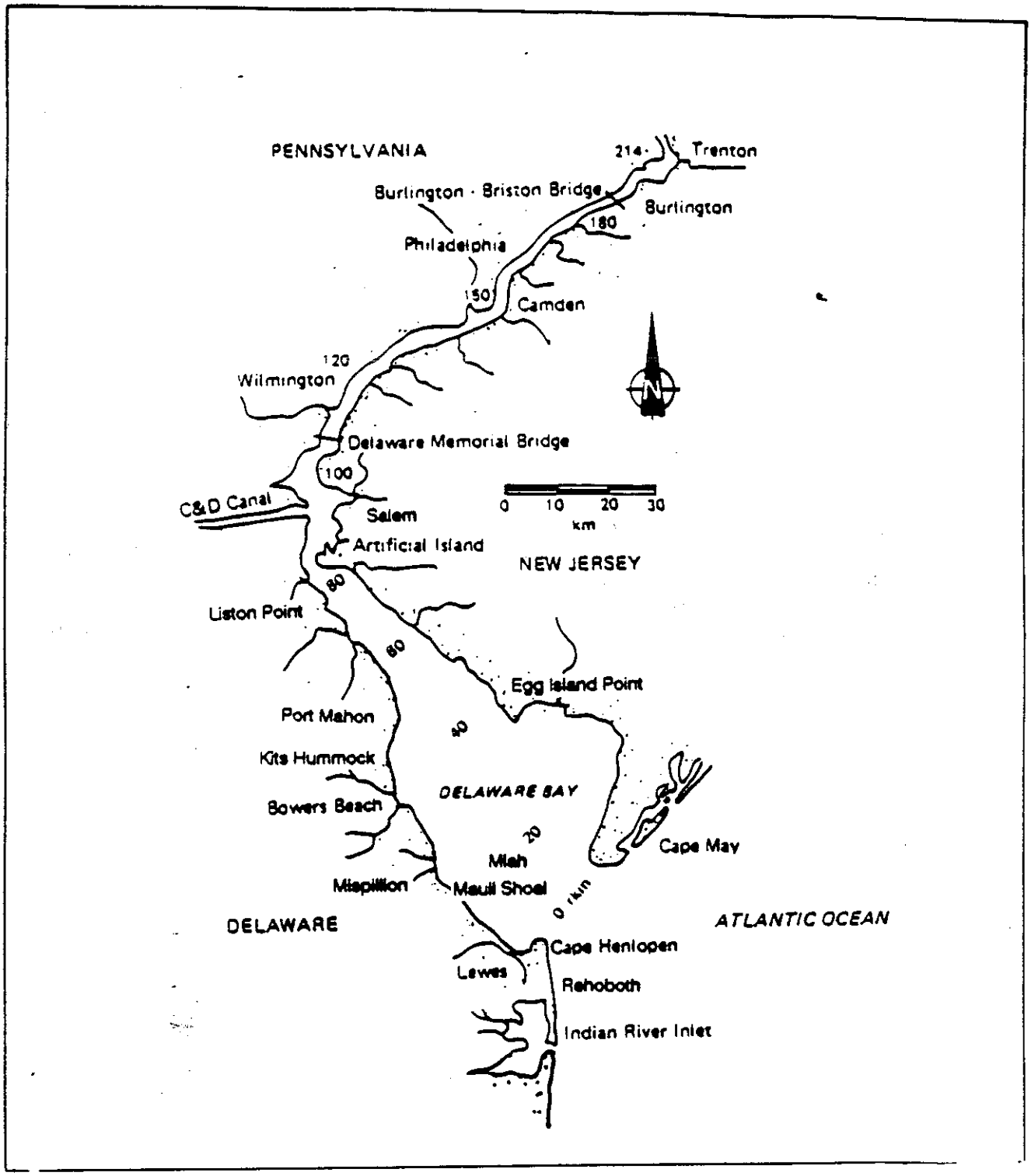


Figure 3-1. The Delaware River Estuary

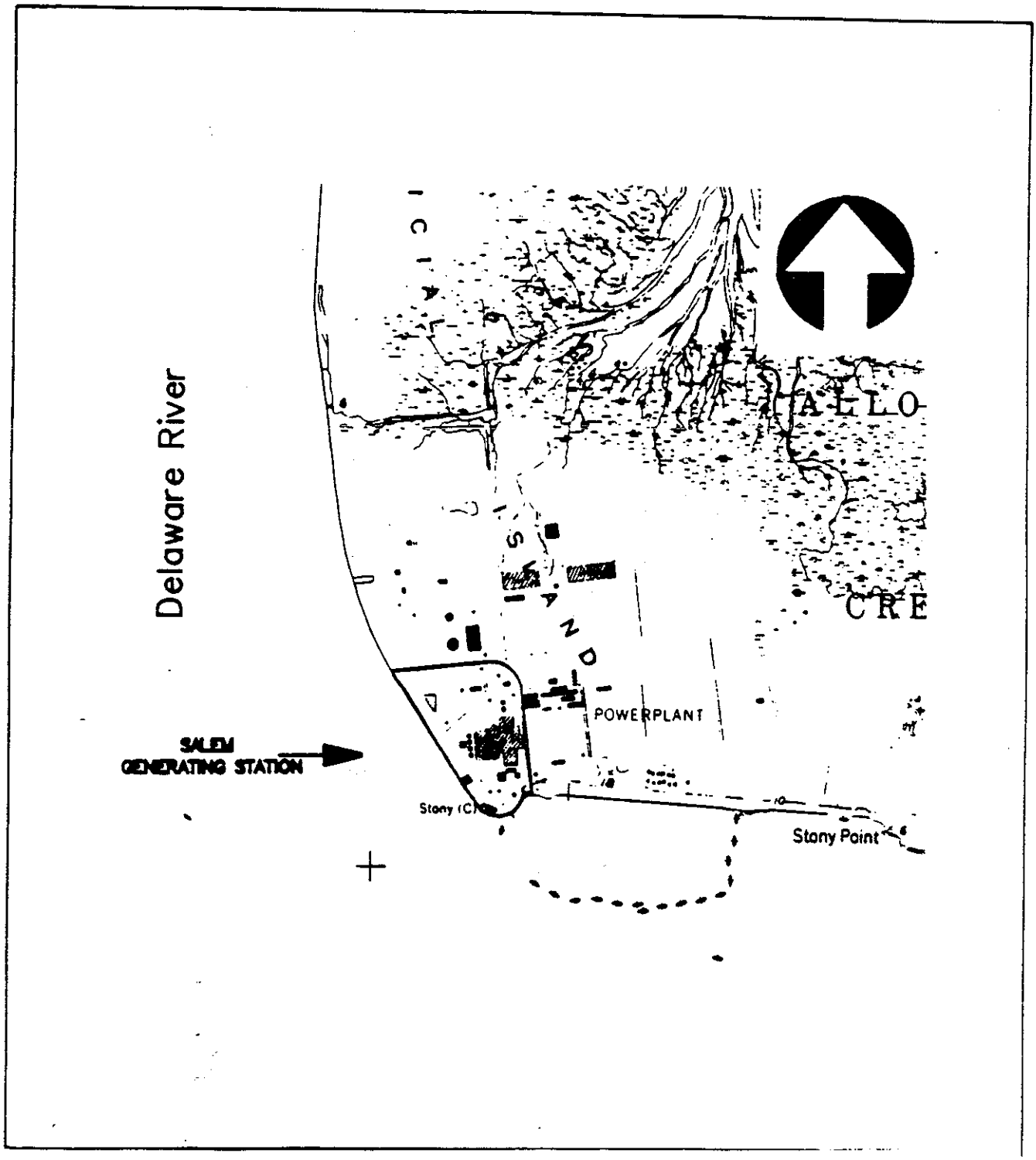


Figure 3-2. Site Location Map of Artificial Island

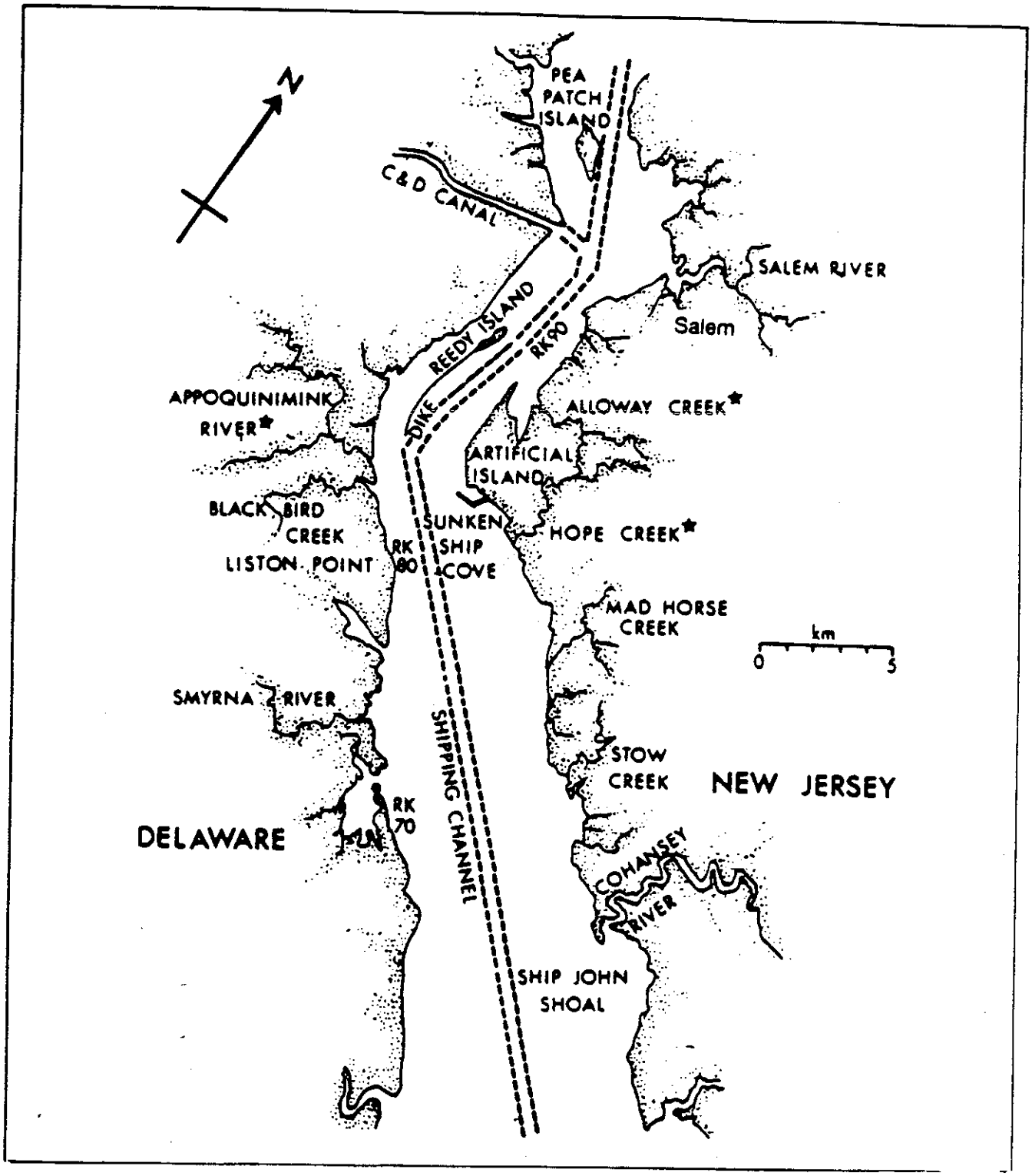


Figure 3-3. Delaware River near Artificial Island

Table 3-1

Listing of Sea Turtles Incidentally Captured at PSE&G's Salem Generating Station from 1980 to 1996

DATE	SPECIES	CSL* (cm)	CSW *(cm)	WEIGHT (kg)	CONDITION
7/11/80	Loggerhead	64	NA	NA	Dead
8/11/80	Kemp's Ridley	28	27	NA	Live
9/3/81	Loggerhead	46.4	41.5	NA	Live
9/8/81	Loggerhead	51	57.5	40.8	Dead
9/13/81	Loggerhead	52.3	43.1	NA	Dead
9/23/81	Kemp's Ridley	32.5	29	NA	Dead
7/10/82	Loggerhead	29	28	3.6	Dead
7/11/83	Loggerhead	45.6	41.7	14	Dead
7/13/83	Kemp's Ridley	23	21	1.83	Dead
7/19/83	Loggerhead	54	34	22	Dead
7/3/84	Loggerhead	35.56	NA	34.02	Dead
8/29/84	Kemp's Ridley	32.3	20.3	NA	Live
6/8/85	Loggerhead	48.3	35.6	7.9	Dead
6/11/85	Kemp's Ridley	25.4	24.1	2.27	Live
6/24/85	Kemp's Ridley	27.9	25.4	1.81	Dead
7/15/85	Loggerhead	52.5	43	15.9	Dead
8/5/85	Loggerhead	59	49.5	27.2	Dead
8/7/85	Loggerhead	50	40	29.5	Dead
8/10/85	Loggerhead	53	43	15.9	Live
9/30/85	Loggerhead	52	43	20	Dead
7/5/86	Kemp's Ridley	18.7	16.5	1	Dead
7/14/87	Loggerhead	40.6	38.1	13.6	Live
7/16/87	Loggerhead	40.5	35.5	11.3	Live
7/20/87	Loggerhead	69	54	36	Live
9/24/87	Kemp's Ridley	21	19	1.3	Live
9/24/87	Kemp's Ridley	25	22	2.3	Dead
9/29/87	Kemp's Ridley	23	22	2.2	Live
6/27/88	Kemp's Ridley	25	23	1	Dead
7/5/88	Kemp's Ridley	29	33	2	Live
7/5/88	Loggerhead	62	47	35	Live
7/9/88	Loggerhead	35	32	16	Live
7/12/88	Loggerhead	48	39	16	Dead
7/12/88	Loggerhead	37	32	7	Dead
7/12/88	Loggerhead	43	39	14	Dead
7/12/88	Loggerhead	43	38	14	Dead
7/15/88	Loggerhead	49	41	20	Dead
7/15/88	Loggerhead	61	46	36	Dead
7/1/89	Loggerhead	55.9	46.9	22.2	Live
7/25/89	Loggerhead	48.3	NA	17.2	Live
8/5/89	Kemp's Ridley	23	NA	1.9	Live
8/6/89	Kemp's Ridley	24	NA	2.2	Live
8/8/89	Kemp's Ridley	25.6	NA	2.7	Live
8/30/89	Kemp's Ridley	23	NA	2.3	Live
9/6/89	Kemp's Ridley	17	NA	1.45	Dead
9/23/89	Kemp's Ridley	30	NA	4.87	Live

Table 3-1 (Continued)

Listing of Sea Turtles Incidentally Captured at PSE&G's Salem Generating Station from 1980 to 1996

DATE	SPECIES	CSL* (cm)	CSW* (cm)	WEIGHT (kg)	CONDITION
6/5/91	Loggerhead	49.5	41.9	20.41	Live
6/11/91	Loggerhead	46.8	NA	15.9	Live
6/15/91	Loggerhead	70.1	NA	31.75	Live
6/23/91	Loggerhead	46.4	NA	18.03	Live
6/24/91	Loggerhead	49.9	NA	NA	Dead
6/27/91	Kemp's Ridley	26.4	25.3	2.72	Live
6/27/91	Loggerhead	57.4	NA	29.48	Live
7/1/91	Loggerhead	57.3	NA	32.55	Live
7/3/91	Loggerhead	51.5	NA	23.93	Live
7/4/91	Loggerhead	44.2	38.9	15.76	Live
7/7/91	Loggerhead	52.9	46.9	27.1	Live
7/9/91	Loggerhead	50.9	44.5	20.4	Live
7/9/91	Loggerhead	58.8	47.9	31.64	Live
7/11/91	Loggerhead	44.6	39.3	15.76	Live
7/20/91	Loggerhead	47	41	15.88	Live
7/23/91	Loggerhead	49.5	43.9	19.28	Live
7/25/91	Loggerhead	51.15	48.3	25.86	Live
8/1/91	Loggerhead	48.9	41	19.05	Live
8/1/91	Loggerhead	39.4	33.9	8.62	Live
8/7/91	Loggerhead	46.5	40.5	17.27	Live (R-7/11/91)
8/24/91	Loggerhead	53.9	46.4	23.1	Live (R-7/9/91)
9/8/91	Loggerhead	46.4	38.6	16.33	Live
9/9/91	Loggerhead	56.8	48.2	28.58	Live
9/10/91	Loggerhead	49.7	43.1	19.96	Live
9/16/91	Green	37.8	32.1	8.16	Live
6/18/92	Loggerhead	53.3	46	21.4	Live
7/29/92	Loggerhead	48.2	43.4	17.7	Live
8/28/92	Loggerhead	52.3	46.6	27	Live
8/31/92	Green	29.9	24.2	3.9	Dead
9/1/92	Loggerhead	50.2	42.3	23.2	Live
9/1/92	Kemp's Ridley	25.8	24.6	2.95	Dead
9/4/92	Kemp's Ridley	28.8	22.5	1.6	Dead
9/9/92	Loggerhead	59.4	54.4	32.7	Live
9/11/92	Loggerhead	50.6	43.2	21.5	Live
9/12/92	Loggerhead	48.4	41.3	17.27	Live
9/19/92	Loggerhead	51.9	44.5	24	Live
9/20/92	Loggerhead	61.7	52.6	34.5	Live
9/22/92	Loggerhead	54.2	46.7	25.5	Live
9/28/92	Kemp's Ridley	25.4	23.1	2.3	Live
10/2/92	Kemp's Ridley	25.4	23.1	2.3	Live (R-9/28/92)
7/17/93	Kemp's Ridley	24.6	22.3	2.05	Live
6/24/94	Loggerhead	47.4	41.7	18.43	Live
7/2/95	Loggerhead	51.1	NA	NA	Dead

TOTAL NUMBERS: Loggerhead = 62
Kemp's Ridley = 24
Green = 2

* CSL = carapace straight length and CSW = carapace straight width

Table 3-2

Listing of Sea Turtle Strandings Reported by Delaware Division of Natural Resources and Environmental Control

DATE	SPECIES	SIZE*	LOCATION	CONDITION**
6/6/91	Leatherback	NA	Slaughter Beach	SD
6/13/91	Loggerhead	NA	Pickering Beach	MD
8/1/91	Loggerhead	SCL = 81.28 cm	Lewes Beach	MD
12/1/92	Kemp's	CCL = 34 cm	Slaughter Beach	Dried Carcass
6/14/93	Loggerhead	CCL = 75.3 cm	Big Stone Beach	MD
7/21/93	Loggerhead	CCL = 116.84 cm	Big Stone Beach	MD
8/27/93	Loggerhead	CCL = 121.92 cm	Prime Hook Beach	MD
9/2/93	Loggerhead	CCL = 91.44 cm	Brockonbridge Ditch	MD
9/3/93	Loggerhead	CCL = 57.15 cm	Kitts Hammock	MD
9/27/93	Loggerhead	NA	1 mile offshore between Simmons River and Leipsic River	MD
9/27/93	Loggerhead	CCL = 81.28 cm	Bombay Hook	MD
8/8/94	Loggerhead	SCL = 74.93 cm	Broadkill Beach	Fresh Dead
9/23/94	Loggerhead	NA	Slaughter Beach	Fresh Dead
10/5/94	Loggerhead	CCL = 63.5 cm	Slaughter Beach	MD
10/18/94	Loggerhead	SCL = 60.96 cm	Fowlers Beach	Fresh Dead
10/19/94	Loggerhead	CCL = 58.42 cm	Woodland Beach	MD
10/27/94	Unknown NA		Fowlers Beach	Bones
11/8/94	Loggerhead	SCL = 60.96 cm	Big Stone Beach	Dried Carcass
6/25/95	Loggerhead	SCL = 49.53 cm	Prime Hook Beach	SD
6/27/95	Loggerhead	SCL = 101.6 cm	Big Stone Beach	MD
7/3/95	Loggerhead	SCL = 76.84 cm	Pickering Beach	MD
7/13/95	Loggerhead	CCL = 54.61 cm	Pierson Cove	Alive
7/24/95	Leatherback	CCL = 149.86 cm	Lewes Canal	MD
8/8/95	Loggerhead	CCL = 48.26 cm	Slaughter Beach	MD
8/18/95	Loggerhead	CCL = 60.96 cm	Broadkill Beach	MD
8/29/95	Loggerhead	CCL = 76.2 cm	Woodland Beach	Alive
9/1/95	Leatherback	CCL = 186.69 cm	Broadkill Beach	SD
9/27/95	Loggerhead	SCL = 55.88 cm	Big Stone Beach	MD
9/27/95	Loggerhead	NA	Big Stone Beach	Skeleton
9/29/95	Loggerhead	CCL = 60.96 cm	Prime Hook	MD
9/30/95	Loggerhead	CCL = 68.9 cm	Slaughter Beach	MD
11/6/95	Kemp's	SCL = 33.02 cm	Broadkill Beach	Skeleton
6/24/96	Loggerhead	CCL = 68.58 cm	Little Creek	SD
9/14/96	Loggerhead	NA	Big Stone Beach	SD
9/21/96	Kemp's	CCL = 53.34 cm	Prime Hook Beach	Skeleton
9/26/96	Loggerhead	CCL = 86.36 cm	Big Stone Beach	Alive
10/3/96	Loggerhead	CCL = 60.96 cm	Little Creek	SD
10/10/96	Loggerhead	CCL = 60.96 cm	Pickering Beach	Alive
10/11/96	Loggerhead	CCL = 50.17 cm	Lewes	MD
10/12/96	Loggerhead	CCL = 82.55 cm	Lewes	MD

* CCL = curved carapace length and CCW = curved carapace width
** SD = severly decomposed and MD = moderately decomposed

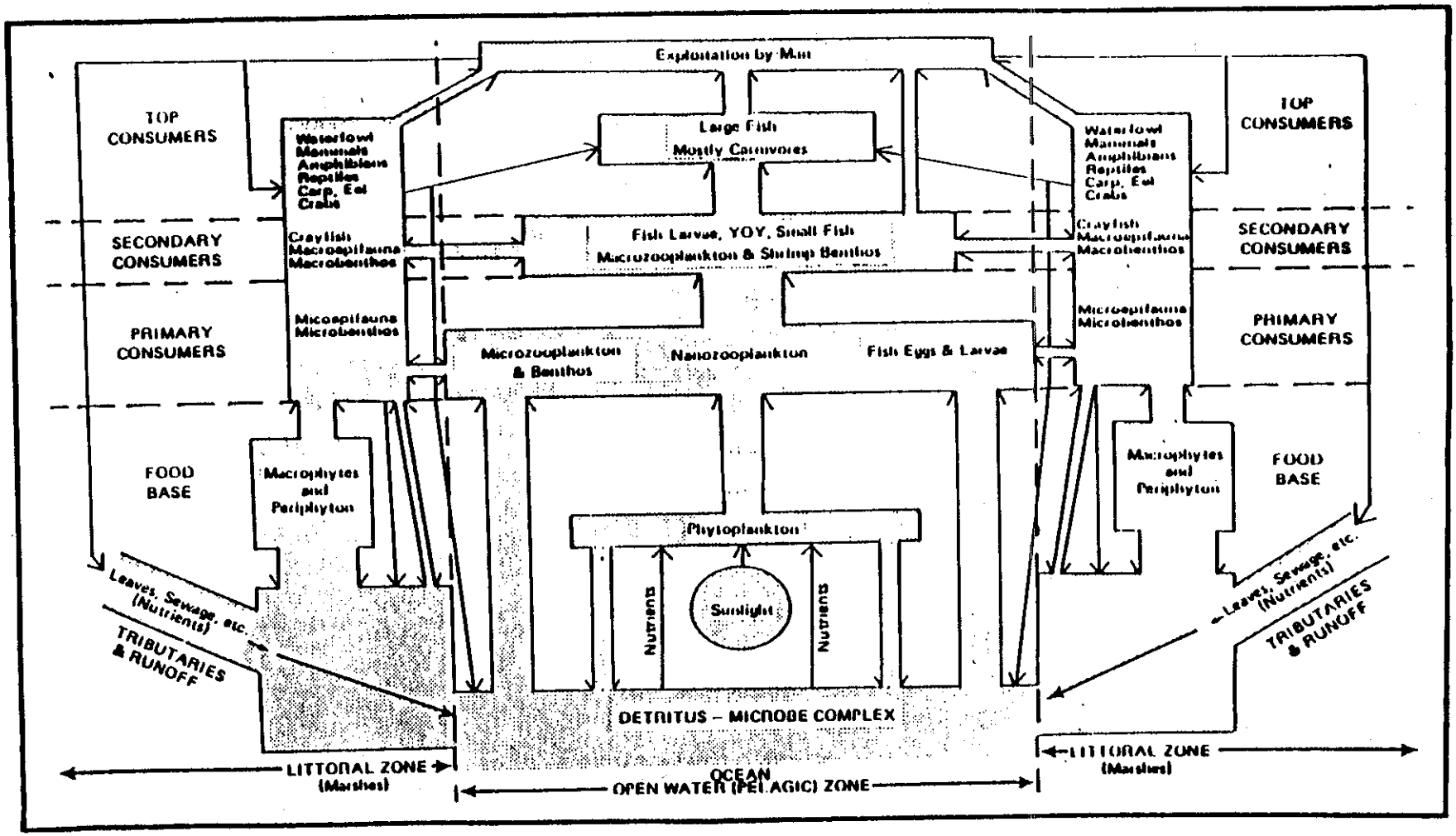


Figure 3-4. Conceptual Energy Flow Diagram for the Delaware Estuary

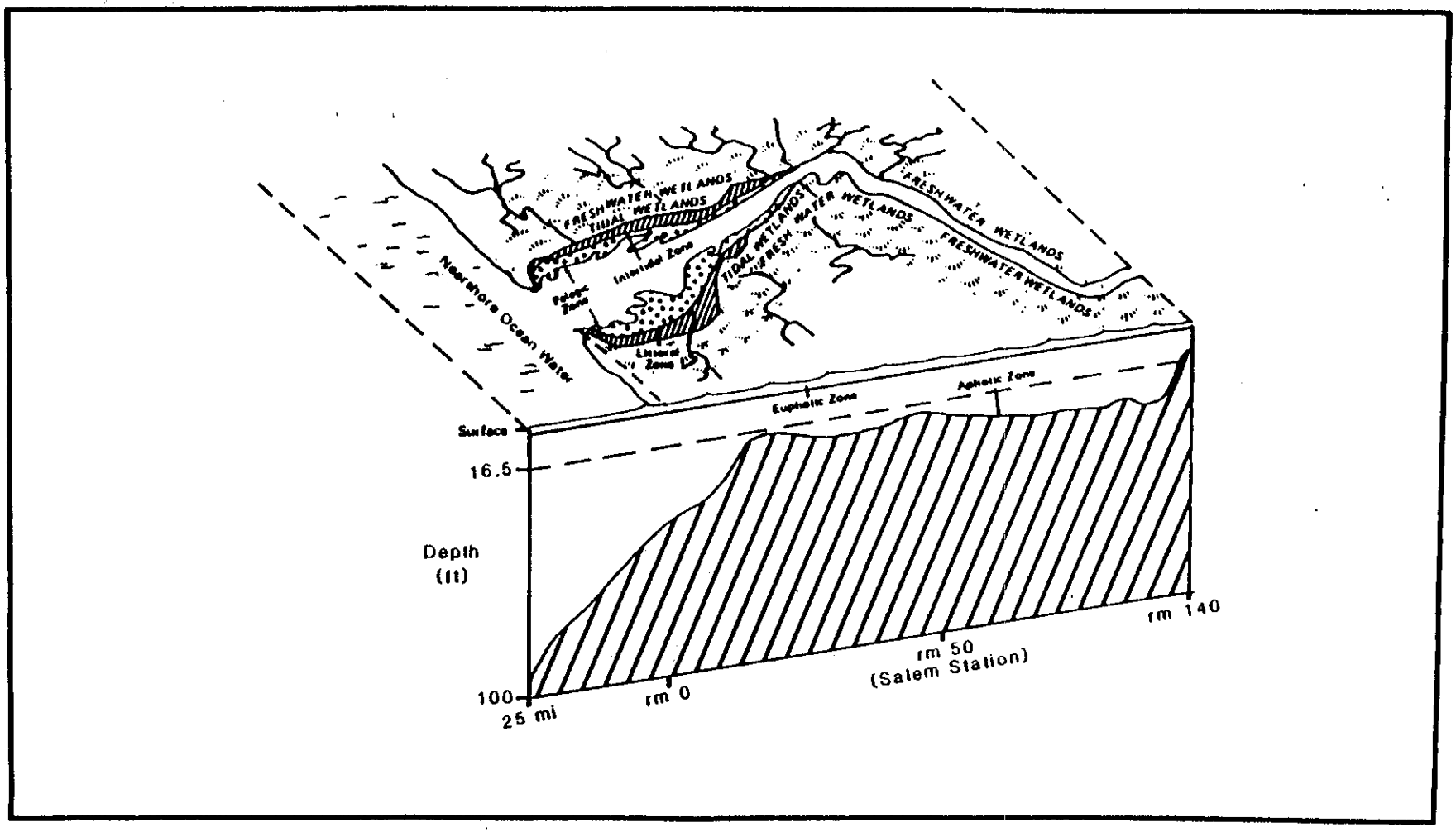


Figure 3-5. Conceptual Diagram of Habitat Zones for Typical Estuaries such as the Delaware Estuary

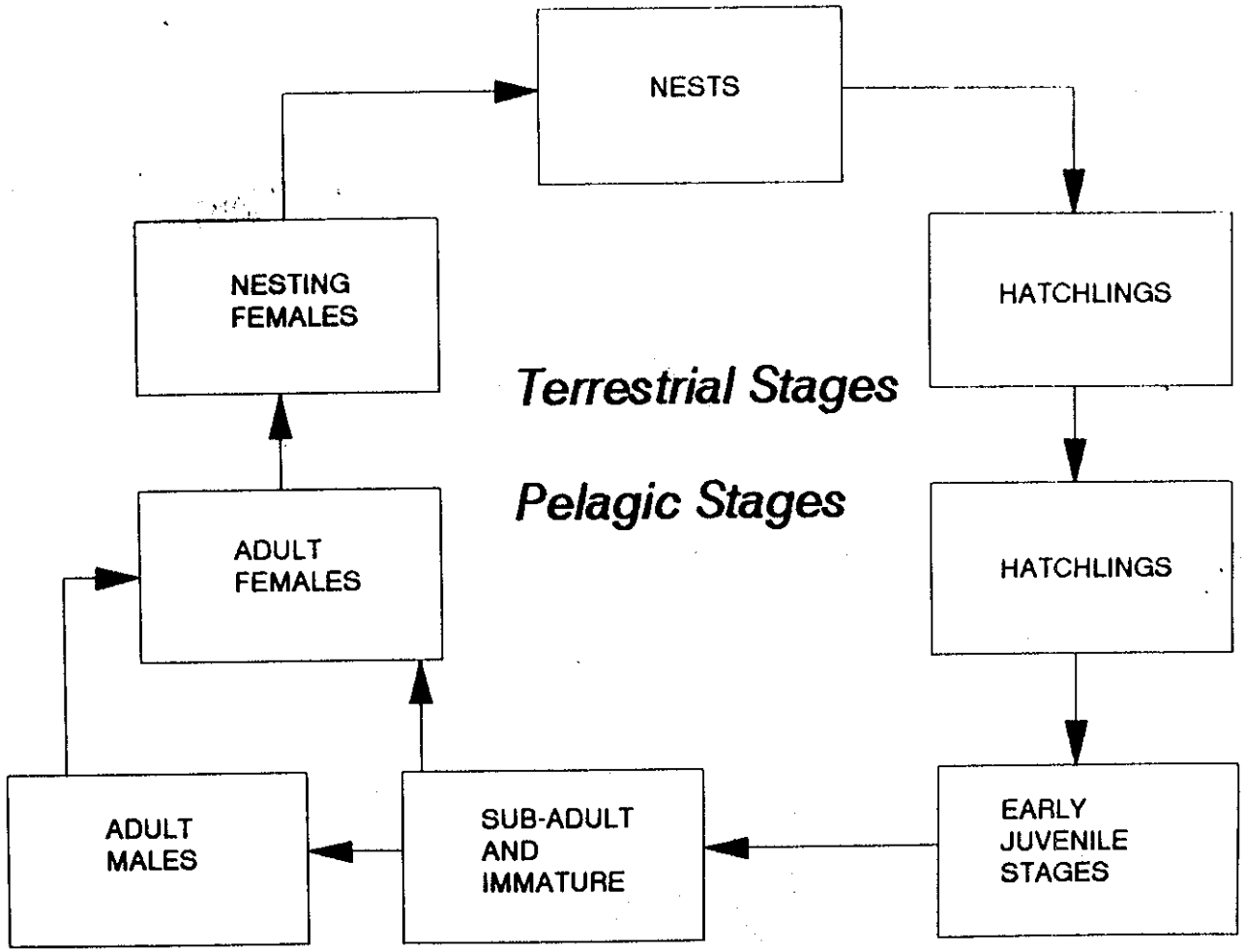
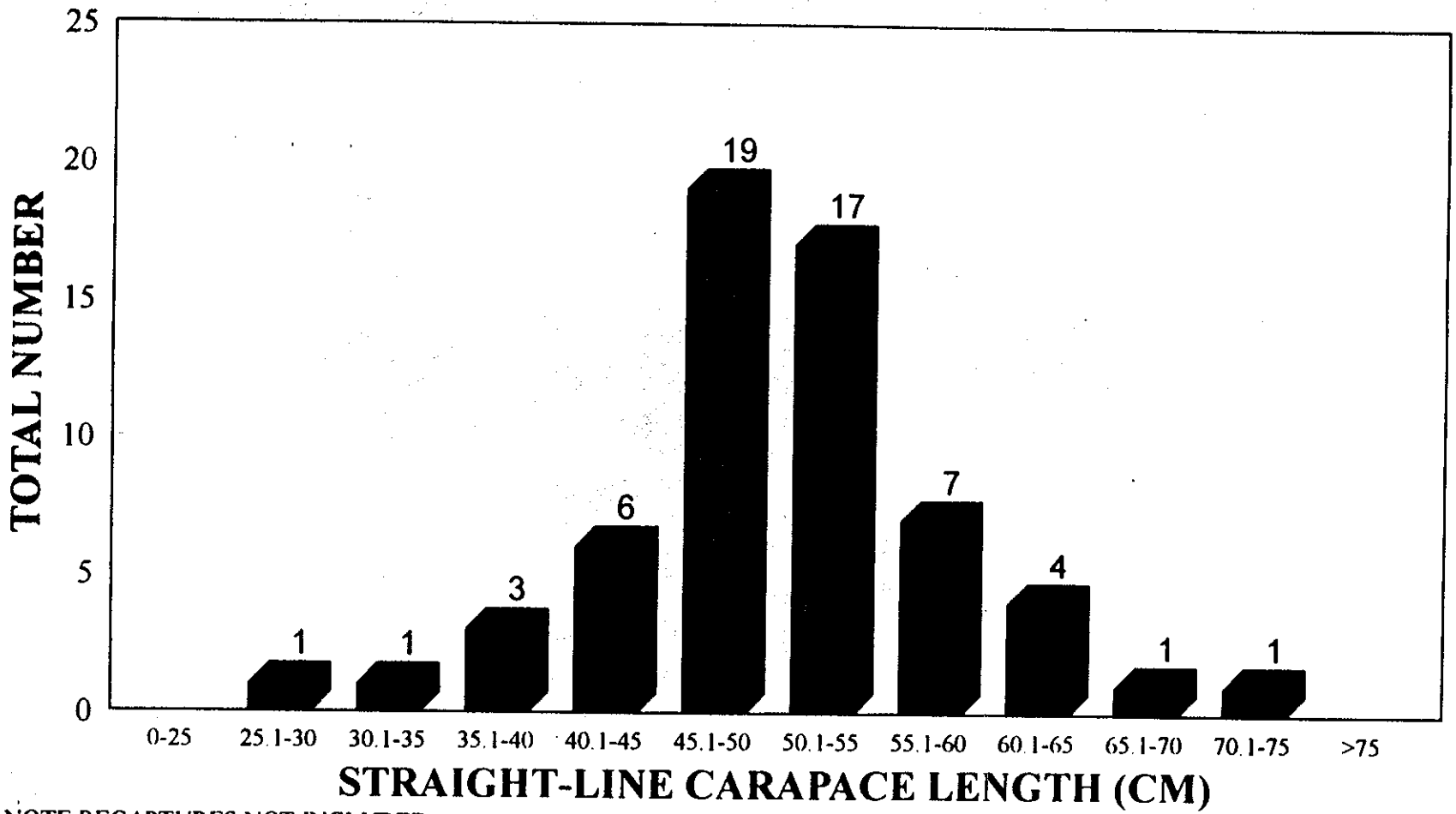
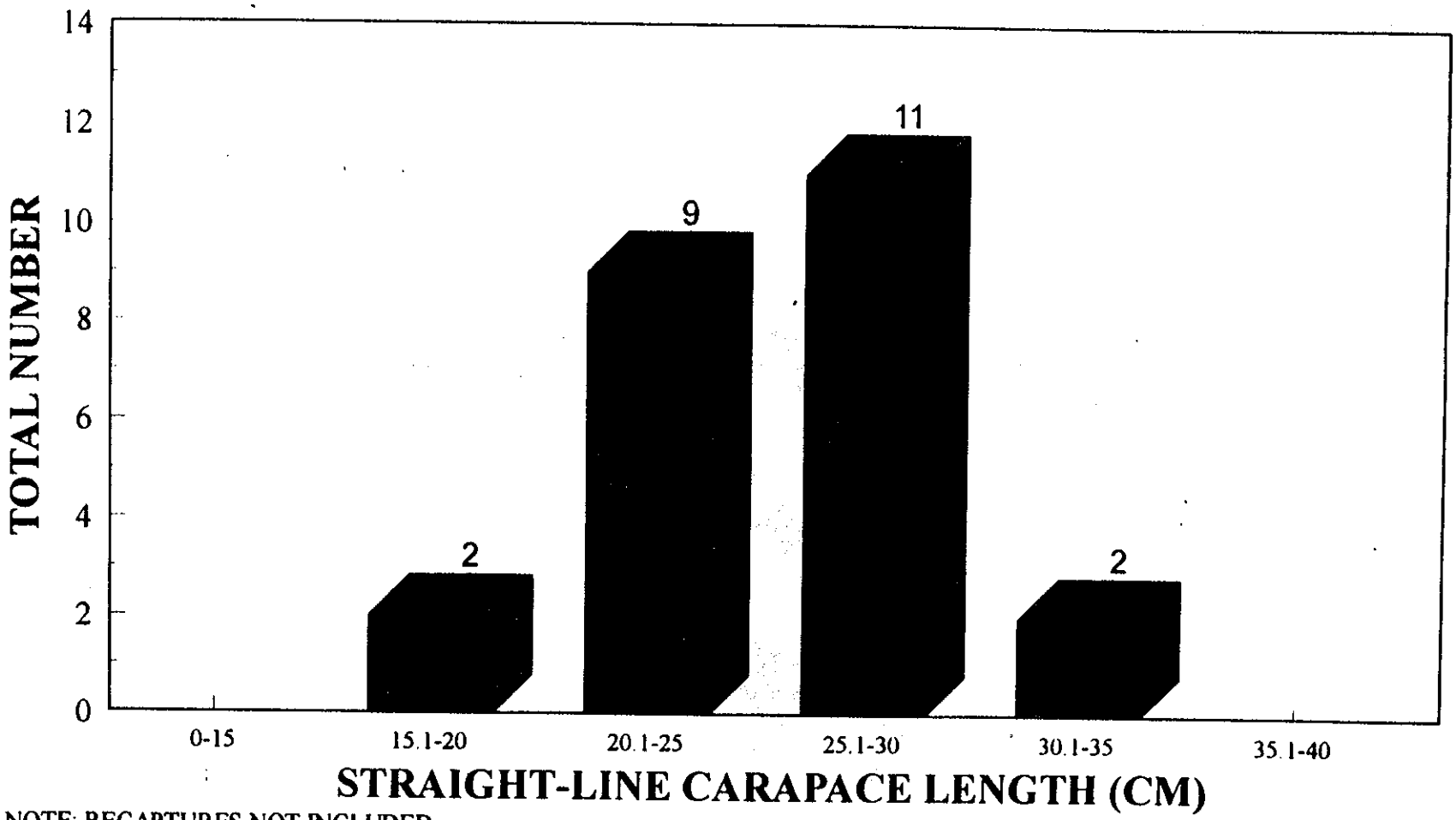


Figure 3-6. Generalized Sea Turtle Life Cycle



NOTE: RECAPTURES NOT INCLUDED

Figure 3-7. Size Class Distribution of Loggerhead Sea Turtle Occurrences at Salem Generating Station from 1980 to 1996



NOTE: RECAPTURES NOT INCLUDED

Figure 3-8. Size Class Distribution of Kemp's Ridley Sea Turtle Occurrences at Salem Generating Station from 1980 to 1996

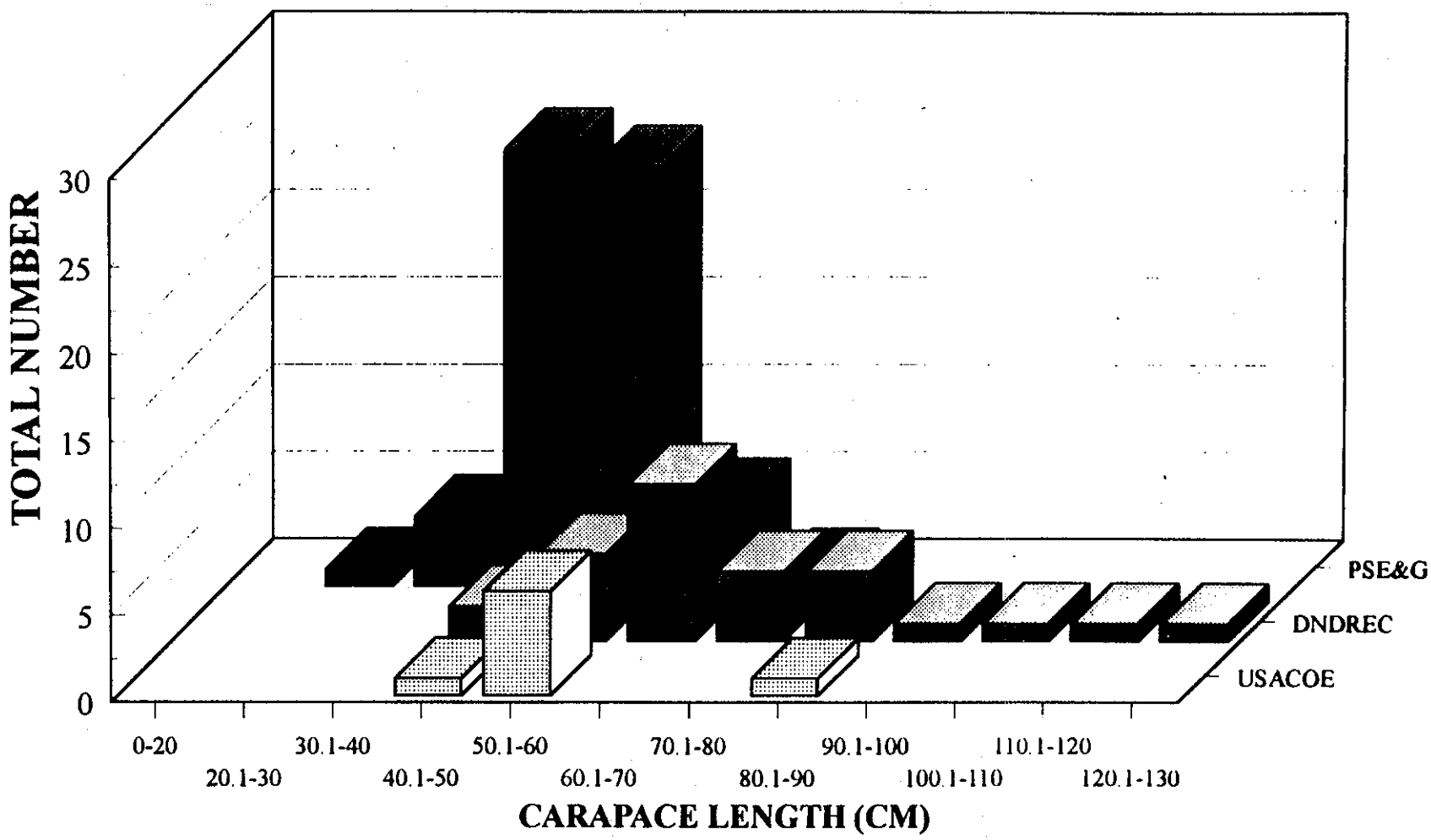


Figure 3-9. Size Class Distribution of Loggerhead's Encountered in the Delaware Estuary

SECTION 4.0
METHODS AND MATERIALS

Sonic, radio and satellite transmitters have often been used to investigate sea turtle behavior and habitat use in near-shore waters (Stoneburner, 1982; Mendonca & Pritchard, 1986; Danton & Prescott, 1988; Morreale et al, 1989; Murphy & Hopkins-Murphy, 1990; Yano & Tanaka, 1991; Renaud & Carpenter, 1994). In order to address NMFS, Incidental Take Statement, Item No. 7, PSE&G agreed to initiate a sonic/satellite turtle tracking program. The intent of this program was to observe the movement and habitat use of sea turtles in the Delaware Estuary in general and relative to the Salem Generating Station. Movements relative to the station were of interest in determining whether the Salem Generating Station served as an attractant for sea turtles. Standard mark and recapture tagging for these turtles was also done in cooperation with NMFS, Cooperative Marine Turtle Tagging Program.

4.1 PRELIMINARY HANDLING OF SEA TURTLES USED IN STUDY

Sea turtles used for the study where those that were incidentally taken at the Salem Generating Station Circulating Water Intake Structure (CWS) from 1992-1996. PSE&G encountered a total of eighteen (18) sea turtles at the Salem Generating Station during this time period, twelve (12) loggerheads, one (1) green, and five (5) Kemp's ridleys (Figure 4-1). The monthly distribution of the total turtles showed over 50 percent of the total turtle takes occurred in September (Figure 4-2). As shown in Figures 4-3 and 4-4, the size class distribution of the turtles during 1992 to 1996 placed them into the small and large juvenile class (Frazer, 1983). The size class distribution for loggerheads and Kemp's is consistent with those seen historically from 1980 through 1996 (Figures 3-4 and 3-5).

In order for a turtle to be a candidate for the "tracking program" it needed to be a larger, healthy animal. Due to the size range of the turtles encountered at the site, the study focused on loggerheads which ranged from 8.6 to 40.8 kilograms (18.9 to 89.8 pounds). Kemp's ridley and green sea turtles which were occasionally taken typically weighed under 8.2 kilograms (19.6 pounds) and were not large enough to handle the transmitter array or numerous enough to design a second transmitter package. The general health of any loggerhead turtle considered for tagging was assessed by an on-call veterinarian

who also assisted with the preparation of the carapace for attaching the transmitter array. Normally the turtle was held in the on-site holding tanks for up to 48-hours to assess its health. Once it was determined that an animal was suitable for the "tracking program" it was transported by boat to a release location approximately 3.5 miles downstream of the Salem Generating Station and released. Upon the release of a tagged turtle, PSE&G immediately started tracking the turtle using both satellite and sonic techniques. In the case of inclement weather, turtles were released from land at the mouth of Stow Creek, and tracked when weather conditions improved.

In support of the Cooperative Marine Turtle Tagging Program (CMTTP) coordinated by the National Marine Fisheries Service, Southeast Fisheries Center, PSE&G attached two metal flipper tags on each sea turtle released since August 1991. Guidance for the proper application of these tags was provided to PSE&G by NMFS Southeast Fisheries Center. Prior to use, the tags were thoroughly washed with betadine to remove any oily residue on the metal. Betadine was also used on the flipper area before and after tag application. Figure 4-5 depicts the proper use of the tag applicators and appropriate tagging sites on the front flippers. Each metal tag was engraved with a unique identification number. These numbers were recorded, along with other pertinent information such as carapace lengths and widths and animal weights prior to release. Annually, this information was forwarded to NMFS Southeast Fisheries Center.

PSE&G was also advised by NMFS and the U.S. Fish and Wildlife Service that it would be appropriate for them to obtain a Scientific Research permit to handle the endangered and threatened species during the course of these studies. This permit was issued to PSE&G on July 28, 1993 (Scientific Research Permit #871) and authorized research on loggerhead, Kemp's ridley, and green sea turtles that have been incidentally taken at the Salem Generating Station. This permit also limited the number of individuals which could be equipped with transmitters annually to five animals.

4.2 SONIC TRACKING

The sonic tracking system selected for use by PSE&G was manufactured by Sonotronics. The system was comprised of transmitters, a receiver, a hydrophone and headphones. The receiver used by PSE&G was a Sonotronics Model USR-5W. This receiver was used with a Sonotronics Model DH-2 hydrophone which was used for tracking the transmitter signals. Standard depth tags (transmitters), Model DT-88-M have been used to date. This sonic transmitter along with the satellite transmitter were attached to a 1/16-inch nylon seine twine tether, with a weak link between the turtle and transmitters (see Figures 4-6 to 4-8). The weak link was a low strength (15 to 20 pound break point) plastic wire tie designed to break should the tether become entangled with an obstruction. The tether was attached to the turtles carapace by passing it through a 3/16-inch hole drilled through the margin of the postcentral scute. The overall weight of this transmitter assembly was 0.5 kilograms (1.2 pounds).

Plots developed from the sonic tracking data indicate the position of the tracking boat. Since the sonic transmitters send signals that were located using a receiver and headphones, the location of the boat was noted in relationship to the turtle. The crew recorded the locations of the strongest signals to stay with the turtle as it moved. Generally, 48-hours worth of data was obtained for each specimen released. However, the second 48-hour set of data was difficult to obtain because of the premature loss of the transmitter array within the two week period between sonic efforts.

During the sonic tracking, PSE&G utilized a 27-foot boat, manufactured by Parker Marine Enterprises, Inc., with a standard crew of two. To cover the 48 hours, shifts were established either in 12 or 24 hour increments. To change crews, the turtle's last location was recorded so that the crew could change at Artificial Island. This posed some drawbacks, due to the movement of the turtle during this change and resulted in losing some turtles if the satellite unit was not available to locate it.

4.3 SATELLITE TRACKING

After discussions with other researchers who had used satellite tracking techniques for observing the movement and behavior of sea turtles, PSE&G selected the Argos global satellite-based location and data collection system for use in the Delaware River. This system has been in use by wildlife researchers since 1978 and was established under agreement between the United States National Oceanic and Atmospheric Administration (NOAA), National Aeronautics and Space Administration (NASA) and the French Space Agency, Centre National d'Etudes Spatiales (CNES). Argos is operated by Collecte, Localisation, Satellites (CLS) and its subsidiary in the United States, Service Argos, Inc. The Argos System allows for the location of mobile platforms carrying suitable transmitters, anywhere in the world, to within 350 meters. The specific transmitter used by PSE&G in this application was a Telonic ST-6 Platform Transmitter Terminal (ST-6 PTT) which is designed for use on large to medium sized animals. The ST-6 PTT is designed specifically to operate through the Argos System.

The transmitter was enclosed in a 1.5 inch tubular plastic housing 13 inches long with a foam flotation at the top and antenna. This transmitter along with the sonic transmitter were attached to a 1/16-inch nylon seine twine tether, with a weak link between the turtle and transmitter array. This transmitter array and its attachment to the turtles carapace have been discussed in detail in Section 4.2. Figures 4-6 to 4-8 depict the general arrangement of the transmitter assembly and the method of attaching the transmitter assembly to the turtles carapace.

Messages from transmitters attached to the sea turtles were automatically sent to the Argos packages flown on NOAA satellites. The satellite orbit is polar (i.e. satellite sees the north and south poles on each orbital revolution) and at any instant the satellite sees all transmitters within a 5,000 kilometer diameter circle. The messages received by the Argos packages on board the satellite are re-transmitted to a ground station when they come into view. Each transmitter is seen by the satellite six to twenty-eight times a day depending on transmitter latitude.

The Argos global processing centers (GPC's) located in Landover, Maryland and Tolouse, France received the raw data from the ground stations, calculated the transmitter platform locations, processed sensor data and distributed results. Results were available on line from the GPC's for up to four days after they were received and were accessed by PSE&G by use of standard modems and data networks. More specifically, Enhanced Location

Software for Argos (ELSA Version 4.0) connected into the Argos system via data distribution networks and downloaded the results to NBU personal computers. The ELSA Program also sorted, stored and displayed the data on a regional map of the Delaware River. These plots and the corresponding tabular transmitter position information were used to examine each sea turtles movement and habitat usage.

The data PSE&G received from the Argos global processing center in Maryland included the latitude and longitude of the transmitter location, the time the signal was received, and a classification of the signal quality. Signals were classified as 0, 1, 2 or 3 with "3" being the best signal and "0" the worst signal. The quality of the signal is reflective of the accuracy of the location which can be affected by satellite position, weather and location of the transmitter. The more transmissions which are made to a passing satellite tends to increase the quality of the signal and more accurately defines the position of the animal being tracked.

PSE&G used it's Geographic Information System (GIS) to perform the necessary data reduction of Argos latitude and longitude values. These data points were loaded into an Oracle database, converted to the mapping plane, merged with the PSE&G landbase, processed into appropriate output data sets and plotted. The GIS software platform is MicroStation GeoGraphics (Bentley Systems Inc. Exton, Pennsylvania) employing the Oracle Relational Data Base Management System. Map products were produced with a Versatec 600 dpi laser plotter. The plots indicate the location and time of the transmission for each turtle. The direction of the turtle symbol indicates the progressive movement of the turtle from point to point. Tide data from Reedy Point, DE is also displayed on the plot for reference of the turtles movements with the tidal cycle. A full size set of the plots are included at end of the report.

Data provided by Argos also indicated the time the signal was received. This information was used to calculate the habitat usage of the turtles. The Delaware Estuary was characterized into four major habitats: New Jersey shoreline, Shipping channel, Delaware shoreline, and Tributary streams both New Jersey and Delaware. By calculating the lapsed time between two transmissions, the period the turtle stayed in each particular habitat could be estimated.

Several problems were encountered with the satellite tracking program. These problems included: 1) premature loss of transmitters because of overly conservative tether line strength; and, 2) transmitter battery failures. These problems resulted in satellite tracking times for sea turtles ranging from 2 to 27 days. Questionable transmitter positions were checked against sonic positions for the same animal when possible. Bad values were discarded based on sonic data but if no sonic data was available for verification questionable data could not be arbitrarily discarded. This results in several instances where turtles are located in upland areas.

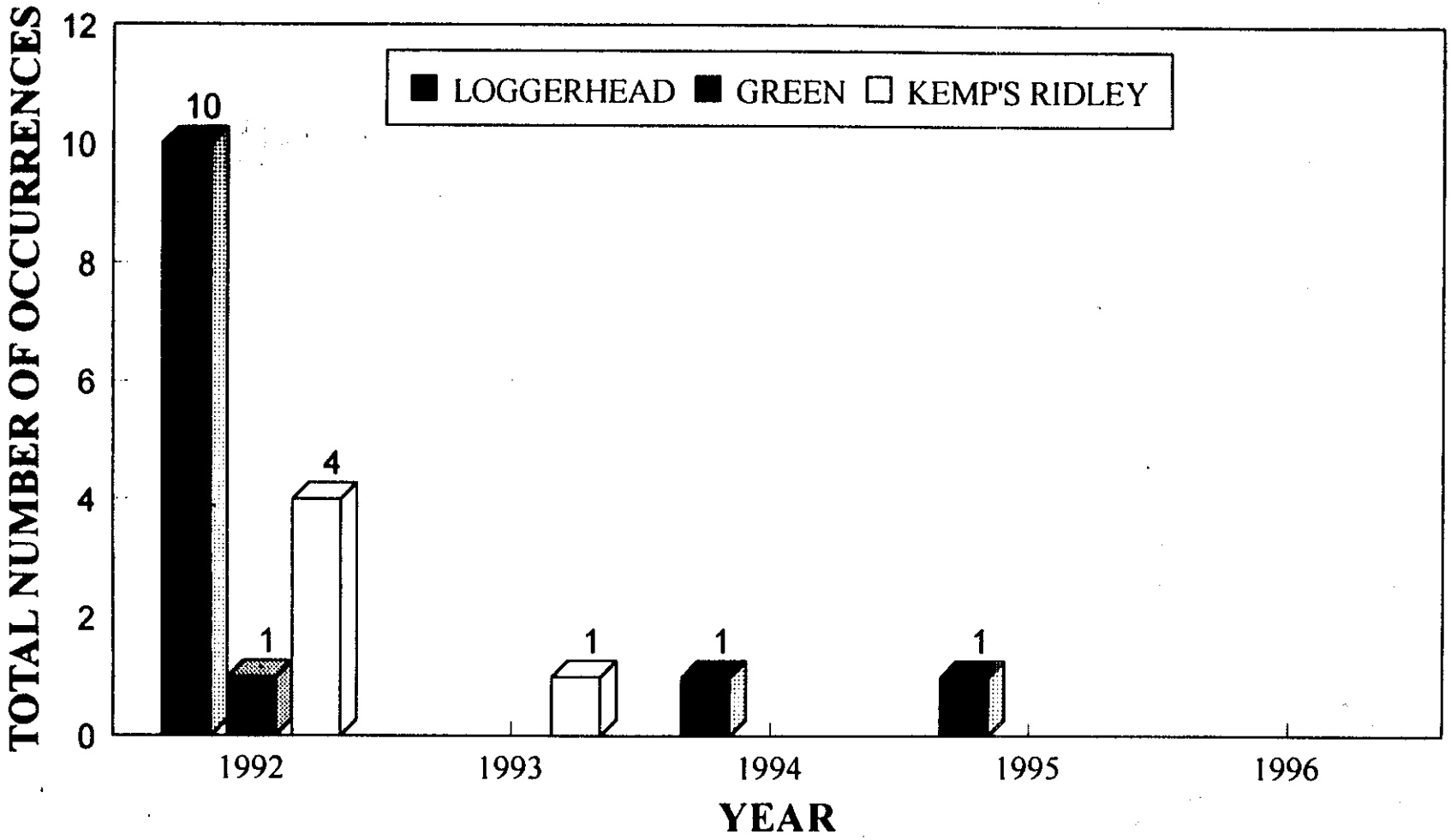


Figure 4-1. Number of Sea Turtle Occurrences Per Year at Salem Generating Station from 1992 to 1996

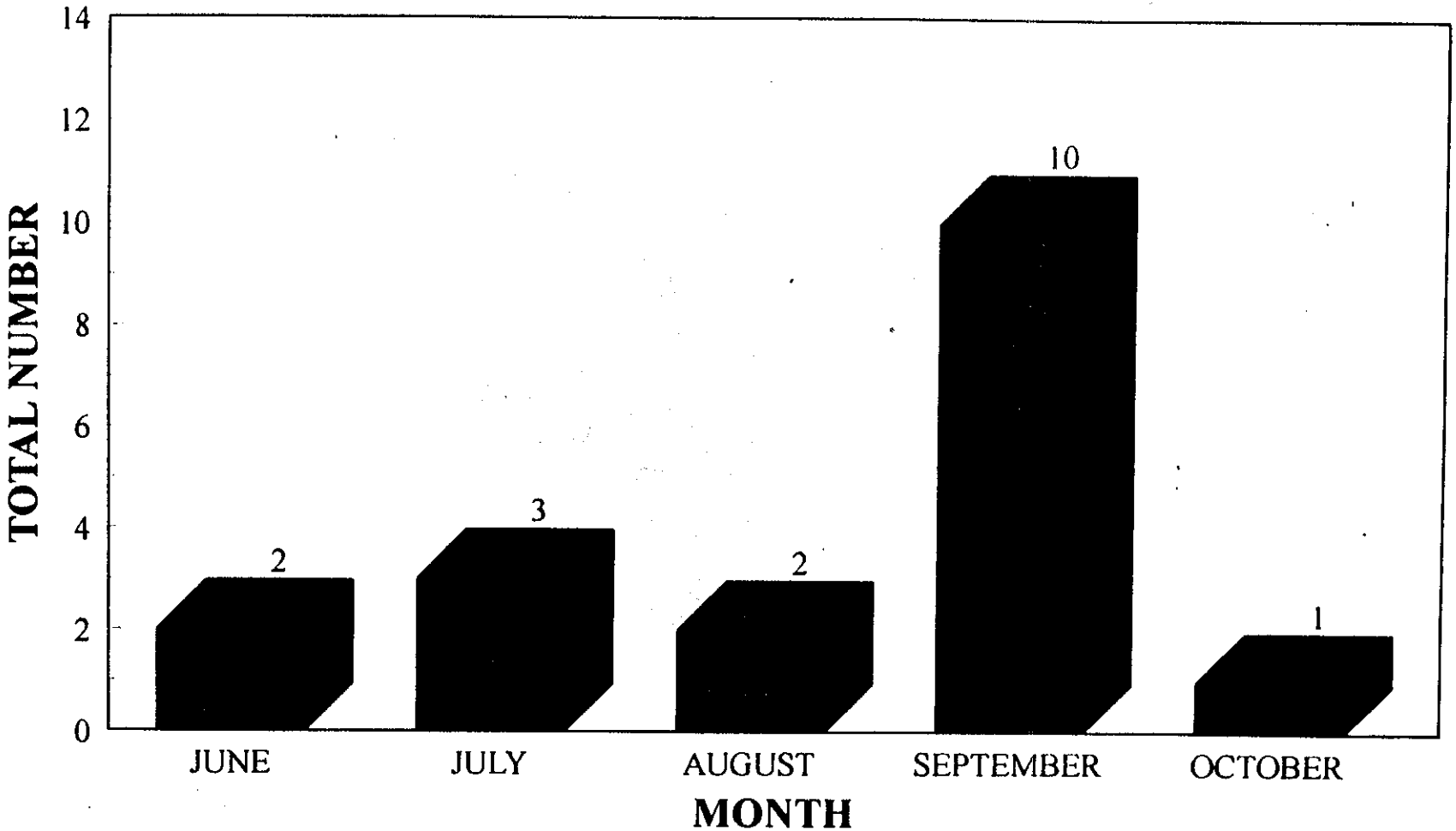


Figure 4-2. Monthly Distribution of Sea Turtle Occurrences at Salem Generating Station from 1992 to 1996

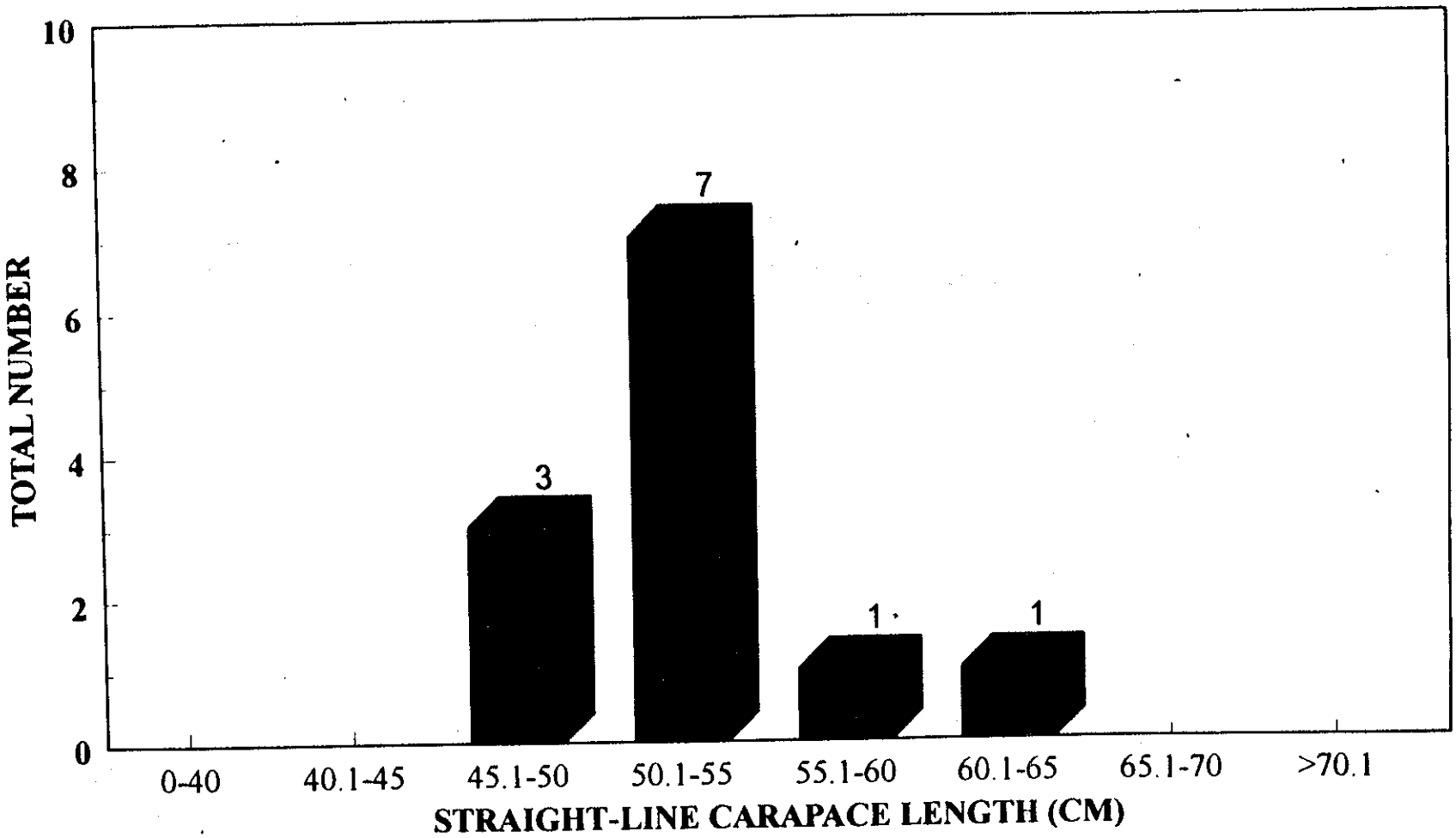


Figure 4-3. Size Class Distribution of Loggerhead Sea Turtle Occurrences at Salem Generating Station from 1992 to 1996

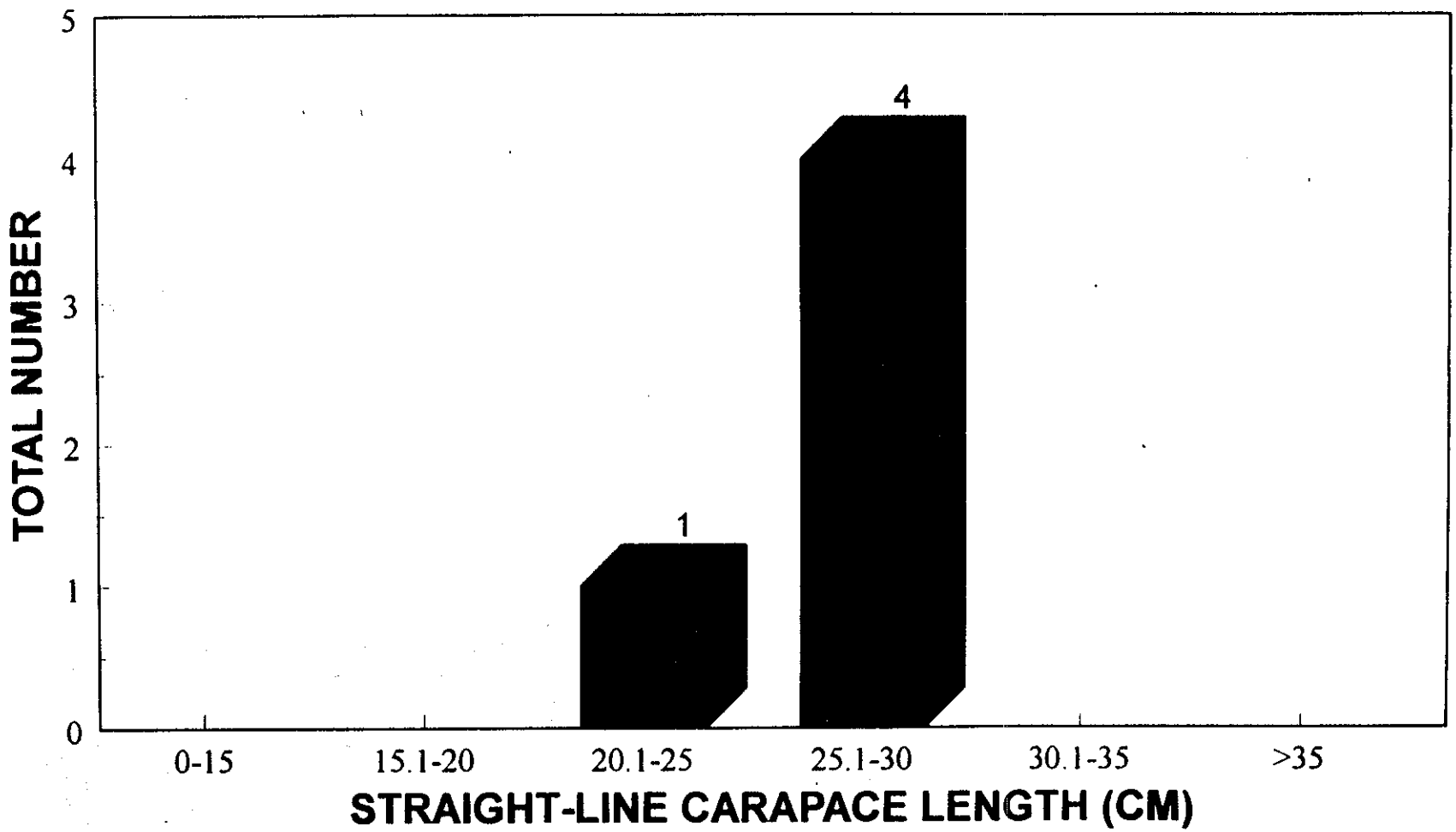


Figure 4-4. Size Class Distribution of Kemp's Ridley Sea Turtle Occurrences at Salem Generating Station from 1992 to 1996

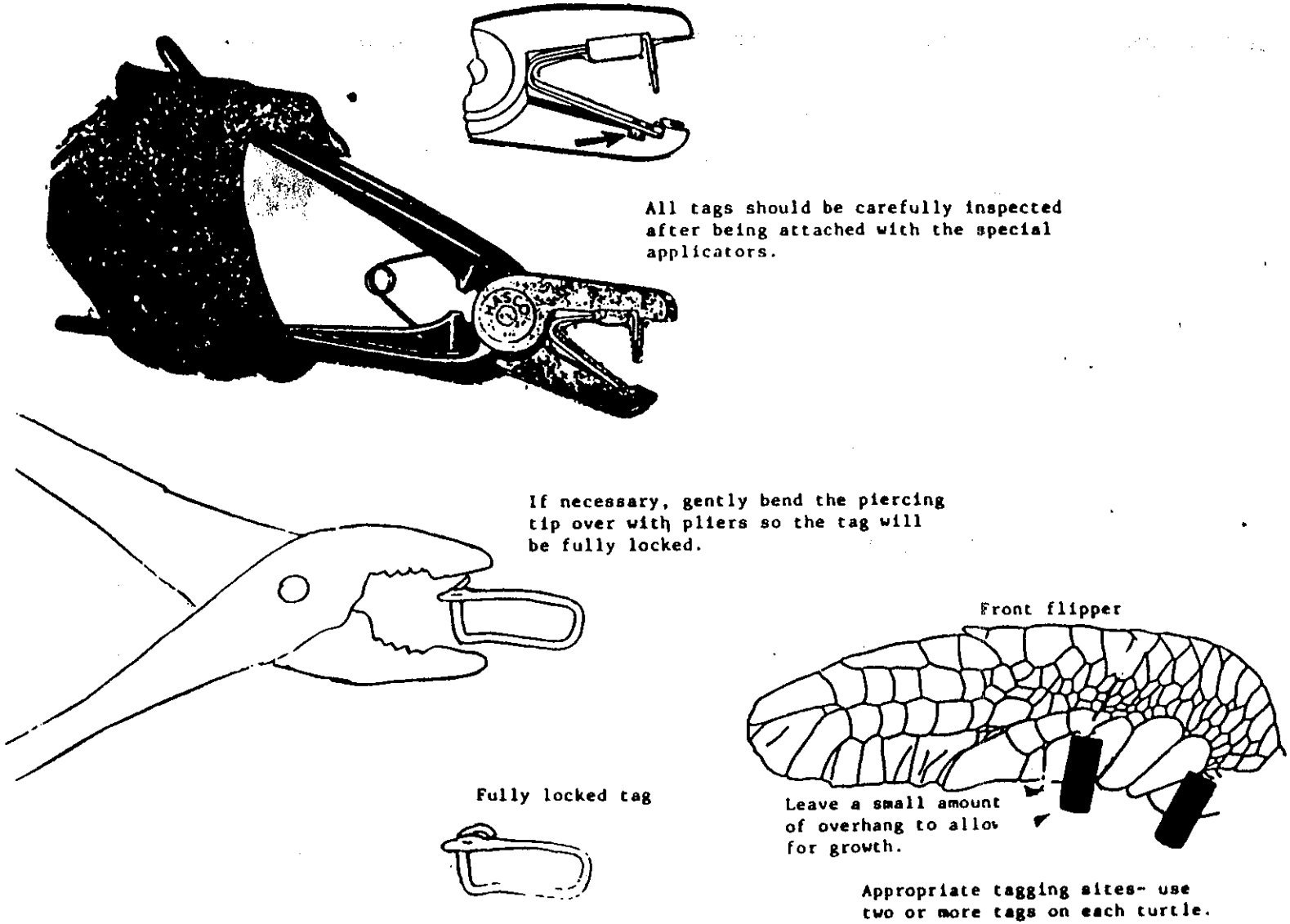


Figure 4-5. Flipper Tagging Procedure

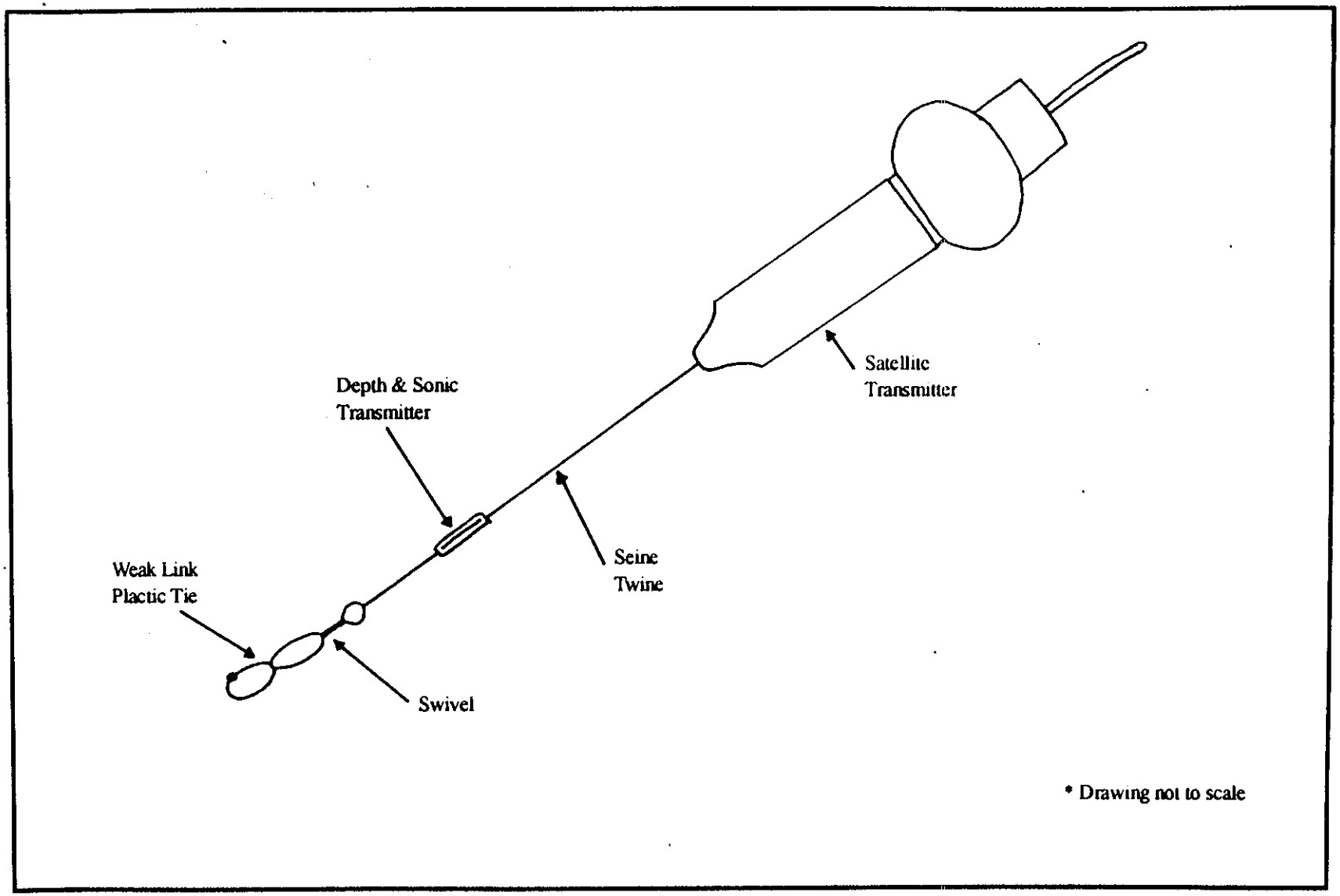


Figure 4-6 Sonic and Satellite Transmitter Arrangement

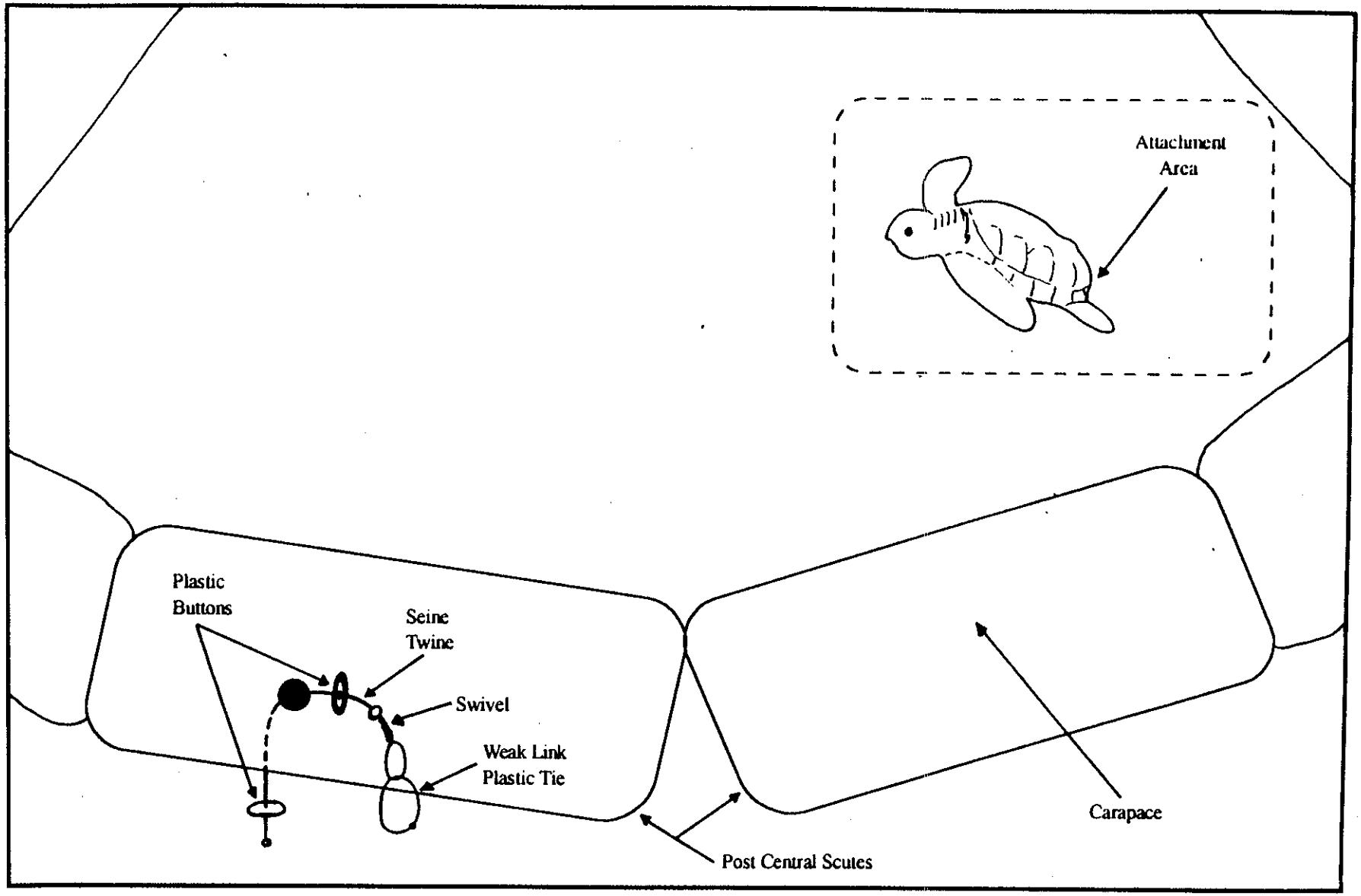


Figure 4-7. Attachment of Tether to Sea Turtle Carapace

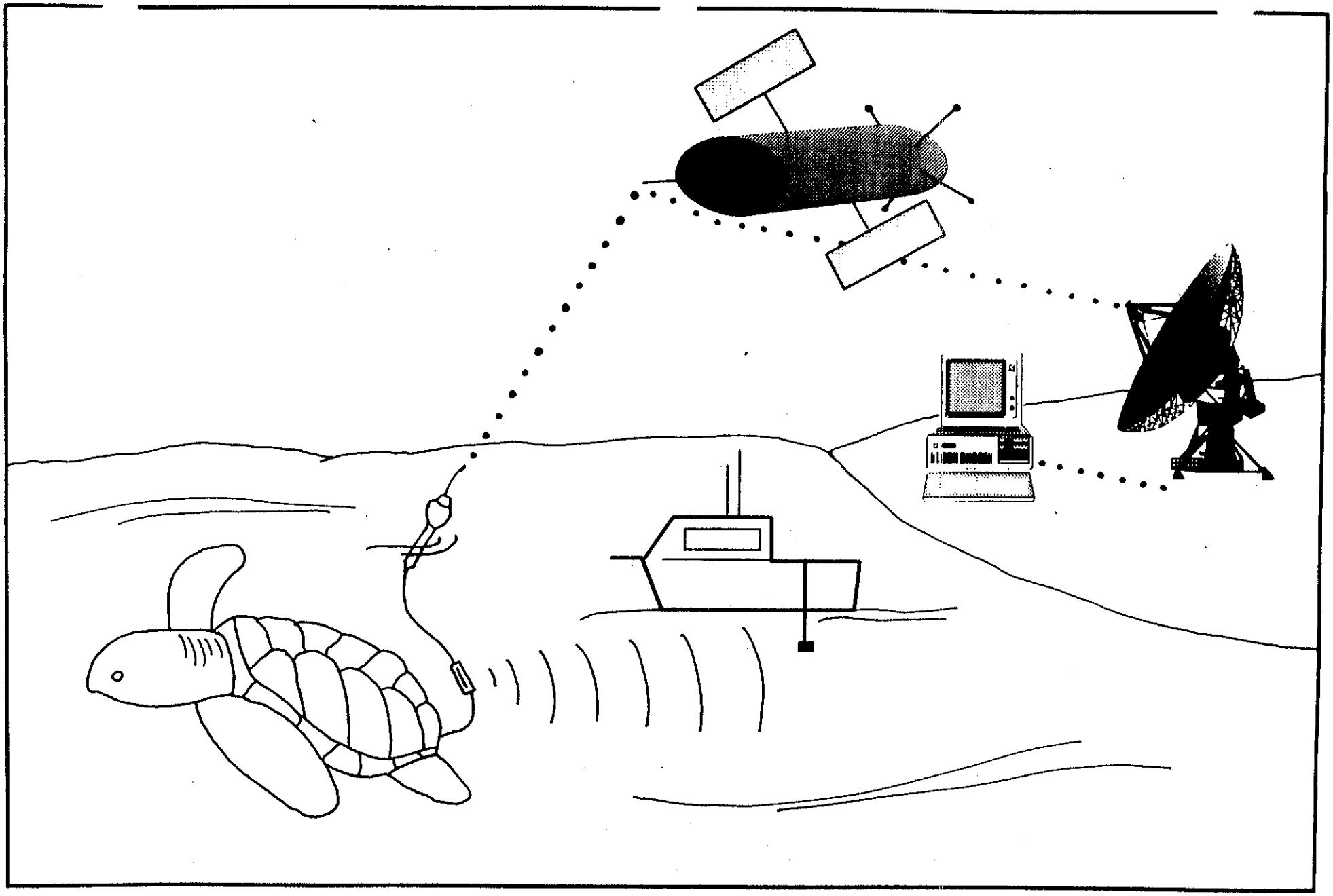


Figure 4-7. Depiction of Sonic and Satellite Transmitter Systems

SECTION 5.0
RESULTS AND DISCUSSION

Since 1992, PSE&G has tracked seven (7) loggerhead sea turtles using satellite and/or sonic equipment. The following paragraphs summarize the details of the release and movement of each of these sea turtles. The less frequently captured, Kemp's ridley and green sea turtles were too small for the transmitter array and were not tracked. Of the eleven (11) loggerheads recovered alive from 1992 to 1996, PSE&G tracked seven loggerhead sea turtles, six in 1992 and one in 1994. Four loggerheads were not tracked because of limits imposed by the Scientific Collection Permit. Table summarizes the incidental takes of sea turtles from 1992 through 1996.

5.1 LOGGERHEAD QQP938/QQP939

Loggerhead sea turtle QQP938/QQP939 was incidentally captured at the Salem Generating Station Circulating Water Intake on June 18, 1992. This animal weighed 21.4 kilograms (47.1 pounds) and had a carapace length of 53.3 centimeters(21 inches) and carapace width of 46 centimeters(18.1 inches). It was flipper tagged with NMFS Cooperative Marine Turtle Tagging Program (CMTTP) tag numbers QQP938 and QQP939, equipped with sonic and satellite tags and released on June 22, 1992. The release point for this loggerhead was approximately 3.5 miles downstream of the Salem Generating Station (latitude 39 24′ 94″ and longitude 75 28′ 27″).

This loggerhead turtle was tracked for approximately 21 hours following its release using the sonic tracking equipment. During the 21 hours of sonic tracking, the turtle stayed near the New Jersey shoreline, making only one foray to the shipping channel. From the shipping channel it returned back to the New Jersey shoreline near Arnold Point. On June 23, 1992, during a boat crew change, the turtle broke free of the transmitter array which was located floating south of the Cohansey River. The last transmission from this turtle was from the area between the New Jersey shoreline and the Liston Range of the shipping channel. Figure 5-1 shows the movement of this loggerhead during the 21 hours sonic data was recorded.

No positioning information was received from the satellite tracking system which appeared to be due to a transmitter failure.

5.2 LOGGERHEAD QQP940/QQP941

Loggerhead sea turtle QQP940/QQP941 was incidentally captured at the Salem Generating Station on July 29, 1992. This animal weighed 17.7 kilograms (38.9 pounds) and had a carapace length of 48.2 centimeters (19 inches) and carapace width of 43.4 centimeters (17.1 inches). It was flipper tagged with NMFS, CMTTP tag numbers QQP940 and QQP941, equipped with sonic and satellite tags and released on August 2, 1992. The release point for this loggerhead was approximately 3.5 miles downstream of the Salem Generating Station.

This loggerhead was tracked for 48 hours following its release using the sonic tracking equipment (Figure 5-2). After its release, this turtle moved up past Artificial Island with a flood tide. On the subsequent ebb tide, the turtle then moved downstream below the station and into the shipping channel. It stayed close to the channel for another tidal cycle. It then moved over towards the Delaware shoreline and entered the Appoquinomink River, located directly across from Artificial Island. The turtle entered the Appoquinomick River during a flood tide and exited it approximately 6 hours later on an ebb tide.

Satellite transmissions for this loggerhead were recorded from August 2 to 7, 1992 (Figure 5-3). During this time, this loggerhead moved in a overall downriver direction. Its last recorded location was near the mouth of Stow Creek. The transmitter array from this turtle was lost.

5.3 LOGGERHEAD QQP942/QQP943

Loggerhead sea turtle QQP942/QQP943 was incidentally captured at the Salem Generating Station on August 28, 1992. This animal weighed 27 kilograms (59.4 pounds) and had a carapace length of 52.3 centimeters (20.6 inches) and carapace width of 46.6 centimeters (18.3 inches). It was flipper tagged with NMFS, CMTTP tag numbers QQP942 and QQP943, equipped with sonic and satellite tags and released on August 31, 1992. The release point for this loggerhead was approximately 3.5 miles downstream of the Salem Generating Station.

The turtle was tracked for approximately 48 hours following its release using the sonic equipment (Figure 5-4). This loggerhead displayed the previously observed movement up and down bay with the tide flows. However, this animal stayed in the vicinity of the shipping channel during the period of sonic observation. It was also observed that this turtles range was more down bay than the previous turtles.

No positioning information was received from the satellite tracking system which appeared to be due to a transmitter failure.

5.4 LOGGERHEAD QQP944/QQP945

Loggerhead sea turtle QQP944/QQP945 was incidentally captured at the Salem Generating Station on September 1, 1992. This animal weighed 23.2 kilograms (51 pounds) and had a carapace length of 50.2 centimeters (19.8 inches) and carapace width of 42.3 centimeters (16.7 inches). It was flipper tagged with NMFS, CMTTP tag numbers QQP944 and QQP945, equipped with sonic and satellite tags and released on September 8, 1992. The release of this turtle was delayed until after the Labor Day holiday to avoid the possibility of injury from heavy weekend boat traffic. The release point for this loggerhead was approximately 3.5 miles downstream of the Salem Generating Station.

Difficulties were encountered with the sonic transmitter while attempting to track this turtle. For some unknown reason, the sonic transmitter gave off a very low signal, making tracking difficult. At one point, the turtle's location was lost by the sonic system but it was relocated by checking the satellite position. This continued to be a problem with this animal during the course of the 48-hour sonic tracking period. Figure 5-5 shows the limited data acquired by sonic tracking. During this time, the turtle stayed close to the New Jersey coastline.

Some data was received from the satellite tracking system from September 9 to 28 (Figure 5-6). However, this data appeared very erratic and of questionable validity.

5.5 LOGGERHEAD QQP901/QQP902

Loggerhead sea turtle QQP901/QQP902 was incidentally captured at the Salem Generating Station on September 9, 1992. This animal weighed 32.7 kilograms (71.9 pounds) and had a carapace length of 59.4 centimeters (23.4 inches) and carapace width of 54.4 centimeters (21.4 inches). It was flipper tagged with NMFS, CMTTP tag numbers QQP901 and QQP902, equipped with a sonic tag and released on September 12, 1992. This animal was not equipped with a satellite tag because only one satellite tag was available and another specimen was incidentally captured on September 12, 1992 and it was decided to use the last satellite tag on that animal. The release point for this loggerhead was approximately 3.5 miles downstream of the Salem Generating Station.

This turtle was tracked for approximately 36 hours following its release using the sonic equipment. Figure 5-7, shows the turtles'

movements during the period of sonic tracking. This turtle stayed very close to the shipping channel crossing from the New Jersey to the Delaware side. In general this animal's movements were more sporadic in terms of the tidal flow, but again it did move up and down the bay. It did make more progression south than north. This may be due to the time period and the cooler water temperatures. The last transmission was during an ebb slack tide. On September 14, 1992 at approximately 6:00 A.M., the crew left the turtle to release another sea turtle, hoping to relocate the turtle again after release. The crew was not able to relocate this turtle.

5.6 LOGGERHEAD QQP905/QQP906

Loggerhead sea turtle QQP905/QQP906 was incidentally captured at the Salem Generating Station on September 12, 1992. This animal weighed 17.3 kilograms (38.1 pounds) and had a carapace length of 48.4 centimeters (19.1 inches) and carapace width of 41.3 centimeters (16.3 inches). It was flipper tagged with NMFS, CMTTP tag numbers QQP905 and QQP906, equipped with a sonic and satellite tags and released on September 16, 1992. The release point for this loggerhead was approximately 3.5 miles downstream of the Salem Generating Station.

This loggerhead turtle was tracked for approximately 48 hours following its release using sonic tracking equipment. Figure 5-6, shows the turtles' movements during the sonic tracking. The turtle stayed near the shipping channel during its movements, traveling up and down with the tide.

No positioning information was received from the satellite tracking system which appeared to be due to a transmitter failure.

5.7 LOGGERHEAD QQP976/QQP977

In 1994, only one loggerhead sea turtle was recovered from the Salem Generating Station Circulating Water Intake. Loggerhead sea turtle QQP976/QQP977 was incidentally captured on June 24,1994. This animal weighed 18.4 kilograms (40.5 pounds) and had a carapace length of 47.4 centimeters (18.7 inches) and carapace width of 41.7 centimeters (16.4 inches). It was flipper tagged with NMFS, CMTTP tag numbers QQP976 and QQP977, equipped with a sonic and satellite tags and released on June 27, 1994. Due to a persistent period of bad weather, this turtle was released from the shoreline at the mouth of Stow Creek.

This extended period of bad weather also precluded the sonic tracking of this animal following its release.

However, this turtle was tracked by satellite for approximately twenty-six (26) days before contact was lost. Figure 5-9 is a satellite plot that shows the turtles' movements throughout the Delaware Bay. This animal spent a large portion of the time on the Delaware shoreline and moved all the way to the mouth of the Bay. The coordinates of the last transmission from this turtle placed it around Sea Breeze, New Jersey just below the Cohansey River in the Delaware Bay, approximately 14 miles south of Artificial Island.

5.8 HABITAT UTILIZATION

The Delaware River in the vicinity of Salem Generating Station is characterized extensive relatively shallow areas adjacent to both the New Jersey and Delaware shorelines, a shipping channel and extensive marshlands intersected by tidal streams. An estimate of the usage of each of these general habitat types by loggerhead sea turtles tracked either sonically or by satellite was constructed by PSE&G. These estimates were constructed by categorizing the area traversed by the turtles into one of these habitat types and compiling the lapsed time between the two concurrent transmissions. Although crude, this provides an estimate of the time each animal spent in each habitat type.

5.8.1 SONIC TRACKING

Table 5-2 summarizes the percent of time each loggerhead turtle spent in the different habitat types described earlier. These data suggest that the bulk of the time loggerheads appear to spend in shallow areas adjacent to the river shoreline in New Jersey or mid-river in the vicinity of the shipping channel. One turtle was observed to move across the river and spend over half a day in the shallow areas adjacent to the Delaware shoreline and even spent approximately six hours in the Appoquinomink River Creek. Following this foray this particular animal moved back towards the shipping channel.

Many of the turtles were observed to stay in the shipping channels, even while on the surface during the day. Other investigators have observed that loggerheads are attracted to channel habitat (Butler et.al, 1987; Dickerson et al., 1990) but it is not understood why. While loggerheads appear to utilize the deeper dredged channels, Kemp's ridleys and greens inhabit the shallower areas outside the channels (Dickinson et.al., 1995). Since this study focused on loggerheads, the behavior of Kemp's ridleys and green turtles within the Delaware Bay is not understood.

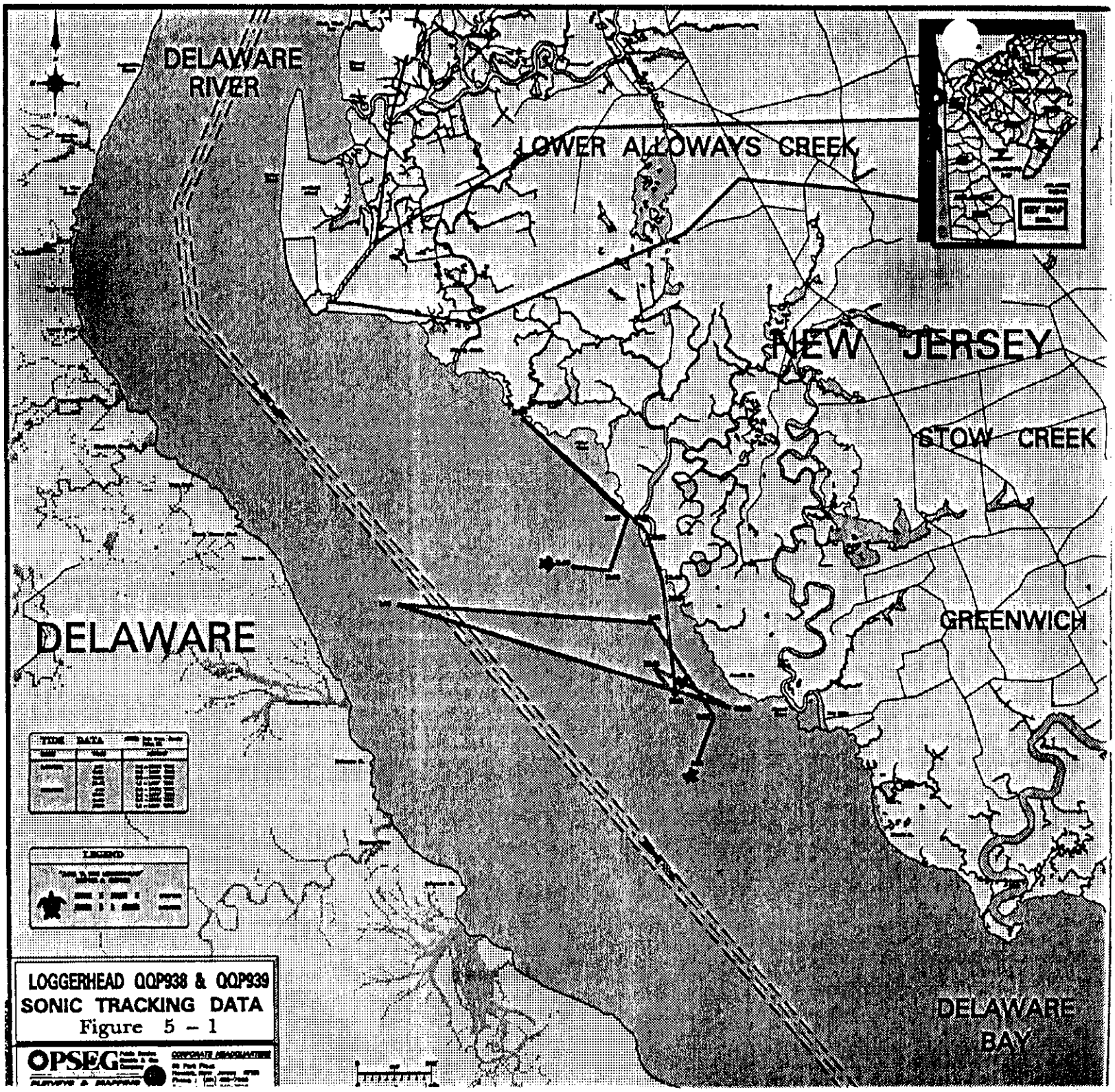
The broad usage of the river by these loggerhead turtles suggests that food and suitable habitat for their other needs (e.g.

basking, etc.) appears to be generally available throughout the river in this vicinity. This broad usage also suggests that there is no apparent affinity by these animals for the Salem Generating Station.

5.8.2 SATELLITE TRACKING

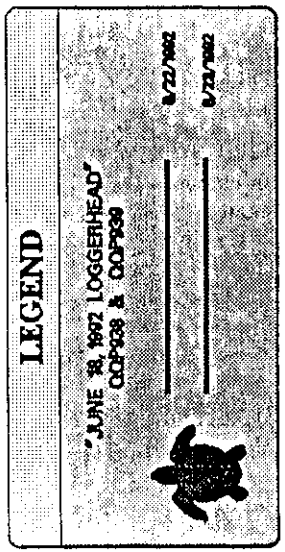
Table 5-2 summarizes the percent of time each loggerhead turtle spent in the different habitat types described earlier. These data suggest that the bulk of the time loggerheads appear to spend in shallow areas adjacent to the river shoreline in Delaware and New Jersey or mid-river in the vicinity of the shipping channel. Two turtles appear to have spent time in two tidal rivers over in Delaware, the Appoquinomink and Mahon Rivers. It also appears one turtle may have spent some time in the New Jersey marshes near Egg Island Point.

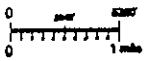
These data also support the broad usage of the river by these loggerhead turtles and also suggest that there is no apparent affinity by these animals for the Salem Generating Station.

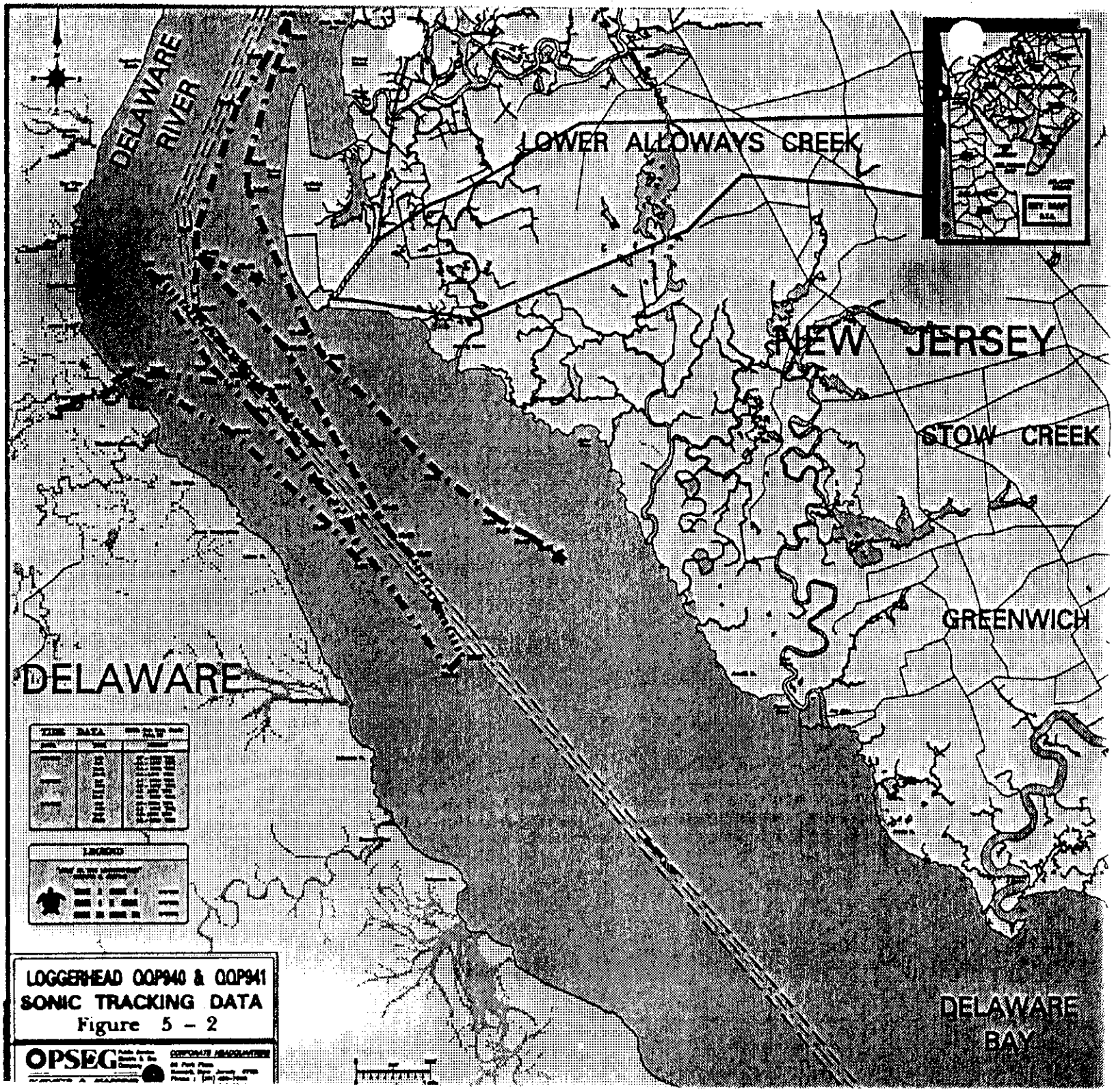


LOGGERHEAD QQP938 & QQP939
SONIC TRACKING DATA
Figure 5 – 1

OPSEG

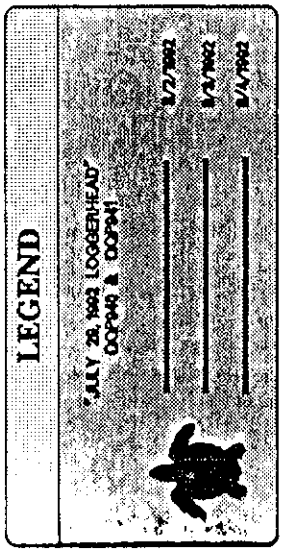


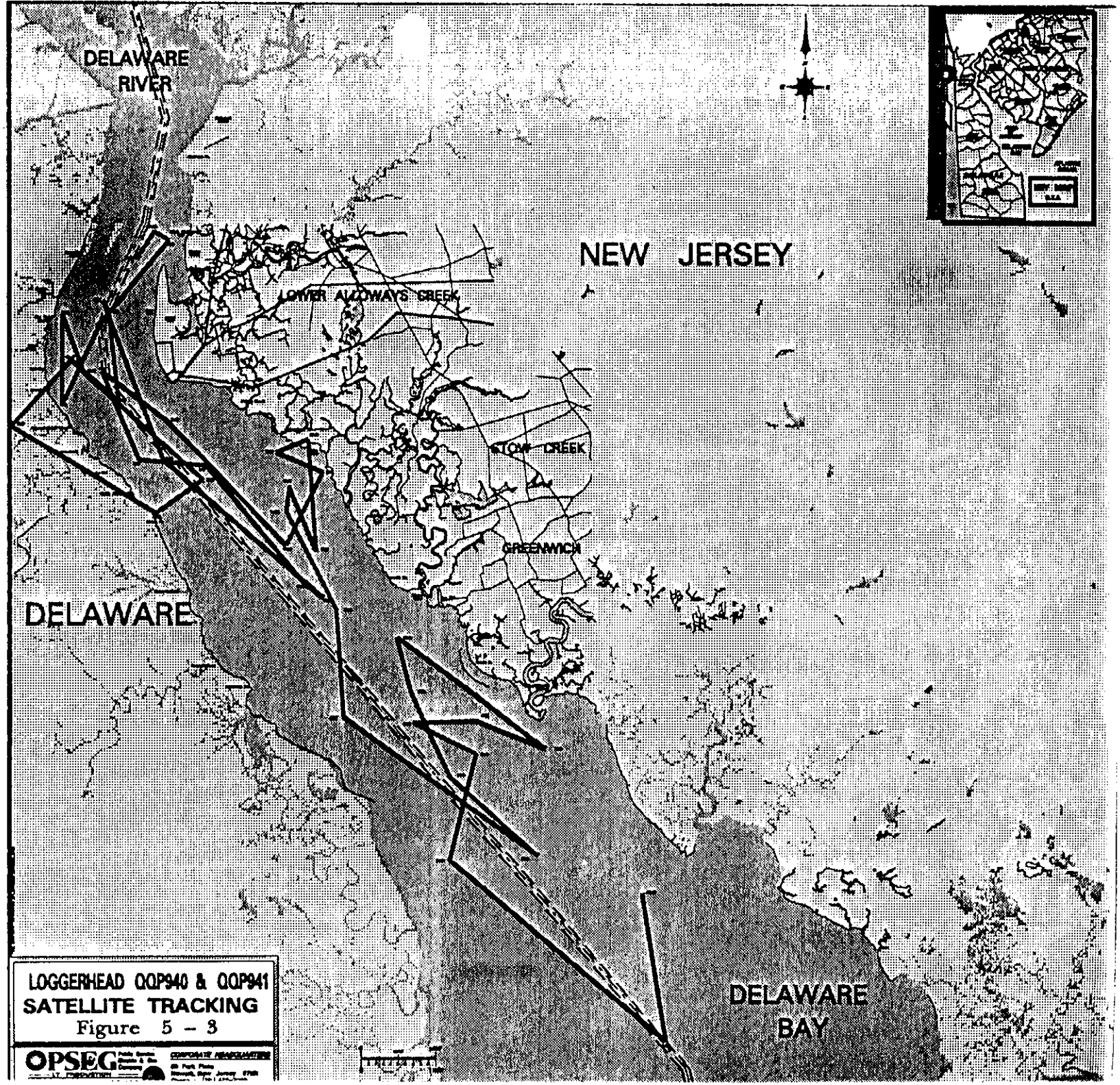




LOGGERHEAD OOP940 & OOP941
SONIC TRACKING DATA
Figure 5 - 2

OPSEG





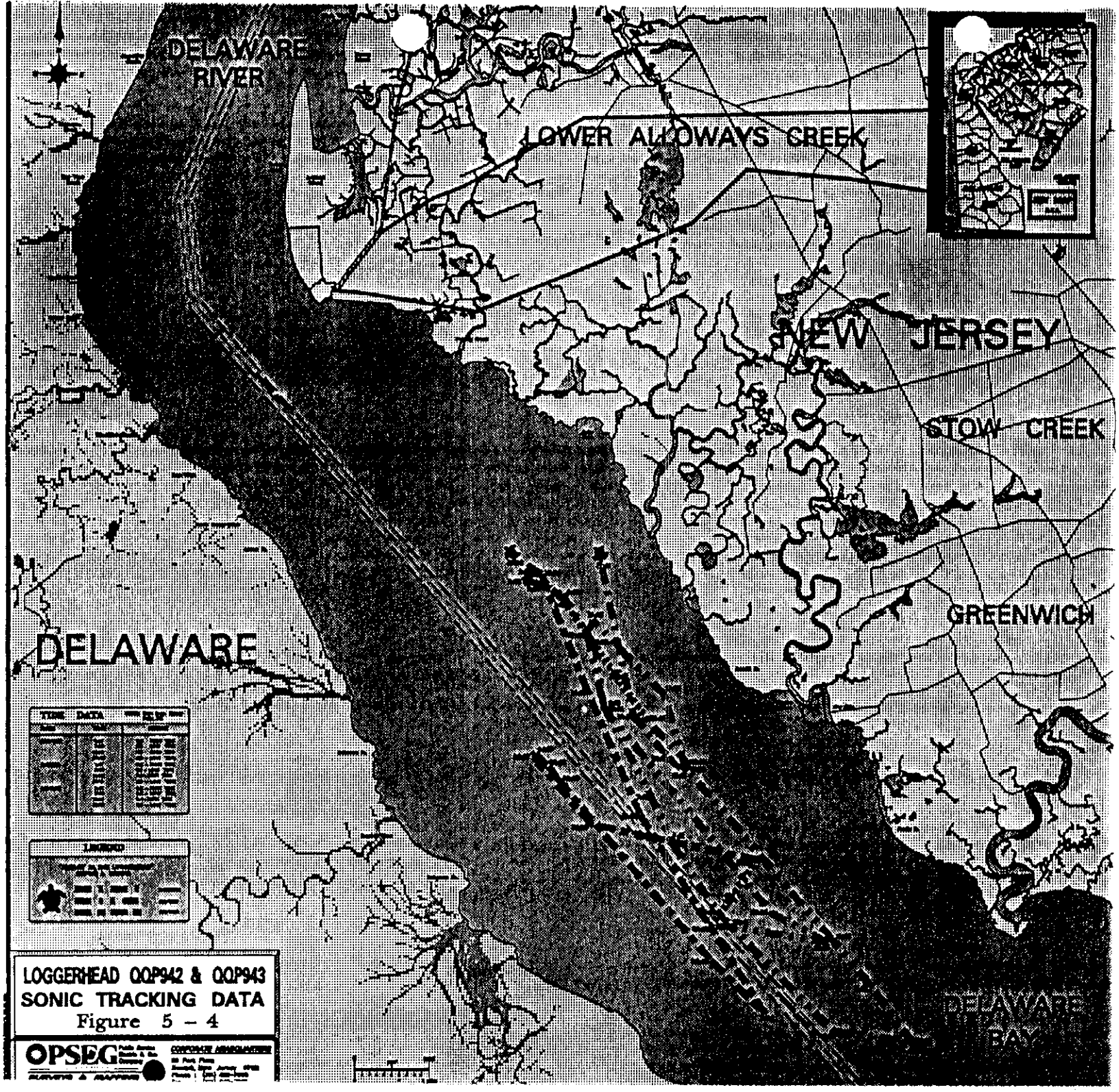
LOGGERHEAD QQP940 & QQP941
SATELLITE TRACKING
Figure 5 – 3

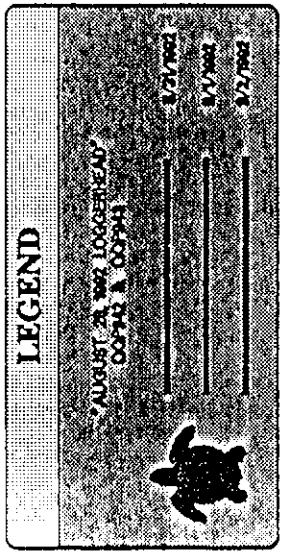
OPSEG

LEGEND

"JULY 20, 2002 LOGGERHEAD" SATELLITE DATA

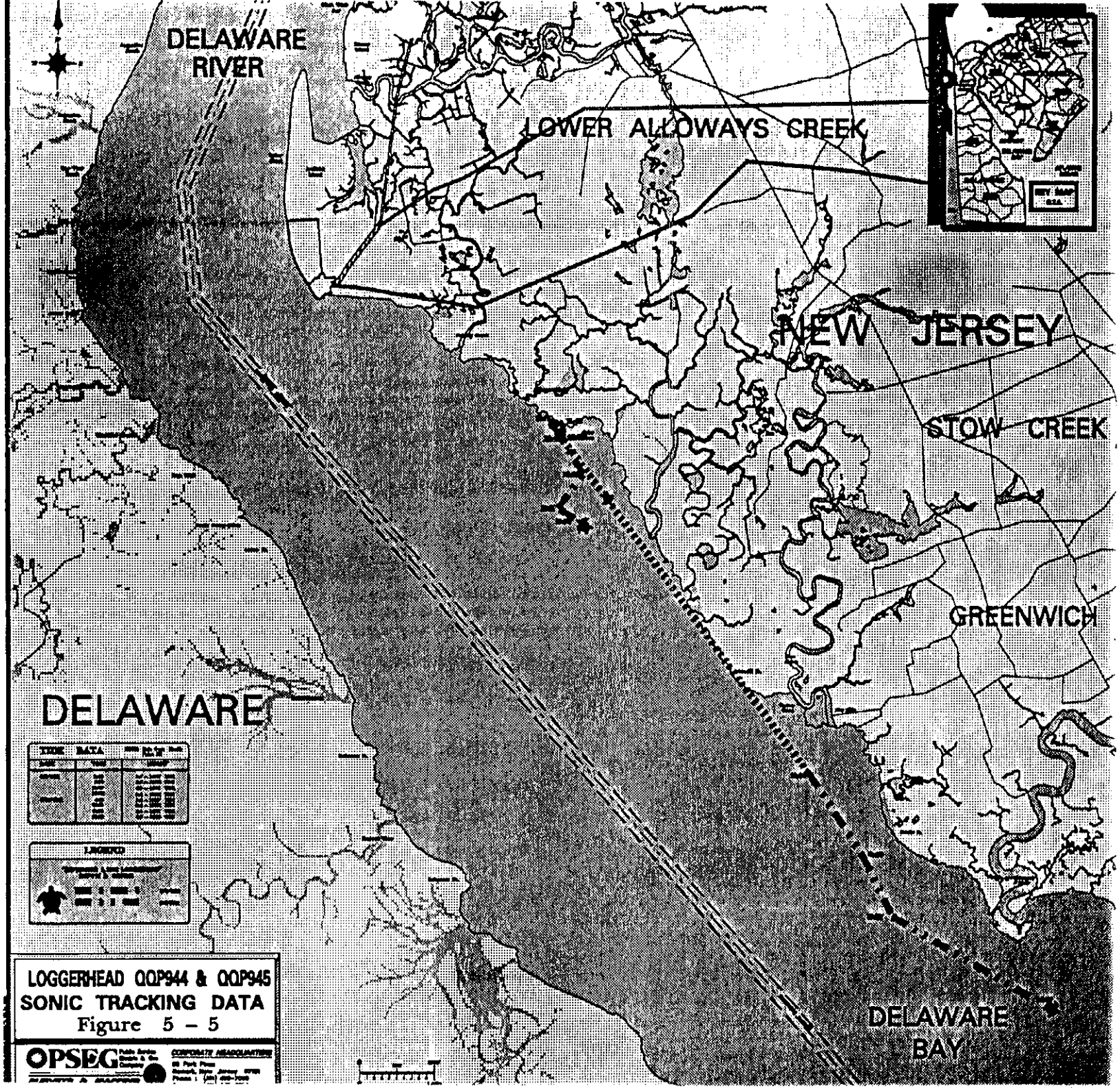
FROM 7/24 TO 7/26





LOGGERHEAD OOP942 & OOP943
SONIC TRACKING DATA
Figure 5 – 4

OPSEG



LEGEND

"SEPTEMBER 1, 1992 LOGGERHEAD"
OOP944 & OOP945

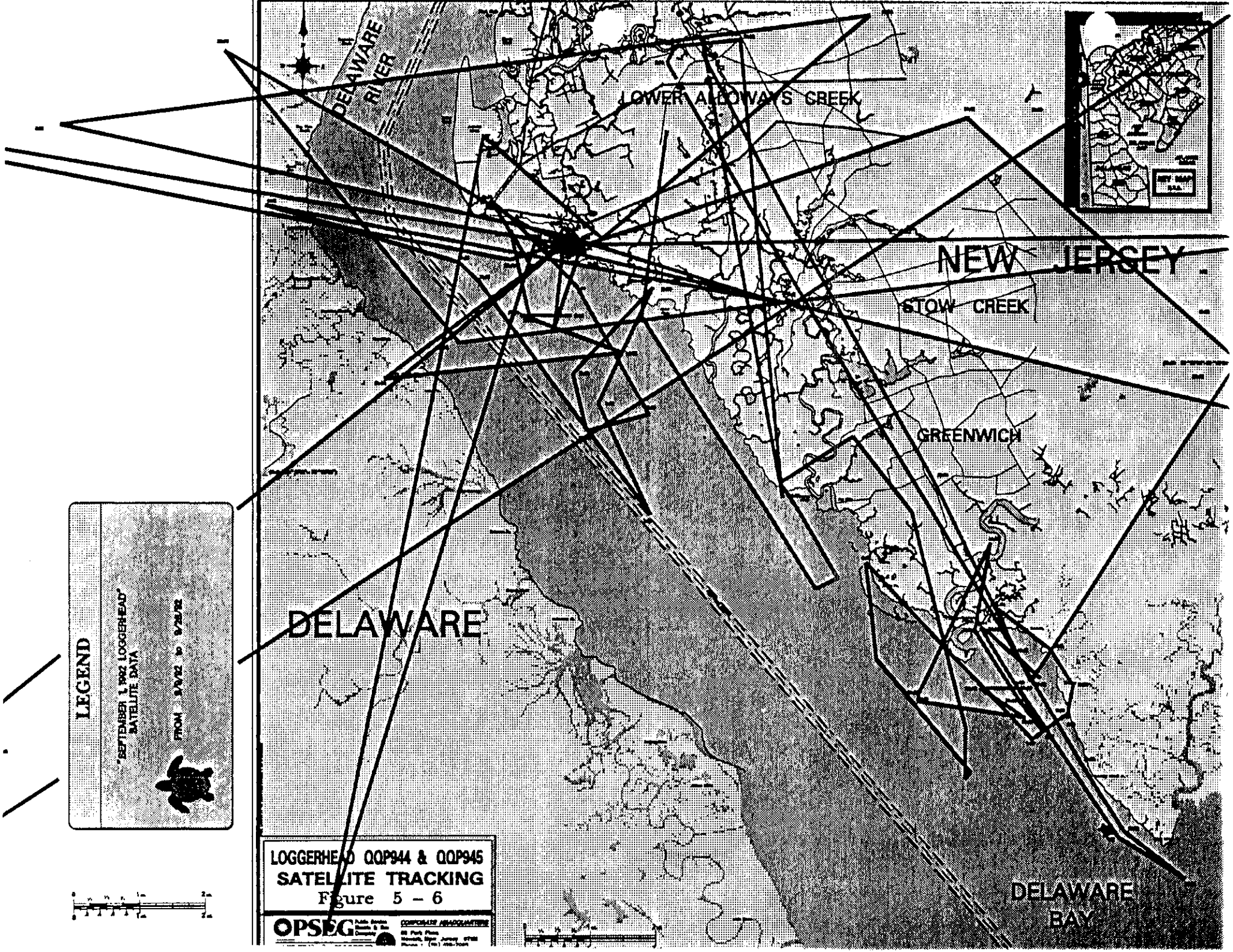
9/1/92

9/1/92

0 1 miles

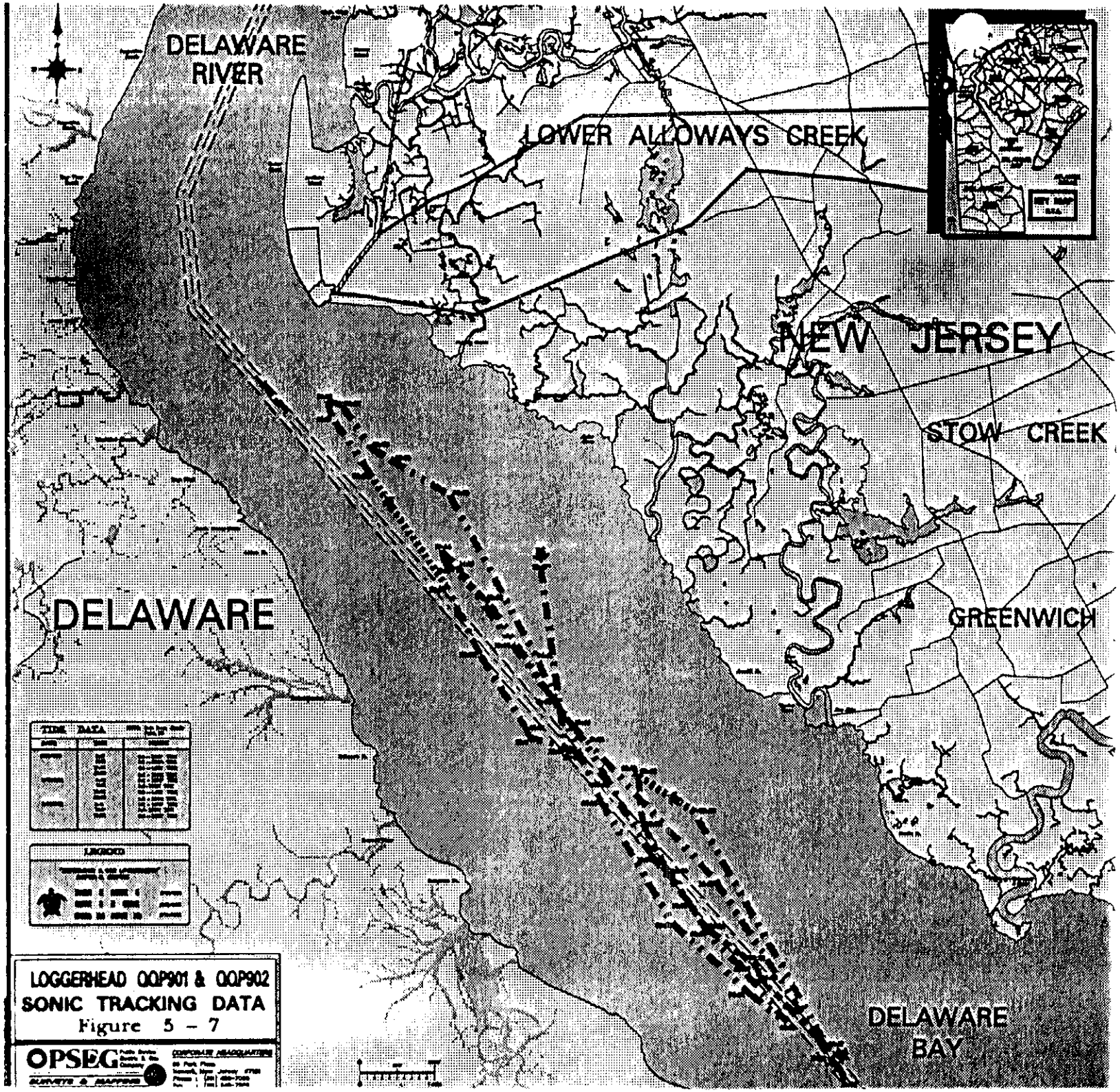
LOGGERHEAD OOP944 & OOP945
SONIC TRACKING DATA
Figure 5 – 5

OPSEG



LOGGERHEAD QQP944 & QQP945
SATELLITE TRACKING
Figure 5 – 6

OPSEG



LEGEND

"SEPTEMBER 8, 1992 LOGGERHEAD" OOP901 & OOP902

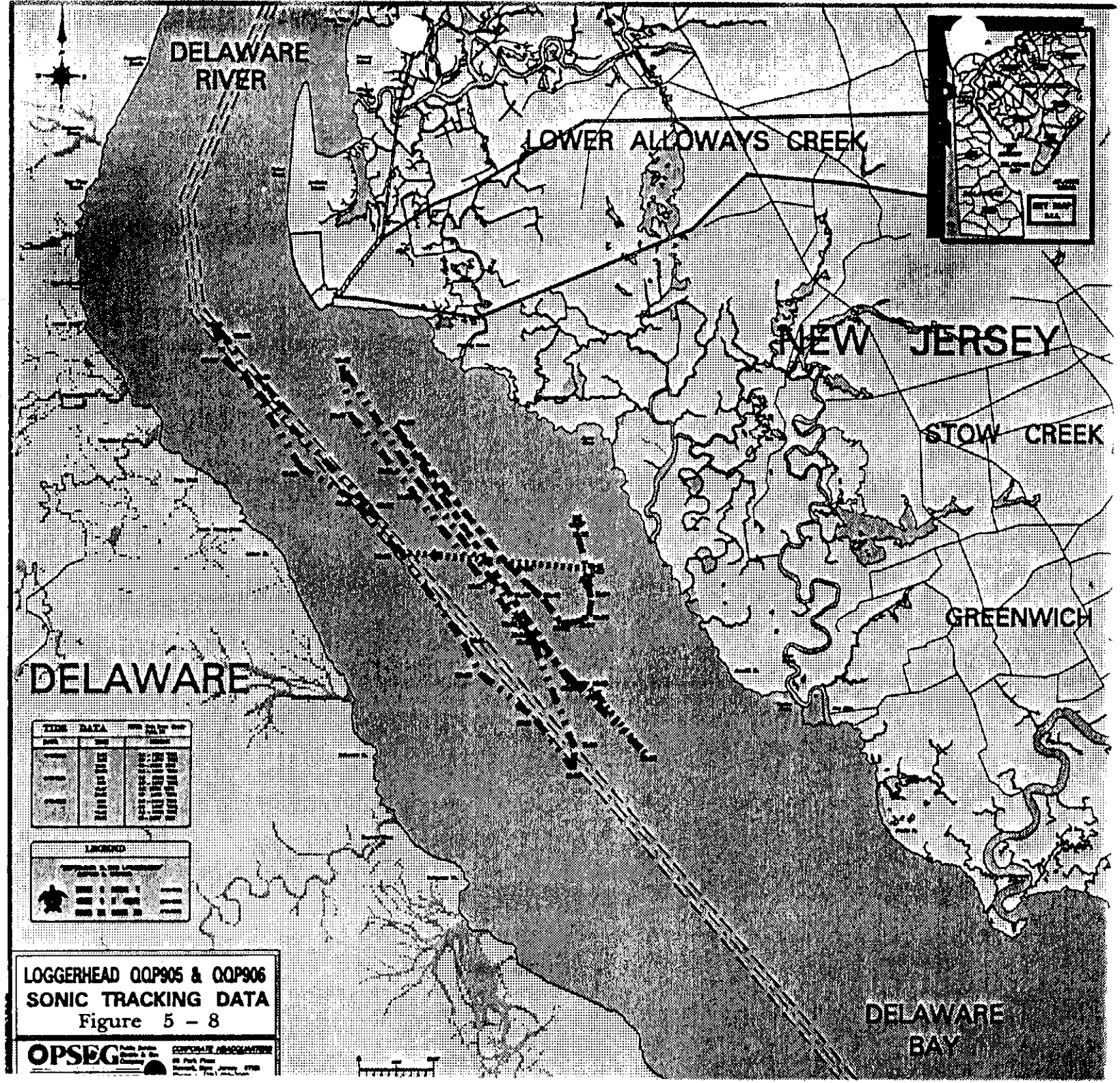
9/12/1992

9/13/1992

9/14/1992

LOGGERHEAD OOP901 & OOP902
SONIC TRACKING DATA
Figure 5 - 7

OPSEG



LEGEND

OOP905 & OOP906 LOGGERHEAD

"REFERENCE"

12/1/2002

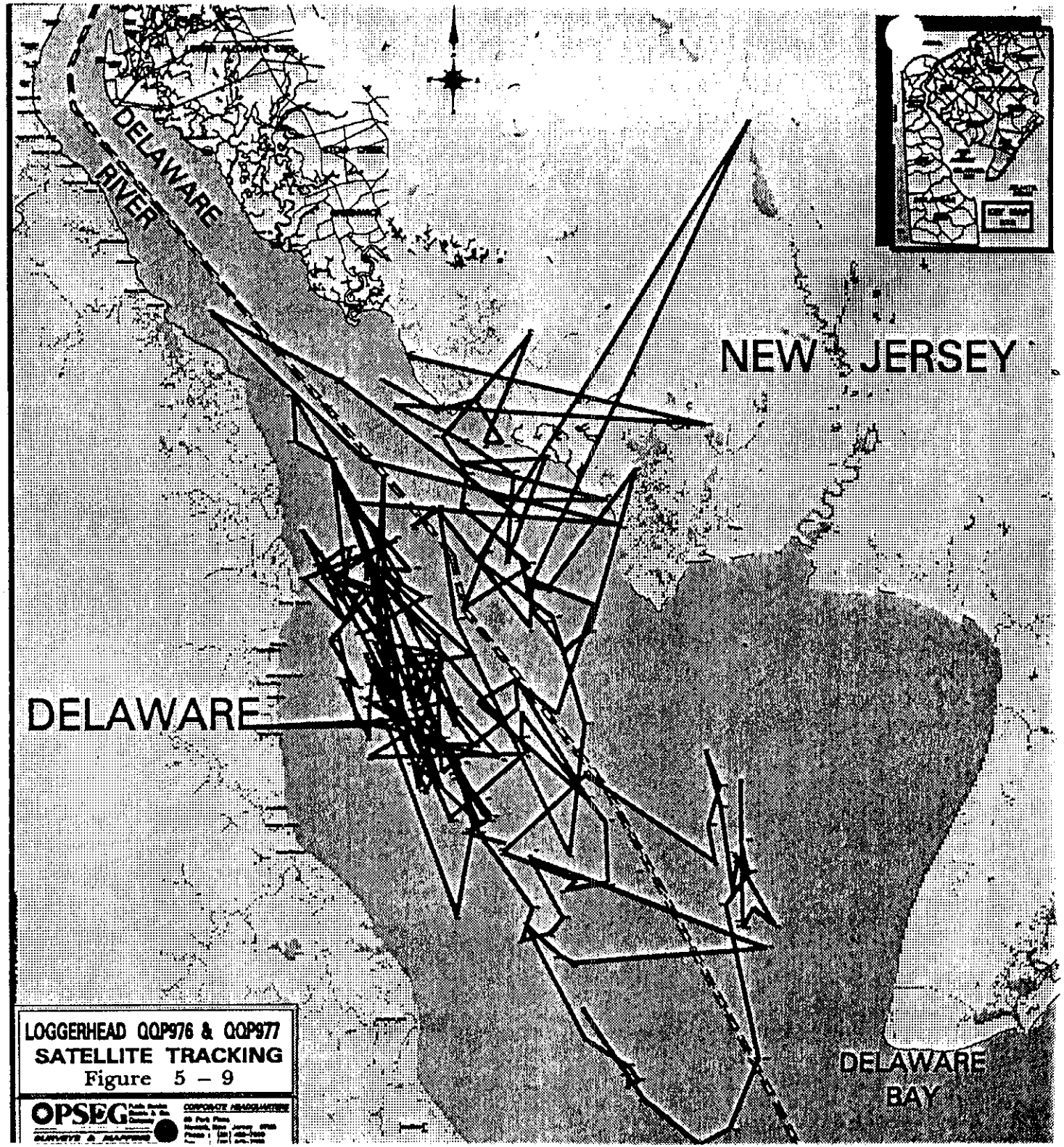
1/14/2002

2/28/2002

0 1 miles

LOGGERHEAD OOP905 & OOP906
SONIC TRACKING DATA
Figure 5 – 8

OPSEG



LOGGERHEAD QQP976 & QQP977
SATELLITE TRACKING
Figure 5 – 9

OPSEG

Table 5-1

Listing of Sea Turtle Incidentally Captured at PSE&G's Salem Generating Station from 1992 to 1996 including Tag Numbers

DATE	SPECIES	CSL* (cm)	CSW* (cm)	WEIGHT (kg)	STATUS	TAG NOS.
06/18/92	Loggerhead	53.3	46	21.4	Live	QQP938 & QQP939
07/29/92	Loggerhead	48.2	43.4	17.7	Live	QQP940 & QQP941
08/28/92	Loggerhead	52.3	46.6	27	Live	QQP942 & QQP943
08/31/92	Green	29.9	24.2	3.9	Dead	NA
09/01/92	Kemp's ridley	25.8	24.6	2.95	Dead	NA
09/01/92	Loggerhead	50.2	42.3	23.2	Live	QQP944 & QQP945
09/04/92	Kemp's ridley	28.8	22.5	1.6	Dead	NA
09/09/92	Loggerhead	59.4	54.4	32.7	Live	QQP901 & QQP902
09/11/92	Loggerhead	50.6	43.2	21.5	Live	QQP903 & QQP904
09/12/92	Loggerhead	48.4	41.3	17.3	Live	QQP905 & QQP906
09/19/92	Loggerhead	51.9	44.5	24	Live	QQP911 & QQP912
09/20/92	Loggerhead	61.7	52.6	34.5	Live	QQP907 & QQP908
09/22/92	Loggerhead	54.2	46.7	25.5	Live	QQP909 & QQP910
09/28/92	Kemp's ridley	25.4	23.1	2.3	Live	QQP913 & QQP914
10/02/92	Kemp's ridley	25.4	23.1	2.3	Live	Recapture from 9/28/92
07/17/93	Kemp's ridley	24.6	22.3	2.05	Live	QQP956 & QQP957
06/24/94	Loggerhead	47.4	41.7	18.4	Live	QQP976 & QQP977
07/02/95	Loggerhead	NA	51.1	NA	Dead	NA

* SCL = straight carapace length and SCW = straight carapace width

Loggerhead: N=12

Mean SCL = 52.51 cm.
Mean SCW = 46.15 cm.
Mean Weight = 23.93 kg.

Kemp's ridley: N=4**

Mean SCL = 26.15 cm.
Mean SCW = 23.13 cm.
Mean Weight = 2.23 kg.

** Recapture not included

Table 5-2

ESTIMATED HABITAT USAGE BY LOGGERHEAD SEA TURTLES IN THE DELAWARE RIVER IN THE VICINITY OF SALEM GENERATING STATION BASED ON SONIC AND SATELLITE TRACKING DATA COLLECTED FROM 1992 TO 1994*

Turtle CMTTP Tag Number	New Jersey Shoreline	Shipping Channel	Delaware Shoreline	Tributary Streams New Jersey	Tributary Streams Delaware
QQP938/QQP939	74.2 (924)	25.8 (321)	0	0	0
QQP940/QQP941	22.4 (623)	44.8 (1245)	23.9 (664)	0	8.9 (249)
QQP942/QQP943	52.0 (1444)	48.0 (1335)	0	0	0
QQP944/QQP945	100.0 (1169)	0	0	0	0
QQP901/QQP902	1.1 (25)	98.9 2215)	0	0	0
QQP905/QQP906	59.8 (1509)	40.2 (1016)	0	0	0
QQP940/QQP941 (satellite data)	*45.3 (3235)*	*35.4 (2527)*	*12.1 (893)*	*0*	*6.8 (484)***
QQP976/QQP977 (satellite data)	*27.1 (9251)*	*15.2 (5180)*	*53.3 (18216)*	*4.2 (1418)****	*<1.0 (101)*****

* Number in parenthesis is approximate time in minutes spent in each habitat area.
** Appoquinimink River
*** Turtle may have spent day in marshes in vicinity of Egg Island Point
**** Mahon River

SECTION 6.0
CONCLUSIONS

1. Loggerhead sea turtles use the full range of macrohabitats available in the Delaware River near Salem Generating Station. These macrohabitats include: shallow shoreline areas adjacent to both New Jersey and Delaware, the shipping channel, and tidal tributary streams.

2. Loggerhead sea turtle movements in the Delaware Estuary are commonly influenced by the tides but otherwise show no discernible pattern.

2. No evidence was observed of any attraction by loggerhead sea turtles to the Salem Generating Station based on the sonic and satellite tracking data collected.

SECTION 7.0
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