PLANNING AID REPORT

COMPREHENSIVE NAVIGATION STUDY
MAIN CHANNEL DEEPENING PROJECT
DELAWARE RIVER FROM PHILADELPHIA TO THE SEA

BENEFICIAL USE OF DREDGED MATERIAL

Prepared by:

U.S. Fish and Wildlife Service
Region 5
Delaware River / Delmarva Coastal Ecosystem Team

August 1995

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Prepared for:

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Philadelphia District
Philadelphia, Pennsylvania 19107

Prepared by:

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August 1995

United States Department of the Interior

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IN REPLY REFER TO:

FP-95/25

August 18, 1995

Lt. Colonel Robert P. Magnifico
District Engineer, Philadelphia District
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, Pennsylvania 19107-3390

Dear Lt. Colonel Magnifico:

Enclosed is the U.S. Fish and Wildlife Service (Service) planning aid report on the Philadelphia District Corps of Engineers' (District) Comprehensive Navigation Study, Main Channel Deepening Project, Delaware River from Philadelphia to the Sea (Beneficial Use of Dredged Material). This report has been prepared pursuant to a Fiscal Year-1995 interagency agreement between the District and the Service.

This planning aid report is provided as technical assistance and does not constitute the report of the Secretary of Interior pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, 16 U.S.C. 661 *et seq.*). Planning aid is valid only for the described conditions and must be revised if changes to the proposed project take place prior to initiation.

This report is also provided pursuant to the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) to ensure the protection of endangered and threatened species and does not address all Service concerns for fish and wildlife resources. Therefore, these comments do not preclude separate review and comments by the Service on any forthcoming environmental documents pursuant to the National Environmental Policy Act of 1969 as amended (83 Stat. 852; 42 U.S.C. 4321 *et seq.*).

Federally-listed Species

The federally-listed endangered bald eagle (*Haliaeetus leucocephalus*) nests near the Delaware Bay, and feeds throughout the project area. Additionally, the federally-listed endangered peregrine falcon (*Falco peregrinus*) also nests on Egg Island Point in the vicinity of the proposed project. Peregrine falcons may be expected to forage for prey throughout the project area and generally feed on songbirds, gulls, terns, shorebirds, and wading birds. Additionally, peregrine falcons use the Delaware Bay shoreline during migration, especially in the fall.

It is the Service's understanding that the District is preparing a Biological Assessment to address potential project-related adverse impacts to the bald eagle, and peregrine falcon. Other than the aforementioned species, no other federally-listed or proposed endangered or threatened flora or fauna under Service jurisdiction are known to occur within the project area. It is also our understanding that the District is coordinating with the National Marine Fisheries Service regarding the federally-listed shortnose sturgeon (*Acipenser brevirostrum*) (endangered), Atlantic Ridley turtle (*Lepidochelys kempii*) (endangered), and loggerhead turtle (*Caretta caretta*) (threatened). Appendix A provides lists of federally-listed endangered and threatened species and federal candidate species in New Jersey and Delaware.

Any questions regarding this report or federally-listed endangered or threatened species should be directed to John Staples or Peter Benjamin of my staff. The Service looks forward to continued cooperation with the District in the planning stages of the proposed project.

Sincerely,

Clifford G. Day
Supervisor

Enclosure

EXECUTIVE SUMMARY

In accordance with a Philadelphia District, U.S. Army Corps of Engineers (Corps) Fiscal Year - 1995 scope-of-work agreement, the U.S. Fish and Wildlife Service (Service) has prepared this planning aid report for the Corps' Delaware River Comprehensive Navigation Study, Main Channel Deepening Project. The material presented in this planning aid report summarizes available data and information on the fish and wildlife resources of Delaware Bay, with an emphasis on those resources that would be most affected by plans currently under consideration by the Corps for the disposal of material dredged from the Delaware Bay portion of the Main Channel.

The proposed Main Channel Deepening Project, authorized by Congress in October 1992 as part of the Water Resources Development Act of 1992, would involve the deepening of the existing federal navigation channel for the Delaware River and Delaware Bay from 40 feet below mean-low-water (mlw) to 45 feet below mlw. The proposed project provides for a full width channel that would follow the existing channel alignment from the Delaware Bay to the Philadelphia / Camden waterfront, a distance of approximately 102.5 miles. Approximately 50 million cubic yards of dredged material would be removed for initial construction over a five year period. Approximately 40 million cubic yards of material to be dredged from the Delaware River would be placed in confined upland disposal areas. An estimated 10 million cubic yards of dredged material, which would be generated by the Delaware Bay portion of the Main Channel Deepening project, is available to be used beneficially to help combat the severe erosion that is threatening bayshore wetlands and properties. Potential beneficial uses evaluated for this report include the use of geotextile tubes for wetland restoration and shoreline stabilization at Egg Island Point, New Jersey, and Kelly Island, Delaware; beach nourishment along the Delaware shoreline; and, the formation of sand stockpiles in Delaware Bay. Such stockpiles would provide a readily available source of sand for future beach nourishment projects.

Information presented in this report includes an assessment of the effects of various dredged material disposal scenarios on fish and wildlife resources and provides Service recommendations regarding the preferred locations and designs for projects that would provide beneficial uses of dredged material, in terms of improving fish and wildlife habitat. Additionally, this planning aid report presents identified data gaps and additional information needed to fully evaluate the effects of the various disposal scenarios, and includes recommendations for future studies.

Based upon review of available information, numerous site visits, and coordination with local sources of expertise, the Service has concluded that the proposed wetland restoration projects at Egg Island Point, New Jersey, and Kelly Island, Delaware, would provide positive benefits to fish and wildlife resources. The Service further concludes that beach nourishment would have the greatest positive effects on beaches between Port Mahon and South Bowers Beach, Delaware, while nourishment of beaches in the more southern sections of the Delaware shoreline would be less beneficial, although still worthwhile. Additionally, the Service concludes that the proposed disposal of dredged material in sand stockpiles would adversely affect fish and wildlife resources and that the use of sand stockpiles should be minimized or eliminated as an alternative.

While the Service supports the proposed wetland restoration and beach nourishment plans, in concept, substantial additional coordination and planning are necessary to ensure maximum project benefits with minimal adverse effects on fish and wildlife. The Service is particularly concerned that the proposed wetland restoration projects at Kelly Island and Egg Island Point may adversely impact oyster beds through increased turbidity and sedimentation. The Service recommends that the Corps continue to coordinate project planning with the Service, the New Jersey Division of Fish, Game and Wildlife (NJDFGW), and the Delware Department of Natural Resources and Environmental Control (DNREC).

The Service recommends that the Corps proceed with plans to conduct a pilot project to study the effectiveness of geotextile tubes in Delaware Bay. Such a pilot project would greatly improve the prospects for successful implementation of the proposed Egg Island Point and Kelly Island wetland restoration projects. Such a pilot project should also include expanded horseshoe crab and shorebird surveys, and assessments of horseshoe crab spawning habitat requirements. The Service recommends that the Corps coordinate with the Service, DNREC, and NJDFGW regarding the design of the pilot project, and related monitoring studies.

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I. INTRODUCTION

This U.S. Fish and Wildlife Service (Service) planning aid report has been prepared in conjunction with a Philadelphia District, U.S. Army Corps of Engineers (Corps) Fiscal Year - 1995 scope-of-work agreement, and is submitted for the Corps' Delaware River Comprehensive Navigation Study, Main Channel Deepening Project. The material presented in this planning aid report summarizes available data and information on the fish and wildlife resources of Delaware Bay, with an emphasis on those resources that would be most affected by plans currently under consideration by the Corps for the disposal of material dredged from the Delaware Bay portion of the Main Channel. Previous Service reports have documented the effects of the proposed dredging on fish and wildlife resources (U.S. Fish and Wildlife Service, 1985, 1989, 1992). Information presented in this report includes an assessment of the effects of various dredged material disposal scenarios on fish and wildlife resources and provides Service recommendations regarding the preferred locations and designs for projects that would provide beneficial uses of dredged material, in terms of improving fish and wildlife habitat. Finally, this planning aid report presents identified data gaps and additional information needed to fully evaluate the effects of the various disposal scenarios, and includes recommendations for future studies.

II. PROJECT DESCRIPTION

The Feasibility Study for the Main Channel Deepening Project was completed in 1992. The proposed Main Channel Deepening Project was authorized by Congress in October 1992 as part of the Water Resources Development Act of 1992, based on the findings of the Feasibility Study. The authorized project would involve modification of the existing federal navigation channel from 40 feet below mean-low-water (mlw) to 45 feet below mlw. The proposed project provides for a full width channel that would follow the existing channel alignment from the Delaware Bay to the Philadelphia / Camden waterfront, a distance of approximately 102.5 miles. The proposed project includes all appropriate bend widenings as well as provision of a two-space anchorage at Marcus Hook.

Approximately 50 million cubic yards of dredged material would be removed for initial construction over a five year period. The approximately 40 million cubic yards of material dredged from the Delaware River would be placed in confined upland disposal areas. The environmental effects of the use of these proposed upland disposal areas are discussed in a separate planning aid report (U.S. Fish and Wildlife Service, 1995a). Various disposal options, including beneficial uses for dredged material, are currently being considered for the approximately 10 million cubic yards of material to be dredged from the Delaware Bay.

The Delaware Bay shoreline is experiencing severe erosion, subjecting shoreline properties to storm damage from waves and tidal inundations. Continual erosion of the Delaware Bay shoreline over the past century has also resulted in substantial wetland losses. These wetlands provide not only

valuable habitat for fish and wildlife, but also protect bayside properties and structures from storms (U.S. Fish and Wildlife Service, 1994a). The estimated 10 million cubic yards of dredged material that would be generated by the Delaware Bay portion of the Main Channel Deepening project could be used beneficially to help combat the severe erosion that is threatening bayshore wetlands and properties. Potential beneficial uses include wetland restoration, shoreline stabilization, beach nourishment, and the formation of sand stockpiles in Delaware Bay. Such stockpiles would provide a readily available source of sand for future beach nourishment projects.

The Corps is currently engaged in the Preconstruction, Engineering and Design phase of the study. The purposes of this phase are to: re-affirm and refine the authorized plan; respond to comments received on the Feasibility Study; establish the final design of the project features; and, finalize the project cooperative agreement with the Delaware River Port Authority, the non-federal project sponsor. A critical component of this phase of the study is to identify and design disposal areas for dredged material from the Delaware Bay portion of the Main Channel. Because the costs of dredged material disposal increases as the distance from the Main Channel to the disposal site increases, the sites evaluated in this report are only those sites closest to the Main Channel, that have the highest potential for providing economically feasible alternatives, as identified by the Corps. These sites include the following: Kelly Island, Delaware, and Egg Island Point, New Jersey, wetland restoration / shoreline protection sites; possible beach nourishment sites along the Delaware shore of the Bay; and, possible sand stockpile sites in Delaware Bay (Figure 1) (J. Brady, pers. comm., 1995). It is recognized that many other areas of Delaware Bay could be suitable sites for beneficial use projects.

The Corps has prepared preliminary designs for the Kelly Island and Egg Island Point wetland restoration / shoreline protection sites. The existing conditions of these sites are described in Section IV below. In summary, the shoreline in both of these areas consists of rapidly eroding tidal marsh. The preliminary plan for both of these sites is to use geotextile tubes and material dredged from the Main Channel to restore wetlands and to stabilize the shoreline.

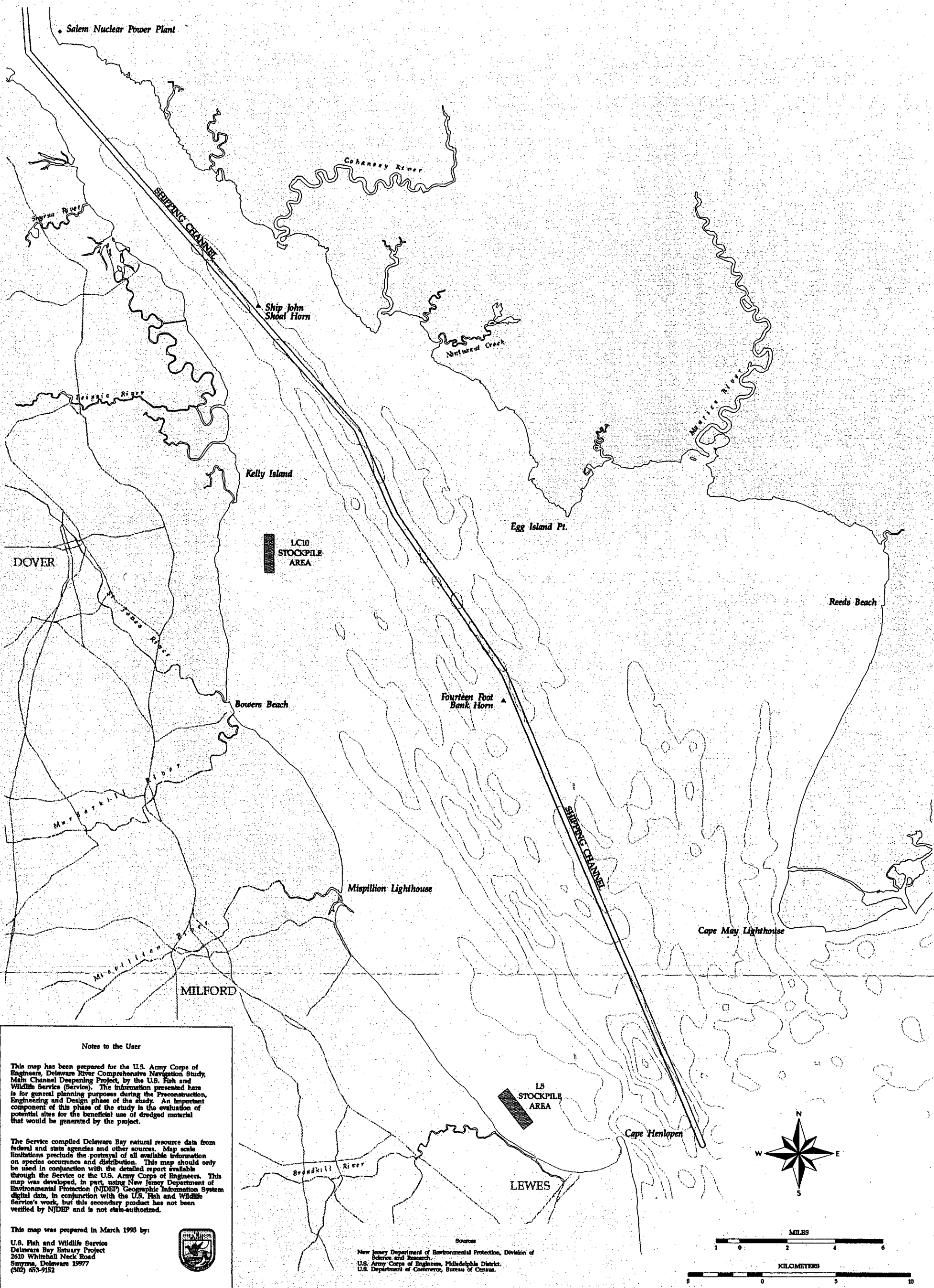
On the Kelly Island site, the goal is to protect the southern tip of Kelly Island and to restore a portion of the historic shoreline to tidal marsh. The preliminary plan (Figure 2a) includes the placement of a single geotextile tube filled with dredged material 50 to 100 feet seaward of the existing shoreline from the southern tip of Kelly Island to approximately 500 feet north of the tip. The tube would be placed on a layer of sand and a geotextile scour blanket for support.

From a point approximately 500 feet north of the southern tip of Kelly Island to Deepwater Point (a distance of 5,000 to 8,000 feet), a second geotextile tube structure would be constructed approximately 500 to 800 feet seaward of the existing shoreline. The structure would consist of a stack of three geotextile tubes filled with dredged material and supported by a layer of sand and a geotextile scour blanket placed on top of the existing substrate (Figure 2b).

Figure 1

Delaware Bay Reference Map

for the Delaware River Beneficial Use Plan



Notes to the User

This map has been prepared for the U.S. Army Corps of Engineers, Delaware River Comprehensive Navigation Study, Main Channel Deepening Project, by the U.S. Fish and Wildlife Service (Service). The information presented here is for general planning purposes during the Preconstruction, Engineering and Design phase of the study. An important component of this phase of the study is the evaluation of potential sites for the beneficial use of dredged material that would be generated by the project.

The Service compiled Delaware Bay natural resource data from federal and state agencies and other sources. Map scale limitations preclude the portrayal of all available information on species occurrence and distribution. This map should only be used in conjunction with the detailed report available through the Service or the U.S. Army Corps of Engineers. This map was developed, in part, using New Jersey Department of Environmental Protection (NJDEP) Geographic Information System digital data, in conjunction with the U.S. Fish and Wildlife Service's work, but this secondary product has not been verified by NJDEP and is not state-authorized.

This map was prepared in March 1995 by:

U.S. Fish and Wildlife Service
Delaware Bay Estuary Project
2610 Whitehall Neck Road
Smyrna, Delaware 19977
(302) 653-9152

Sources

New Jersey Department of Environmental Protection, Division of Science and Research.
U.S. Army Corps of Engineers, Philadelphia District.
U.S. Department of Commerce, Bureau of Census.

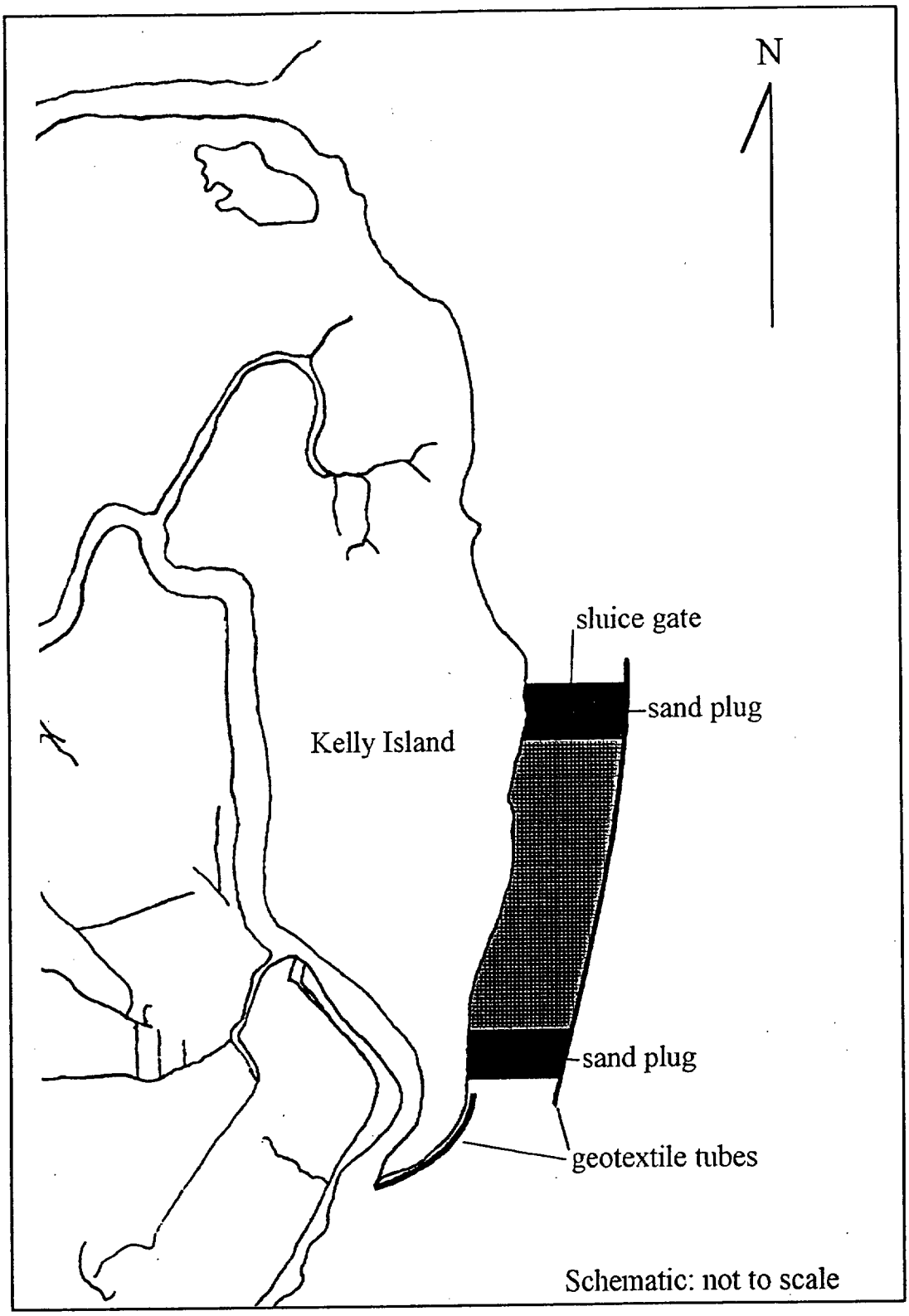


Figure 2a. Preliminary shoreline stabilization and marsh restoration plan for Kelly Island, Delaware (overhead view).

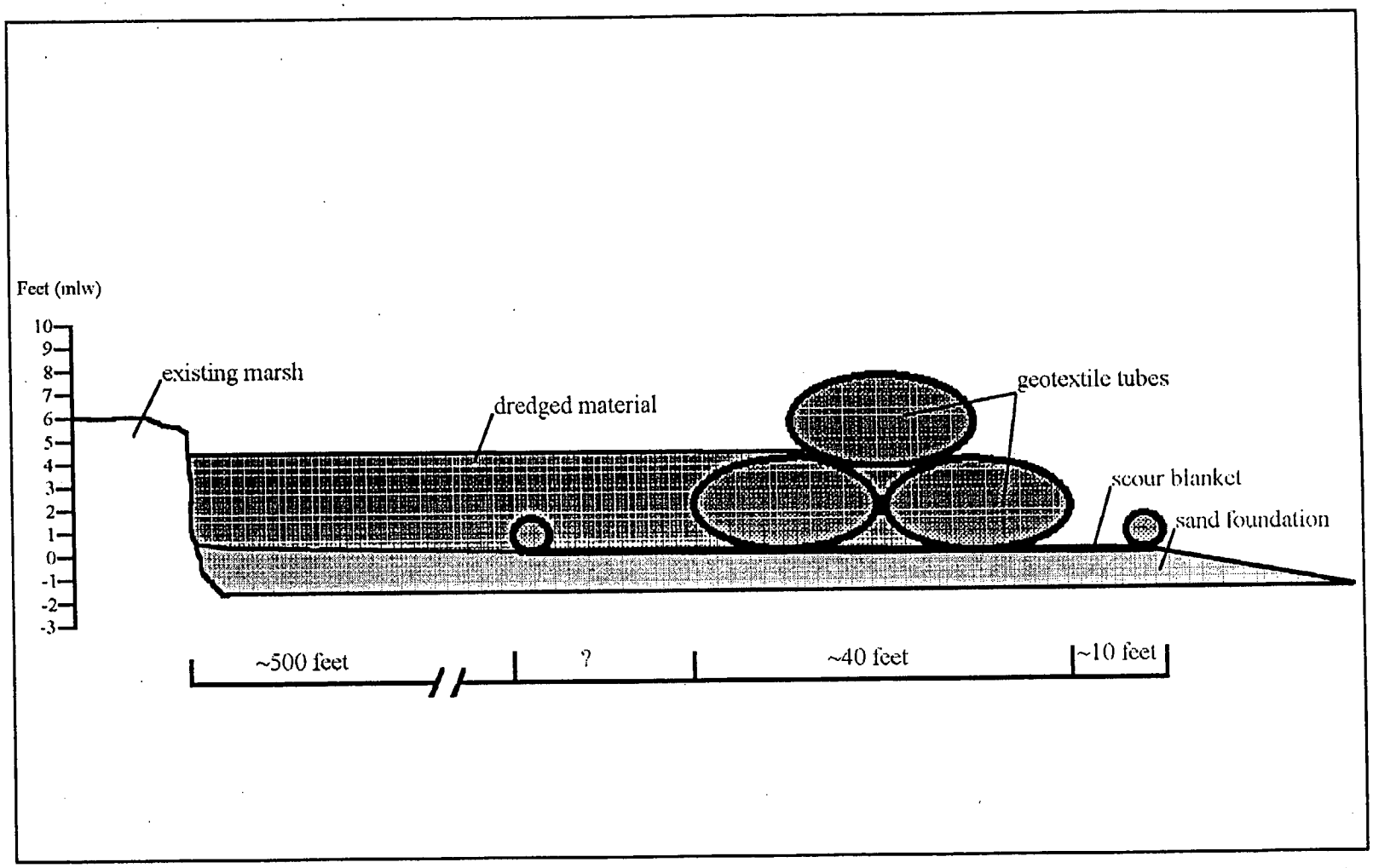


Figure 2b. Preliminary shoreline stabilization and marsh restoration plan for Kelly Island, Delaware (cross-sectional view).

The top elevation of the sand foundation would be approximately mean low water (mlw). The top elevation of the top tube would be approximately 10 feet above mlw. The areas between the shoreline and the northern and southern ends of the geotextile tube structure would be plugged with sand berms to create a confined compartment for the placement of dredged material.

Once the geotextile structure is in place, approximately one million cubic yards of silt and fine-grained material from the Main Channel would be deposited within the compartment. The site would be designed such that the dredged material would settle to the approximate elevation of the adjacent low marsh (4.5 to 5 feet above mlw). The drainage of slurry water from the site would be controlled by one or more sluice gates installed in the sand plugs. The filled area would then be planted or allowed to naturally vegetate with salt marsh cordgrass (*Spartina alterniflora*) and other native salt marsh vegetation. Approximately 80 to 125 acres of wetland would be restored, depending on the location of the geotextile tube structure.

The preliminary plan for the Egg Island Point site is similar to the Kelly Island plan in that geotextile tubes would be used to provide wetland restoration and shoreline protection (Figure 3). The structure would extend approximately two miles in each direction from Egg Island Point; northwest to Straight Creek, and northeast to Oranoaken Creek. The Corps is considering a number of design options for the proposed structure, including whether or not to place dredged material landward of the geotextile tubes. If dredged material is placed behind the structure it would be designed to stabilize at the approximate level of the adjacent low marsh, similar to the Kelly Island site. If dredged material is not placed landward of the structure, it is expected that the existing marsh would gradually advance to seaward toward the structure via sedimentation. These and other specific design options are discussed in Section VI below.

The Corps is also considering plans to nourish beaches along the Delaware shoreline using sand dredged from the Main Channel. Sites currently under consideration include the entire shoreline from Port Mahon to Lewes Beach, Delaware. The Corps is currently assessing whether beach nourishment is economically feasible.

The Corps is currently proposing to use the sand dredged from the Main Channel that is not used for either wetlands restoration or beach nourishment to create two or more sand stockpiles near the Delaware shoreline. Depending on the volume of sand used for other projects, the sand stockpiles could contain up to 9.5 million cubic yards of sand. The stockpiled sand would be available for use by the State of Delaware for erosion control, shoreline stabilization and beach nourishment (U.S. Army Corps of Engineers, 1994). The proposed stockpile sites were chosen based upon the economics of future use by the State of Delaware and environmental considerations (J. Brady, pers. comm., 1995).

Sand stockpile Site L-5 is approximately 500 acres, and is located approximately 1,000 yards offshore from Broadkill Beach, Delaware (Figure 1).

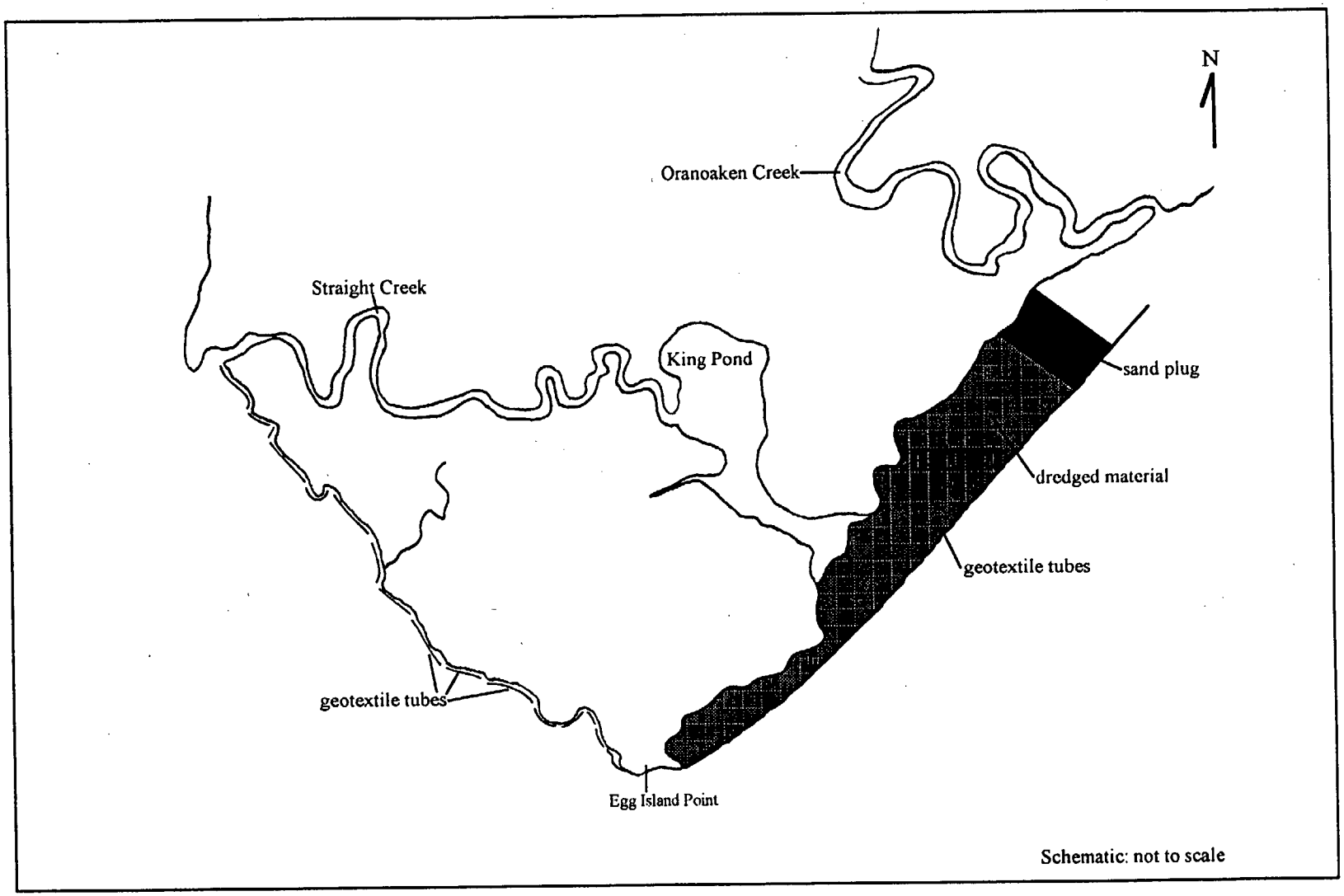


Figure 3. Preliminary shoreline stabilization and marsh restoration plan for Egg Island Point, New Jersey (overhead view).

The Corps had previously identified Site LC-10 (also 500 acres) as a second site for sand stockpiling; however, further coordination with the Service and the Delaware Department of Natural Resources and Environmental Control (DNREC) indicated that deposition of dredged material in this area would have serious environmental consequences, as discussed below. Therefore, Site LC-10 has been eliminated from further consideration (J. Brady, pers. comm., 1995). The Corps is presently considering an alternative site in the vicinity of Big Stone Beach, Delaware. No information is currently available regarding the exact location or areal extent of the proposed alternative sand stockpile site; however, the site would most likely be located in the vicinity Site MS-19, which was previously investigated by the Corps. The top elevation of the proposed stockpiles would be approximately 5 feet below mlw.

III. METHODOLOGY

The information for this planning aid report was compiled from reports provided by the Corps, searches of Service field office files and libraries, meetings and telephone conversations with local sources of expertise and representatives from DNREC and the New Jersey Department of Environmental Protection, Division of Fish, Game and Wildlife (NJDFGW). Several site visits were conducted by Service biologists to the following beaches in Delaware during February 1995: Kelly Island; Port Mahon; Pickering Beach; Kitts Hummock; South Bowers; Bennetts Pier; Big Stone Beach; Cedar Beach; Mispillion Jetty; Slaughter Beach; Fowler Beach; Roosevelt Inlet (Beach Plum Island); Lewes Beach; and, Cape Henlopen Breakwater Harbor. Additionally, Egg Island Point, New Jersey, was visited in January 1995. Two helicopter trips in February 1995 allowed for aerial observation of the area between Egg Island Point and the mouth of the Maurice River; and, from Kelly Island to Cape Henlopen.

Beach nourishment using sand dredged from the Main Channel could potentially improve spawning habitat for horseshoe crabs (*Limulus polyphemus*). Therefore, a major focus of this report is to identify those areas that are currently providing below optimal spawning habitat for horseshoe crabs as potential sites for beneficial use projects. As discussed in detail below, horseshoe crabs are habitat generalists and will spawn in a wide variety of shoreline conditions; as such, the presence of large numbers of horseshoe crabs on a given beach is not necessarily an indication of habitat quality (Shuster, 1994). However, spawning success is highest on gently sloping beaches consisting of sand at least 8 inches deep.

To assess the current suitability of individual beaches as horseshoe crab spawning habitat, field observations were recorded during the February site visits. Specifically, beach characteristics, including beach slope, sand depth, and sediment composition were recorded. Because beach conditions may vary substantially between winter and summer, the field observations discussed below may not necessarily reflect beach conditions during the horseshoe crab spawning season; however, these observations should be useful in assessing the relative suitability of individual beaches for horseshoe crabs.

Measurements for beach slope were taken with a Staedtler Mars 964 51-10 split protractor wired with a spirit level and placed on a board. Readings in degrees were taken every two meters from the highest Spring tide wrack line to the waterline. Observations were also recorded regarding the nature of the beach substrate in the area of each beach estimated to be the center of horseshoe crab spawning activity. This area is generally several meters below the wrack line, and is the area that would be uncovered between the Spring high tide and one to two hours after high tide, when horseshoe crab spawning is likely to be most intense. Sediment was sieved to ascertain suitability for spawning by horseshoe crabs. Sieve sizes of 0.425 mm and 4.25 mm were used to obtain percentages by weight of fine sand, medium and coarse sand, and gravel. Samples have been retained at the Service's Delaware Bay Estuary Project for further analysis by the Corps if desired. In sandy areas, the approximate depth of sand was also recorded.

Maps produced in a Geographic Information System have been included in this report to aid the reader in visualizing biologically sensitive areas and species distributions along the Delaware shoreline of the Bay. These maps are graphical representations of electronic data obtained by the Service from a variety of sources (listed on the maps). Only the Delaware shoreline area was mapped for this report because of the wide range of disposal scenarios currently under consideration by the Corps along the Delaware shoreline.

IV. STUDY AREA DESCRIPTION

A. DELAWARE BAY

The Delaware Bay covers a 782 square-mile area from the point at which the Delaware River widens at Liston Point, Delaware, to the mouth of the Bay between Cape Henlopen, Delaware, and Cape May, New Jersey. The general orientation of the Delaware shoreline is from the northwest to the southeast, except for Cape Henlopen, which turns north. The lower Delaware Bay is semicircular, with minimal shoreline topographic development. This flat shoreline topography has resulted in the long contiguous sandy beaches that are typical of the Delaware Bay. In fact, the Delaware Bay contains the longest contiguous sandy beaches of any estuary on the mid-Atlantic coast (C. Shuster, pers. comm., 1995).

The open mouth of the Delaware Bay exposes much of the shoreline to the open ocean. The fetch (distance across open water to shore) is large, and the shoreline can experience fully developed seas even when they are created within the bay under local wind conditions. Much of the wave energy responsible for the constant, incremental (non-storm) erosion is thought to be developed from local wind patterns (Kraft *et al.*, 1976). However, severe tropical and extra-tropical storms are responsible for the most damaging events (French, 1990). A long history of erosion, subsidence, and sea level rise continues to result in dynamic, unstable shoreline conditions in many

areas. Tidal amplitude is high; from 4 to 7 feet compared to the Chesapeake Bay, which averages about 1.5 feet. There are also strong currents in Delaware Bay; up to 4 knots (Kraft *et al.*, 1976).

The average net change for the Delaware shoreline from Kelly Island to Lewes, Delaware, between the years 1882 and 1977 was 419.3 feet to landward or approximately 2.6 feet per year (French, 1990). Average net change for the more highly erosive northern portion of the shoreline, north of the Mispillion River Inlet, between 1842 and 1977 was 978.9 feet to landward (French, 1990). This translates to an average rate of erosion of 7.2 feet per year (French, 1990). Unlike the southern and central sections of the Delaware shoreline, the pattern of erosion in the northern areas does not appear to be storm-driven. Instead the shoreline appears to be retreating at a relatively regular rate (French, 1990). The reasons for these differences in erosion rates in various sections of the Bay are not clear, but erosion is expected to continue or possibly accelerate (French, 1990).

The pattern of shoreline change along the New Jersey shoreline of the Bay is less well documented than on the Delaware side. The shoreline in the vicinity of Fortescue, New Jersey, which is approximately two miles northwest of the Egg Island Point project site, experienced average erosion of approximately one foot per year between 1940 and 1978. However, the area around Maurice River Cove, immediately to the east of Egg Island Point, had erosion rates between 3 and 12 feet per year over the same period (U.S. Army Corps of Engineers, 1991). Egg Island Point itself appears to be eroding more rapidly, and the Corps estimates the shoreline at Egg Island Point to be eroding at a rate of between 15 and 30 feet per year (J. Brady, pers. comm., 1995).

B. DESCRIPTION OF SITES UNDER CONSIDERATION FOR DREDGED MATERIAL DISPOSAL

For the purposes of this report the Delaware shoreline of Delaware Bay has been divided into four segments: (1) Kent Island and Kelly Island; (2) Port Mahon to South Bowers Beach; (3) Bennetts Pier to Big Stone Beach; and, (4) Mispillion Jetty to Lewes Beach. While this division is somewhat arbitrary, and considerable variation occurs among the beaches within each segment, the beaches within each of these segments share certain properties that make this grouping useful for discussion.

Additional information regarding beach characteristics and historic shoreline changes along the Delaware shoreline can be obtained from the following sources:

Robert Henry
Division of Soil and Water
Delaware Department of Natural Resources
and Environmental Control
89 Kings Highway
P.O Box 1401
Dover, Delaware 19903
(302) 739-4411

Jonathan Sharp
University of Delaware
College of Marine Studies
700 Pilottown Road
Lewes, Delaware 19958
(302) 645-4259

Robert Jordan
Delaware Geological Survey
University of Delaware
Delaware Geological Survey Building
Newark, Delaware 19716
(302) 831-2833

1. Egg Island Point

This section of the New Jersey shoreline is characterized by eroding salt marsh, with limited areas of sandy beach. Most of the shoreline consists of steep scarps of eroded peat four to six feet tall interfacing directly with open water of Delaware Bay. Some areas, particularly along the southwestern shoreline, have small sandy beaches consisting of thin layers of sand over eroded peat. These areas and the tip of Egg Island Point are the only areas of the site with substantial sandy beaches. Scattered small dunes immediately landward of the shoreline are vegetated primarily by common reed (*Phragmites australis*) and high-tide bush (*Iva frutescens*). The salt marsh in this area is typical of Delaware Bay salt marshes with the dominant vegetation being salt marsh cordgrass. There are also numerous shallow tidal and non-tidal ponds and tidal creeks scattered across the surface of the salt marsh.

2. Kent Island and Kelly Island

This section of the Delaware shoreline is part of the Bombay Hook National Wildlife Refuge. The shoreline in this area can be characterized as eroding salt marsh, with limited areas of sandy beach. The shoreline of Kent Island consists of approximately 1.5 miles of salt marsh interfacing directly with open water of Delaware Bay. The erosional rate in this portion of the Bay is extremely high. Recession averaged nearly 20 feet per year between 1848 and 1972 (Kraft *et al.*, 1976). The marsh substrate is a thick layer of peat; 18 to 30 feet deep (Kraft *et al.*, 1976). The dominant vegetation is a mixture of salt marsh cordgrass and common reed.

Kelly Island has approximately 2.5 miles of shoreline consisting of sheltered tidal flats, small mixed sand and gravel beaches, and outcrops of salt marsh in erosional areas. The small beaches in this area consist of thin layers of sand and gravel over exposed peat. Service biologists visited the southern tip of Kelly Island on February 13, 1995. The substrate consists of compacted peat with vertical scarps 3 to 5 feet high at the waterline. Large sections of the marsh mat at the island's southern tip have been broken off by recent wave action. The southern tip of the island is eroding rapidly, and has migrated northward more than 5,000 feet since 1842; an average of over 37 feet per year (French, 1990). The marsh substrate in this area exceeds 30 feet in depth (Kraft *et al.*, 1976). Sand taken from a small beach face in front of Bombay Hook Marsh just north of Kent Island in 1978 had a mean sediment size of 0.339mm (French, 1990).

According to a map of percent silt / clay in Delaware Bay sediments (Maurer *et al.*, 1978), sediments in Kelly Island area were between 70 and 100 percent silt / clay. Similarly, the Greeley-Polhemus Group (1994) found that substrates at this site included sandy areas and areas consisting of silt / clay.

In the event of an oil or hazardous materials spill, three Boom Deployment sites have been identified in the Delaware Bay and River Cooperative's Oil Spill Response Plan Appendices (Delaware Bay and River Cooperative, Inc., 1991) along the Kent Island shoreline, along a 1.5-mile-long section between the Leipsic River and the Simons River, indicating the sensitivity of this area to disturbance and pollution.

3. Port Mahon to South Bowers Beach

This section of the Delaware Bay shoreline can be characterized as experiencing moderate to severe erosion. The individual beaches in this section vary in their physical characteristics depending upon whether beach nourishment or other shoreline stabilization mechanisms have been employed. There is little to no longshore sediment transport in the area between Port Mahon and Pickering Beach (French, 1990).

The Port Mahon site extends approximately one mile from the mouth of the Mahon River to the mouth of Little Creek. The shoreline is rip-rapped and bulkheaded for most of this length; however, small beaches of sand and crushed oyster shell occur in areas where the bulkhead has collapsed or at the ends of the bulkhead, and salt marsh has filled in some areas behind the bulkhead. Numerous pilings and remnant piers are scattered along the shoreline. Rip-rapped sections of the Port Mahon site are washed over in some areas by spring tides and storm tides. There is a fishing fleet at the road's northern terminus, and the boat ramp is heavily used by small-boat traffic. Hundreds of bird watchers come to Port Mahon in May and conflicts often arise because too many cars block the narrow, washed out road that runs parallel to the beach.

The most suitable horseshoe crab spawning habitat at Port Mahon is the approximately 660-foot-long section of shoreline just north of the Dover Air Force Base Aviation Gas pipeline / barge unloading pier. Field observations of beach conditions in this area collected during a February 1995 Service site inspection indicated that the sand was fairly uniform in grain size from the surface to a depth of about 8 inches. Buried rip-rap was encountered at two sample spots, and a layer of gravel and oyster shells was found at a depth of approximately 10 inches along the mid-tide line. Sediment samples taken at the southern end of Port Mahon, near the mouth of Little Creek were composed almost entirely of unconsolidated peat.

The thickness of the coastal mud offshore of Port Mahon ranges from 30 feet or less near the mouth of the Mahon River at the north end of the site to greater than 30 feet along the remainder of shoreline. These deep mud deposits extend south most of the way to Kitts Hummock (Kraft *et al.*, 1976).

Pickering Beach is a small summer resort community, with approximately 40 summer cottages located about 20 feet behind the landward edge of the barrier dune. Pickering Beach consists of approximately 0.75 mile of mixed sand and gravel beach, grading into exposed marsh substrate covered with a thin layer of sand at the northern and southern ends of the site. An extensive mud flat occurs in the offshore area.

Pickering Beach has experienced an average, long-term erosion rate of 5.6 feet per year (French, 1990). This rate is higher than Kitts Hummock, but lower than Port Mahon. The Pickering Beach community is extremely vulnerable to storm damage, and has experienced severe erosion following storms events.

Pickering Beach is part of the State's beach replenishment program, and was also one of six sites selected for a demonstration project of low-cost shoreline protection (U.S. Army Corps of Engineers, 1981). The scrap-tire breakwater structure located about 300 feet off the mid-southern portion of the beach was installed in 1978, and aerial observation indicates some accretion of sediment around it. Sand taken from Pickering Beach in 1978 had a mean sediment size of 0.724mm (French, 1990).

Kitts Hummock consists of approximately 0.5 mile of mixed sand and gravel beaches surrounded by extensive tidal mud flats and marshes. Sand taken from Kitts Hummock in 1978 had a mean sediment size of 0.550mm (French, 1990). Long-term erosion rates for Kitts Hummock average approximately 4.2 feet per year (French, 1990).

The normal tidal range at Kitts Hummock is approximately 5 feet, and nearly tops the barrier dunes at high tide (National Oceanic and Atmospheric Administration, 1995). This renders the small coastal community of Kitts Hummock vulnerable to storm damage. While beach nourishment has slowed the rate of erosion somewhat, the area is still undergoing landward recession. Three breakwaters were installed by the Corps in 1978 and 1979 as part of the above-mentioned demonstration project (U.S. Army Corps of Engineers, 1981). Each breakwater was constructed of different materials. The northernmost breakwater is approximately 300 feet in length and was constructed of pre-cast concrete boxes; the center breakwater is also approximately 300 feet in length and was constructed of nylon sandbags, which have apparently failed; and the southernmost breakwater is a 300-foot-long mound of rubble. The breakwaters are separated by gaps of about 300 feet. Conversations with a local resident suggested that extensive buildup of mud in front of the beach has accelerated since the breakwaters were built.

Bowers Beach consists of approximately 2,400 feet of medium sand and gravel beaches. The average grain size of sand taken from Bowers Beach in 1978 was 0.586mm (French, 1990). Analysis of Corps data indicates that shoreline erosion in the Bowers Beach area averaged slightly over 4 feet per year between 1843 and 1954 (Kraft *et al.*, 1976). Bowers Beach is periodically renourished by the State of Delaware, and the mouth of the Murderkill River is stabilized on both sides by large sand-filled bags. The combination of sandbag groins and beach nourishment has performed reasonably well in reducing

beach loss (U.S. Army Corps of Engineers, 1981); although the net erosion over the long term has still averaged 5.4 feet per year (French, 1990). While littoral sediment transport in this area is weak and erratic (French, 1990), wave heights averaging 1-2 feet with a maximum of 4 feet have the potential to move significant amounts of sediment (U.S. Army Corps of Engineers, 1981).

The beaches of South Bowers Beach are mixed sand and gravel. The area of the beach near the waterline consist of a thin layer of sand and gravel over peat, whereas the upper portions of the beach have thicker layers of sand and gravel. There are extensive mud flats offshore. The distance from the wrack line to the beginning of the mud flats (with 0 degrees slope) was approximately 55 feet during February 1995 site investigations.

Field observations of beach conditions collected during a February 1995 Service site inspection indicated that the sand depths on South Bowers Beach are somewhat variable, ranging from less that 2 inches in depth near the mean low water line to in excess of 15 inches near the high tide line.

In the event of an oil or hazardous materials spill, two boom deployment sites have been identified in the Delaware Bay and River Cooperative's Oil Spill Response Plan Appendices (Delaware Bay and River Coopratives, Inc., 1992) at Port Mahon; they are at the mouths of Little Creek and the Mahon River. Additionally, there are boom placement sites at the mouth of the Little River, along the marshes off the Little Creek Wildlife Management Area, and at the mouth of Lewis Ditch.

4. Bennetts Pier to Big Stone Beach

This section of the Delaware shoreline consists of relatively stable to slightly accreting beaches; in part due to the more erosion-resistant Pleistocene neck formations in this area. The shoreline on either side of the Murderkill River has oscillated between periods of erosion and periods of accretion. These beaches eroded substantially between 1842 and 1943 (French, 1990), followed by slight accretion during the period between 1943 and 1954, and again by erosion between 1954 and 1969. From 1969 to 1977 the area experienced the highest average annual accretion rate in recorded history (French, 1990).

Nothing remains of the pier that once stood at Bennetts Pier except for a few rotted pilings. Sand taken from Bennetts Pier in 1978 had a mean sediment size of 0.587mm (French, 1990). Field observations taken during the Service's February 1995 site inspection indicate that large segments of the beach between Bennetts Pier and Big Stone Beach can be characterized as either predominantly sand or sand-covered peat outcrops ranging in height from 1 to 3 feet. Mud flats occur adjacent to the beach in some areas, particularly near Clark Point. In this area, 3.2 miles south of Bennetts Pier, the beach is very narrow with steeper slope and peat scarps at the waterline; high tide completely inundates this beach up to the dune.

The Big Stone Beach portion of the Delaware shoreline appears to be experiencing relatively little erosion. Sand taken from Big Stone Beach in 1978 had a mean sediment size of 1.117mm (French, 1990). The Nature Conservancy and Delaware Wildlands own a significant portion of Big Stone Beach in the Milford Neck area.

5. Mispillion Jetty to Lewes Beach

Cedar Beach (at the Mispillion Jetty) consist of approximately 0.6 mile of unconsolidated peat, eroded marsh embankments and a thin layer of mixed sand and gravel. Most of Cedar Beach (the undeveloped portion) is in the shadow of the large jetty at the mouth of the Mispillion River. The jetty extends more than 1.1 miles from the shore toward the southeast. There is no sand on the northern portion of Cedar Beach except for a small pocket near the foot of the large jetty and a small sand island about halfway out from the jetty. Sand taken from Cedar Beach at the Mispillion River in 1978 had a mean sediment size of 0.708mm (French, 1990). The entire northern half of the beach is composed of unconsolidated peat with shell fragments and common reed stem fragments in three or more large scarps beginning at the waterline and ending near the edge of detrital marsh grass, an average distance of 50 feet. Peat outcrops from relict marshes are also present. Unconsolidated peat is at least 25 inches deep at a point 20 feet below the highest wrack line. Bordering the peat beach is a dense stand of common reed. The southern portion of Cedar Beach, most of which is inhabited, is a layer of mixed sand and gravel of variable thickness overlying densely packed peat.

Extensive mud flats lie offshore from Cedar Beach. The thickness of the mud exceeds 30 feet (Kraft *et al.*, 1976). The silt dredged out of the Mispillion River by the Corps has been historically deposited in the area immediately to the south of the jetty (J. Brady, pers. comm., 1995), but will in future operations be placed on the Bay side of the rubble breakwater along the north shore of the inlet (T. Mercer, pers. comm., 1995).

The sand island about halfway out from the jetty measures approximately 150 feet wide by 800 feet long, and is surrounded by mud flats. The sand along the mid-tide line was at least 12 inches deep during the February 1995 site inspection. The distance from the waterline at low tide to the vegetation near the jetty was approximately 100 feet.

Slaughter Beach consists of approximately 2.8 miles of mixed sand and gravel beach interspersed with peat outcrops and offshore mud flats. No tidal creeks intersect this segment of beach, but several are located just behind the dunes. Sand taken from Slaughter Beach in 1978 had a mean sediment size of 1.125mm (French, 1990).

Slaughter Beach has experienced an oscillatory pattern of low accretion or limited erosion, followed by periods of substantial accretion (French, 1990). Long-term analysis shows an average annual accretion rate of +1.0 foot per year (French, 1990). These relatively stable shoreline conditions are due, in part, to shoreline stabilization efforts in this area.

Approximately one mile south of the southernmost house on Slaughter Beach is a large washover or dune blowout. During February 1995 site inspections, the opening in the dune was approximately 250 feet wide at the top of the dune, and sand extended into flats over the marsh, covering it for a distance of approximately 1,000 feet. Large numbers of horseshoe crab remains were observed, especially in a low muddy spot just inside the opening. The beach to seaward of the washover consists of a thin layer of sand overlying peat outcrops near the water's edge.

Fowler Beach is primarily mixed sand with some gravel. From the wrack line to 75 feet down slope, the beach is primarily sand and gravel. The sand is fairly deep (greater than 15 inches) in the upper portion of the intertidal zone. Sand taken from Fowler Beach in 1978 had a mean sediment size of 0.739mm (French, 1990). The sand is eroded near the waterline, exposing peat in hard, rib-like formations about 4 inches wide oriented perpendicular to the shoreline.

Broadkill Beach was not visited during field investigations for this project. However, information on this area is available from a previous Service Planning Aid Report (U.S. Fish and Wildlife Service, 1994a). A Service biologist inspected the Broadkill Beach shoreline on November 11, 1994, just after a beach replenishment effort by the State of Delaware. The existing beach is exposed to a fetch of 12 miles or more across Delaware Bay. Houses along Broadkill Beach are linearly distributed in a narrow zone between the beach and an extensive salt marsh. There is only a narrow low vegetated dune between the back of the beach and the houses. The vegetation is primarily beach grass (*Ammophila breviligulata*). Sand taken from Broadkill Beach in 1978 had a mean sediment size of 0.669mm (French, 1990).

The beach north of the jetty at Roosevelt Inlet is mixed sand and gravel, thinning out to the north. Immediately inside the inlet at the foot of the jetty are large peat outcrops covered with a thin layer of sand that appears to have been blown or washed over the jetty from the north side.

Lewes Beach consists of approximately 2 miles of mixed sand and gravel from Roosevelt Inlet to the ferry terminal. The site was recently nourished by the State of Delaware as part of an ongoing program of beach maintenance. Lewes Beach is lined with houses for the entire distance from the ferry terminal to the breakwater at Roosevelt Inlet.

The DNREC, Division of Soil and Water, has identified the northern 1,000 to 2,000 feet of Lewes Beach as an area in continual need of replenishment because the sand from this location is carried by water currents and deposited beside the jetty at the ferry terminal (R. Henry and T. Pratt, pers. comm., 1995).

6. Sand Stockpiles

The Corps evaluated a number of aquatic sites for potential use as locations for sand stockpiles. Preliminary assessments conducted by the Corps and the Greeley-Polhemus Group (1994) identified two sites (L-5 and LC-10) as the most

practicable sites for sand stockpiles (Figure 1). Based on additional information and interagency coordination during the preparation of this report, the LC-10 site was eliminated from consideration due, in part, to the environmental constraints discussed below. The Corps is currently considering an alternative sand stockpile site to be located in the vicinity of Big Stone Beach. The nearest site for which data are available is the previously evaluated Site MS-19, located near Slaughter Beach. Information on Site MS-19 is summarized below because it is expected that the offshore area in the vicinity of Big Stone Beach is similar in nature to Site MS-19; although, once a site is selected for the proposed sand stockpile, site specific conditions should be verified.

Site L-5 is 500 acres located approximately 1,000 yards offshore of Broadkill Beach, Delaware. Water depths in this area range from 10 to 17 feet at mlw. The Greeley-Polhemus Group (1994) characterized the sediments at this site as mostly sand, with some areas of silt / clay. Site LC-10 is a 500-acre site located approximately one mile offshore of Kelly Island in approximately 9 to 12 feet of water. Maurer *et al.* (1978), characterized the LC-10 area as mostly composed of 70 to 100 percent silt / clay sediments, with slightly sandier (40 to 70 percent silt / clay) sediments to the immediate north. This concurs with the Greeley-Polhemus Group (1994) who characterized the sediments at Site LC-10 as mostly fine sand and silt / clay. Site MS-19 is a 500-acre site located approximately 1,000 feet offshore of Slaughter Beach, Delaware, in approximately 8 to 10 feet of water. Maurer *et al.* (1978) characterized the area around the MS-19 site as having sediments ranging from 0 to 40 percent silt / clay (i.e., consisting mostly of sand or other hard substrate). The Greeley-Polhemus Group (1994) characterized the substrate at this site as consisting of sand and silt / clay.

V. FISH AND WILDLIFE RESOURCES

A. GENERAL

The Delaware Bay supports diverse and abundant fisheries and shellfisheries resources of high ecological, commercial and recreational value. Additionally, the extensive tidal marshes and shallow water areas bordering most of the Delaware Bay receives heavy use throughout the year by migratory shorebirds, waterfowl, raptors, and passerines. The interspersion of beach and marsh cover types annually hosts the second largest concentration of migrating shorebirds in the Western Hemisphere, including 80 percent of the hemispheric population of red knots (*Calidris canutus)* (Myers *et al.*, 1987; Clark *et al.*, 1993).

1. Macroinvertebrates

a. Horseshoe crabs

The largest population of spawning horseshoe crabs in the world is found in Delaware Bay (C. Shuster, pers. comm., 1995). Each spring, adult horseshoe crabs migrate from deep water in the Delaware Bay and the Atlantic continental shelf to spawn on Delaware Bay beaches. The minimal geologic shoreline development and smooth morphology of Delaware Bay's lower shoreline facilitates movement of horseshoe crabs and enables them to find suitable spawning beaches in large numbers. Spawning generally occurs from April to July, with the peak spawning activity occurring on full moon high tides in May and June. The average width of the intertidal area used by horseshoe crabs for spawning is about 45 feet on Delaware Bay beaches (C. Shuster, pers. comm., 1995). Eggs are deposited in the upper portion of the intertidal zone in clusters approximately 6 to 8 inches below the surface. The average cluster contains between 3,000 and 4,000 eggs.

Horseshoe crab reproductive success is greatest under the following conditions: (1) the egg clusters are moistened by water with salinity of at least 8 parts per thousand; (2) the substrate around the egg clusters is well oxygenated; (3) the beach surface is exposed to direct sunlight to provide sufficient incubation; and, (4) the slope of the beach is adequate for larvae to orient and travel downslope to the water upon hatching (Shuster, 1994). These conditions are found on sandy beaches along the lower portion of Delaware Bay.

The mechanism by which horseshoe crabs locate preferred spawning habitat is not completely understood. While horseshoe crabs spawn in greater numbers and with greater fecundity along sandy beaches, horseshoe crabs can tolerate a wide range of physical and chemical environmental conditions, and will spawn in less suitable habitats if ideal conditions are not encountered. Therefore, the presence of large numbers of horseshoe crabs on a beach is not necessarily an indicator of habitat suitability (Shuster, 1994). It is known that shoreline areas with high concentrations of silt or peat are less favorable to horseshoe crabs, because the anaerobic conditions reduce egg survivability. It also appears that horseshoe crabs can detect hydrogen sulfide, which is produced in the anaerobic conditions of peat substrates, and that horseshoe crabs actively avoid such areas (Shuster, 1994).

Beach slope is also thought to play an important role in determining the suitability of beaches for horseshoe crab spawning (C. Shuster, pers. comm., 1995). Horseshoe crabs generally travel downslope after spawning and appear to become disoriented on flat areas (T. Jacobsen, pers. comm., 1995). Although the optimal beach slope is unknown, beaches visited by the Service during February 1995 had slopes of between 3 and 7 degrees to seaward. As previously noted, beach conditions vary substantially from season to season, and these observations may not reflect beach conditions during the horseshoe crab spawning season.

In addition to the intertidal zone used for spawning, horseshoe crabs also use shallow water areas (less than two fathom depths) such as intertidal flats and shoal water as nursery habitat for juvenile life stages. Adult horseshoe crabs forage in deep water habitat during most of the year, except during the breeding season when they move into shallow and intertidal water.

The presence of offshore mud flats may also influence the use of certain beaches by spawning horseshoe crabs. Horseshoe crabs may congregate on mud flats to wait for full moon high tides, because these areas provide protection from wave energy. Female horseshoe crabs can carry over 88,000 eggs per animal (Shuster and Botton, 1985). Therefore, several tidal cycles are required to complete spawning. Offshore mud flats may provide safe areas to rest between tide cycles.

Under normal conditions spawning mortality on beaches averages approximately 10 percent of the spawning individuals. Factors contributing to normal mortality include age, excessive energy expenditure during spawning, stranding, desiccation, or predation by gulls. Entrapment in man-made structures such as rip-rap, bulkheads, and jetties, and commercial harvest also account for significant additional mortality.

Annual beach surveys of Delaware Bay horseshoe crab spawning activity conducted by volunteers since 1990 appear to indicate an overall decline in the horseshoe crab population in recent years (Swan *et al.*, 1994). Preliminary results from the 1995 beach surveys appear to further support the conclusion that horseshoe crab numbers are declining (B. Swan, pers. comm., 1995). Additionally, trawl surveys conducted by DNREC appear to corroborate the findings of the beach surveys (S. Michels, pers. comm., 1995). Weather and other factors influence the timing and intensity of spawning; therefore, additional data are needed before valid conclusions can be drawn regarding population trends. Nonetheless, the observed downward trend in the existing data is reason for concern.

The beach surveys are also useful in documenting relative use of various shoreline segments by spawning horseshoe crabs. For example, the survey data indicate declining numbers of spawning horseshoe crabs on beaches experiencing the highest erosion; Kelly Island and Port Mahon, in particular. The most consistent spawning beaches in Delaware appear to be those between Kelly Island and South Bowers Beach, which have extensive mud flats offshore.

While horseshoe crabs have some commercial value, the primary importance of this species is food chain support, particularly for migratory shorebirds. Shorebirds congregate along the Delaware Bay shoreline during their northward migration each spring because the massive amounts of horseshoe crab eggs provide a food source unlike that in any other site in the Western Hemisphere. Shorebirds passing through Delaware Bay spend, on average, 15 days replenishing body fat reserves before

continuing their migration to nesting areas in the Arctic. During that period, these shorebirds consume massive quantities of horseshoe crab eggs. For example, sanderling (*Calidris alba*) have been estimated to eat 9,000 eggs per individual per day (Castro *et al.*, 1989).

The bills of most shorebirds are too short to allow them to dig up horseshoe crab egg clusters (C. Shuster, pers. comm., 1995). Most, shorebirds rely on successive waves of horseshoe crabs to come ashore and inadvertently dig up previously deposited egg clusters while attempting to deposit new egg clusters. Therefore, a large population of horseshoe crabs, laying many more eggs than are needed to maintain the population, is necessary to provide a sufficient food supply for migrating shorebirds. However, the minimum size of the population needed to sustain shorebird populations is unknown.

b. Other macroinvertebrates

Commercially and recreationally important macroinvertebrate species found in Delaware Bay include Blue crab (*Callinectes sapidus*), American oyster (*Crassostrea virginica*) and hard clam (*Mercenaria mercenaria*). Blue crabs are abundant throughout the area, foraging in tidally influenced waters and wetlands from May through November. During the Winter (December through April) blue crabs stay in water greater than 15 feet deep.

In waters within the State of Delaware, oysters occur in naturally reproducing seed beds offshore and north of Kelly Island and in leased bed areas south of Kelly Island down to the Mispillion River area. In New Jersey waters, oyster seed beds occur from south of Artificial Island to Fortescue; lease beds occur from southwest of Egg Island Point throughout much of the lower Bay. Hard clams occur throughout the area, on soft sandy bottoms in water with salinity greater than 12 ppt (J. Dobarro, pers. comm., 1995).

Maurer *et al.* (1978) found a total of 169 species of benthic macroinvertebrates in the Delaware Bay over two summers of sampling (1972 and 1973). Maurer *et al.* (1978) noted that there are marked seasonal and annual fluctuations in the distributions of animal assemblages. The number of species and number of individuals increased with increasing salinity and increasing median sediment grain size.

The general composition of the benthic invertebrate community is similar to that of other temperate estuaries in the Northern Hemisphere (Maurer *et al.*, 1978). Dominant species include the polychaetes *Glycera dibranchiata, Heteromastus filiformis,* and *Scoloplos fragilis*; and mollusks such as *Tellina agilis, Ensis directus, Nucula proxima, Gemma gemma, Mulinia lateralis, and Mytilus edulis.* These species are found in community assemblages throughout the Mid-Atlantic Bight (Pratt, 1973).

2. Finfish

The Delaware Bay supports substantial recreational and commercial fisheries. Weakfish (*Cynoscion regalis*), summer flounder (*Paralichthys dentatus*), and bluefish (*Pomatomus saltatrix*) are the most popular recreational species, but the recreational catch also includes striped bass (*Morone saxatilis*), scup (*Stenotomus chrysops*), tautog (*Tautoga onitis*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), red hake (*Urophycis chuss*), black sea bass (*Centropristis striata*), skates, and sharks (Seagraves, 1988). The Delaware Bay also supports important anadromous fish species including American shad (*Alosa sapidissima*), alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*). Stocks of several of these species, most notably weakfish, have declined in recent years due largely to over-fishing (R. Miller, pers. comm., 1995).

Weakfish are one of the most important species in Delaware Bay in terms of abundance and value to the recreational and commercial fisheries. Weakfish are seasonal residents of Delaware Bay from April through October and spawn throughout the project area. Spawning occurs throughout the summer, but peaks in June and July. The larvae are transported by currents to the middle and upper portions of the Bay where they develop into juveniles. During the fall, after juveniles have attained a length of 4 to 6 inches, weakfish migrate to wintering areas off Virginia and North Carolina (Mercer and Moran, 1989).

Striped bass occur in all seasons, throughout the project area; although young-of-the-year use the project area only sporadically, concentrating primarily in the spawning area, which is in the Wilmington / Philadelphia area of the Delaware River.

Black sea bass, scup, and tautog stay in close proximity to reefs or other hard irregular structures. These species can be found throughout the project area, during any time of the year.

American shad use the project area during two time periods. In the spring and early summer (April through July) the channel and other deep areas of the bay serve as a "multi-stock" staging area for adults as they wait for water temperatures to warm upstream in the Delaware River and further up the Atlantic coast. Fish from the north Atlantic then move back out to the coast, while the Susquehanna and Delaware River stocks migrate upstream to spawn. In the fall (September through November) the "young-of-the-year" move down into the Bay as the water temperatures decrease, and then leave the Bay for the open ocean (MacKenzie *et al.*, 1985).

3. Reptiles

The northern diamondback terrapin (*Malaclemys t. terrapin*) is relatively common throughout the study area. Estuarine emergent marshes and associated creeks and near shore waters are used for foraging (April through December) (Palmer and Cordes, 1988). Salt marsh snails and fiddler crabs form the bulk of the diamondback terrapin diet. Egg laying occurs from early June through mid-July on sandy beaches with little or no vegetation, as well as on bayshore

beaches surrounding the mouth of tidal marsh creeks. Hibernation occurs in mud banks and creek bottoms within the foraging areas, as well as within the nests themselves.

The northern diamondback terrapin is a candidate for inclusion on the federal List of Endangered and Threatened Wildlife and Plants, pursuant to the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.). Candidate species receive no protection under the Endangered Species Act; however, the Service encourages federal agencies and other planners to consider candidate species in project planning. Additional information on federally-listed species is provided in section V.A.5 below.

4. Avifauna

a. Waterfowl

Waterfowl are abundant in tidally influenced wetlands and shallow water areas throughout the study area, reaching peak numbers in the fall and winter months. The Little Creek Management Area south of Kelly Island and the Bombay Hook National Wildlife Refuge area are important concentration areas for snow goose (*Chen caerulescens*), Canada goose (*Branta canadensis*) and dabbling ducks such as mallard (*Anas platyrhynchos*), American black duck (*Anas rubripes*), northern pintail (*Anas acuta*), and green-winged teal (*Anas crecca*). Black ducks are known to concentrate in the scalloped, cut-out areas along Kelly Island, created as the shoreline erodes (E. Smith, pers. comm., 1995). In addition, diving ducks such as scaup (*Aythya sp.*) and canvasback (*Aythya valisineria*) use the Little Creek area of the Bay itself (generally within the oyster leasing area).

b. Shorebirds

As many as 1.5 million shorebirds may pass through the Delaware Bay each spring (Niles *et al.*, 1994); the largest concentration of shorebirds on the east coast. As previously mentioned, the shorebird stopover coincides with the spawning period of horseshoe crabs. The most commonly occurring shorebird species that migrate through Delaware Bay are the red knot, ruddy turnstone (*Arenaria interpres*), semipalmated sandpiper (*Calidris pusilla*), sanderling, dunlin (*Calidris alpina*), and dowitchers (*Limnodromus* spp.). The first four species listed comprise 97 percent of all shorebirds observed in aerial surveys conducted since 1986 (Clark *et al.*, 1993).

Shorebirds are dependent on a mosaic of beach and salt marsh cover types to meet their requirements for foraging, roosting, and resting (Burger *et al.*, in press; Niles *et al.*, 1994). While the horseshoe crab eggs found on Delaware Bay beaches are an essential food source for migrating shorebirds, other cover types are also used extensively by shorebirds. Shorebirds feed in salt marsh ponds and creeks during high tide when bayshore beaches are inaccessible, and shorebirds roost in protected areas of the salt marsh.

Little information exists on the historical use of the Delaware Bay by migrating shorebirds. Since 1985, the NJDFGW, Endangered and Nongame Species Program, and the DNREC, Endangered and Nongame Species Program, have conducted annual shorebird surveys along Delaware Bay. Aerial surveys of approximately 50 miles of shoreline in both Delaware and New Jersey are conducted once per week for six weeks each May and June. The Delaware portion of the survey extends from Woodland Beach south to Cape Henlopen. The New Jersey portion of the survey extends from the Cohansey River to Cape May Canal. Estimates are made of total bird numbers, by species. Clark *et al.* (1993) summarize 7 years of data (1986-1992) by upper and lower portions of the Bay. Niles *et al.* (1994) summarize data for the same period, using 18 shoreline segments to cover the Delaware and New Jersey shorelines. Clark (1991) summarizes five years of data (1986-1990), using individual beaches as organizing units.

The survey data indicate that the beach areas from the Mispillion River north to Simons River are the most heavily used by shorebirds (Clark, 1991). In 1990, this area accounted for over 80 percent of all the shorebirds observed in the Delaware portion of the survey (Gelvin-Innvaer, 1991). The Mispillion River area, including the mud flats of the Mispillion jetty, experience the heaviest use, both in terms of total numbers of birds and species density. Survey data also indicate heavy shorebird use along the entire New Jersey shoreline, particularly near Dennis Creek, Moores Beach, Thompson Beach, Egg Island Point, and Fortescue.

Two trends in shorebird abundance are important to note from the surveys. First, the number of sanderlings using the Delaware Bay has apparently declined markedly (Howe *et al.*, 1989; Clark *et al.*, 1993). In 1990, sanderling were observed at only four Delaware beaches, all south of Big Stone Beach (Gelvin-Innvaer, 1991). Second, there is also evidence that semipalmated sandpipers are declining significantly (Clark *et al.*, 1993).

5. Federally-listed and State-listed Threatened and Endangered Species

The federally-listed endangered bald eagle (*Haliaeetus leucocephalus*) is known to nest near the Delaware River and Delaware Bay in New Jersey and Delaware, and also winters in, and migrates through, the area. There are currently 11 active eagle nests in New Jersey, most of which are located within 10 miles of the Delaware Estuary. Additionally, adult eagles from many of these nests appear to be year-around residents of the Delaware Estuary area (K. Clark, pers. comm., 1995).

The federally-listed endangered peregrine falcon (*Falco peregrinus*) is known to feed on waterfowl and shorebirds in the vicinity of Kent Island in spring and fall. Additionally, the NJDFGW, Endangered and Nongame Species Program, maintains a peregrine falcon nesting tower on Egg Island Point. This tower is currently used by nesting peregrine falcons (K. Clark, pers. comm., 1995).

The active peregrine falcon nesting tower on Egg Island Point is located near the existing shoreline in an area that is eroding rapidly. If steps are not taken in the near future to either relocate the tower or halt the shoreline erosion, this tower will be lost. Additionally, if the tower is still functional when the proposed project is implemented it is likely that project construction activities would disturb nesting peregrine falcons. The Endangered and Nongame Species Program has expressed interest in having a new tower constructed in an area that is less susceptible to erosion. The Service recommends that the Corps coordinate with the Endangered and Nongame Species Program and the Service to incorporate relocation of the peregrine tower into the current project plans.

The National Marine Fisheries Service (NMFS) has jurisdiction over the federally-listed endangered shortnose sturgeon (*Acipenser brevirostrum*), the endangered Atlantic Ridley turtle (*Lepidochelys kempii*) and leatherback turtle (*Dermochelys coriacea*), and federally-listed threatened loggerhead turtle (*Caretta caretta*), and green turtle (*Chelonia mydas*).

The shortnose sturgeon has been found throughout the Delaware Bay study area, though spawning is limited to areas upstream of the study area. Little information is available regarding shortnose sturgeon use of Delaware Bay, but it is believed that this area is used by all age classes to some extent, except young-of-the-year. Shortnose sturgeon orient to the channel and channel-like linear depressions or troughs. The Main Channel may provide localized areas where shortnose sturgeon currently concentrate or may concentrate as the population recovers (J. O'Herron, pers. comm., 1995).

Sea turtles, especially the loggerhead turtle, but also the Atlantic Ridley turtle, green turtle, and leatherback turtle, may occur in the lower Delaware Bay from June to November. Current lists of federally listed, proposed, and candidate species in New Jersey and Delaware, are provided in Appendix A.

Project-related activities could adversely affect the above-mentioned species. The lead federal agency for a project has the responsibility under Section 7(c) of the Endangered Species Act of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) to prepare a Biological Assessment if the project is a construction project that requires an Environmental Impact Statement and the project may affect federally-listed species. The Service is aware that the Corps is currently preparing a Biological Assessment to address potential project-related adverse impacts to the above-mentioned species. The Service recommends that the Corps continue to consult with the Service and the NMFS during preparation of the Biological Assessment.

A list of State-listed threatened and endangered species in New Jersey is provided in Appendix B. For additional information on State-listed species, the Service recommends that the Corps contact the NJDFGW, Endangered and Nongame Species Program at the following address:

Mr. Larry Niles
Endangered and Nongame Species Program
Division of Fish, Game and Wildlife
CN 400
Trenton, New Jersey 08625
(609) 292-9101

B. SITE SPECIFIC FISH AND WILDLIFE RESOURCES

1. Egg Island Point

Information regarding fish and wildlife resources of the Maurice River Cove area, immediately east of the proposed Egg Island Point project site, has been summarized in previous Service reports (U.S. Fish and Wildlife Service, 1994b, 1995b).

Based on survey information collected at Fortescue to the northwest and East Point to the east of the project site, Egg Island Point receives moderate to heavy use by horseshoe crabs. However, the shoreline conditions are generally not conducive to high spawning success, except at the tip of Egg Island Point and along the small sandy beach segments on the southwestern shoreline.

Commercially important oyster lease beds are located throughout the offshore area around Egg Island Point. Most of these lease beds are located 500 to 800 feet offshore; but in some cases lease beds are located within close proximity to the shoreline (J. Dobarro, pers. comm., 1995). Oyster seed beds occur to the northwest of Straight Creek and this area also supports a commercially important blue crab fishery.

The Egg Island Point area receives heavy use each spring by migratory shorebirds. Shorebirds feed in large numbers along the shoreline and along the sandy deltas at creek mouths. Additionally, the numerous small tidal and non-tidal ponds on the adjacent salt marsh provide valuable shorebird feeding and roosting habitat. The most common species using this area include ruddy turnstone, red knot, and semipalmated sandpiper.

The wetlands and nearshore shallows of Egg Island Point also provide valuable habitat for a large number of migratory waterfowl. Species identified during mid-winter waterfowl surveys conducted between 1985 and 1989 include mallard, American black duck, green-winged teal, scaup, merganser (*Mergus sp.*), gadwall (*Anas strepera*), bufflehead (*Bucephala albeola*), American widgeon (*Anas americana*), Northern shoveler (*Anas clypeata*), Canada goose, and snow goose (New Jersey Division of Fish, Game and Wildlife, 1990).

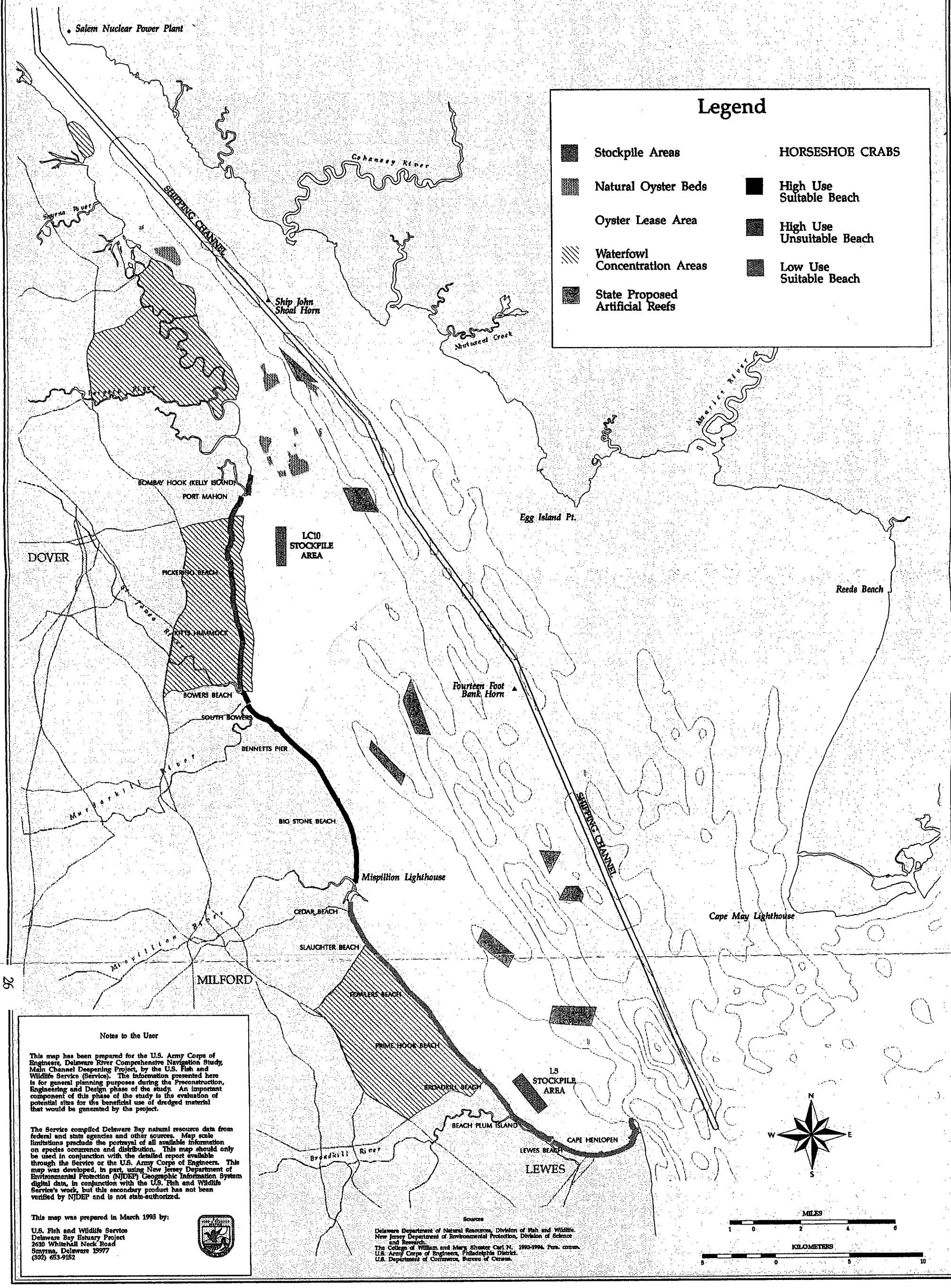
2. Kent Island and Kelly Island

While horseshoe crabs spawn in the Kent Island area, conditions are generally not conducive to egg development, and reproductive success is probably low (Figure 4a). The value of horseshoe crab eggs at this site may be more as a food source for migrating shorebirds, than as a source for sustaining horseshoe crab populations.

Figure 4a

Preliminary Delaware Bayshore Ecological Analysis

for the Delaware River Beneficial Use Plan



Notes to the User

This map has been prepared for the U.S. Army Corps of Engineers, Delaware River Comprehensive Navigation Study, Main Channel Deepening Project, by the U.S. Fish and Wildlife Service (Service). The information presented here is for general planning purposes during the Preconstruction, Engineering and Design phase of the study. An important component of this phase of the study is the evaluation of potential sites for the beneficial use of dredged material that would be generated by the project.

The Service compiled Delaware Bay natural resource data from federal and state agencies and other sources. Map scale limitations preclude the portrayal of all available information on species occurrence and distribution. This map should only be used in conjunction with the detailed report available through the Service or the U.S. Army Corps of Engineers. This map was developed, in part, using New Jersey Department of Environmental Protection (NJDEP) Geographic Information System digital data, in conjunction with the U.S. Fish and Wildlife Service's work, but this secondary product has not been verified by NJDEP and is not state-authorized.

This map was prepared in March 1993 by:

U.S. Fish and Wildlife Service
Delaware Bay Estuary Project
2610 Whitehall Neck Road
Smyrna, Delaware 19977
(302) 653-9152

Sources

Delaware Department of Natural Resources, Division of Fish and Wildlife.
New Jersey Department of Environmental Protection, Division of Science and Research.
The College of William and Mary Shuster Carl N. 1993-1994. Pers. comm.
U.S. Army Corps of Engineers, Philadelphia District.
U.S. Department of Commerce, Bureau of Census.

Commercially important oyster seed beds exist in the area offshore of Kent Island and Kelly Island (Figure 4b). There are also oyster beds inside the mouth of the Leipsic River. Additionally, hard clams and blue crabs are distributed throughout the Kelly Island area. Blue crabs in this area are commercially important.

The most frequently occurring species of benthic macroinvertebrates in samples taken in the vicinity of Kelly Island area by Maurer *et al.* (1978) in 1972 and 1973 included polychaetes such as *Nephtys picta*, *Glycera capitata*, *Glycera dibranchiata*, and *Heteromastus filiformis*; mollusks such as *Tellina agilis*, *Nassarius trivittatus*, *Ensis directus*, *Mulinia lateralis*, and *Nucula proxima*; and, crustaceans including *Cancer irroratus*, *Paraphoxus spinosus*, *Protohaustorius wigleyi*, and *Pagurus longicarpus*.

The Greeley-Polhemus Group (1994) found 23 macroinvertebrate species at the Kelly site in 1993. Crustaceans (11 species) and polychaetes (5 species) dominated the samples. Dominant species included mollusks such as *Mulinia lateralis*, and polychaetes including *Glycera dibranchiata*. Small horseshoe crabs were also collected. The Greeley-Polhemus Group (1994) reported sampling problems associated with the thick cohesive silt / clay substrate, which made it difficult to dredge for commercially or recreationally important species.

Striped bass use the mouth of the Leipsic River in all seasons. This area is also a spawning area in spring and summer for riverine and anadromous fish such as American shad, river herring, and white perch (*Morone americana*) (R. Miller, pers. comm., 1995).

Kent Island marshes provide significant shelter, wintering and breeding habitat for American black duck and other waterfowl species (E. Smith, pers. comm., 1995). Gulls, terns, and large numbers of wading birds such as glossy ibis (*Plegadis falcinellus*) use the Kent Island and Kelly Island areas, especially in spring.

The beach on the southern tip of Kelly Island historically supported large numbers of spawning horseshoe crabs, with corresponding heavy use by shorebirds, particularly ruddy turnstones and semipalmated sandpipers. As the beach at the southern tip of Kelly Island has eroded, horseshoe crab spawning activity has declined. While horseshoe crabs still spawn here in large numbers, conditions are generally no longer suitable for egg survival. Although horseshoe crab spawning activity has declined, shorebird use of this area has remained high. In fact, the area between Kelly Island and South Bowers Beach still supports one of the largest springtime concentrations of shorebirds in the entire Delaware Bay (Niles *et al.*, 1994). This large shorebird concentration could be due in part to the inaccessibility of this area to humans.

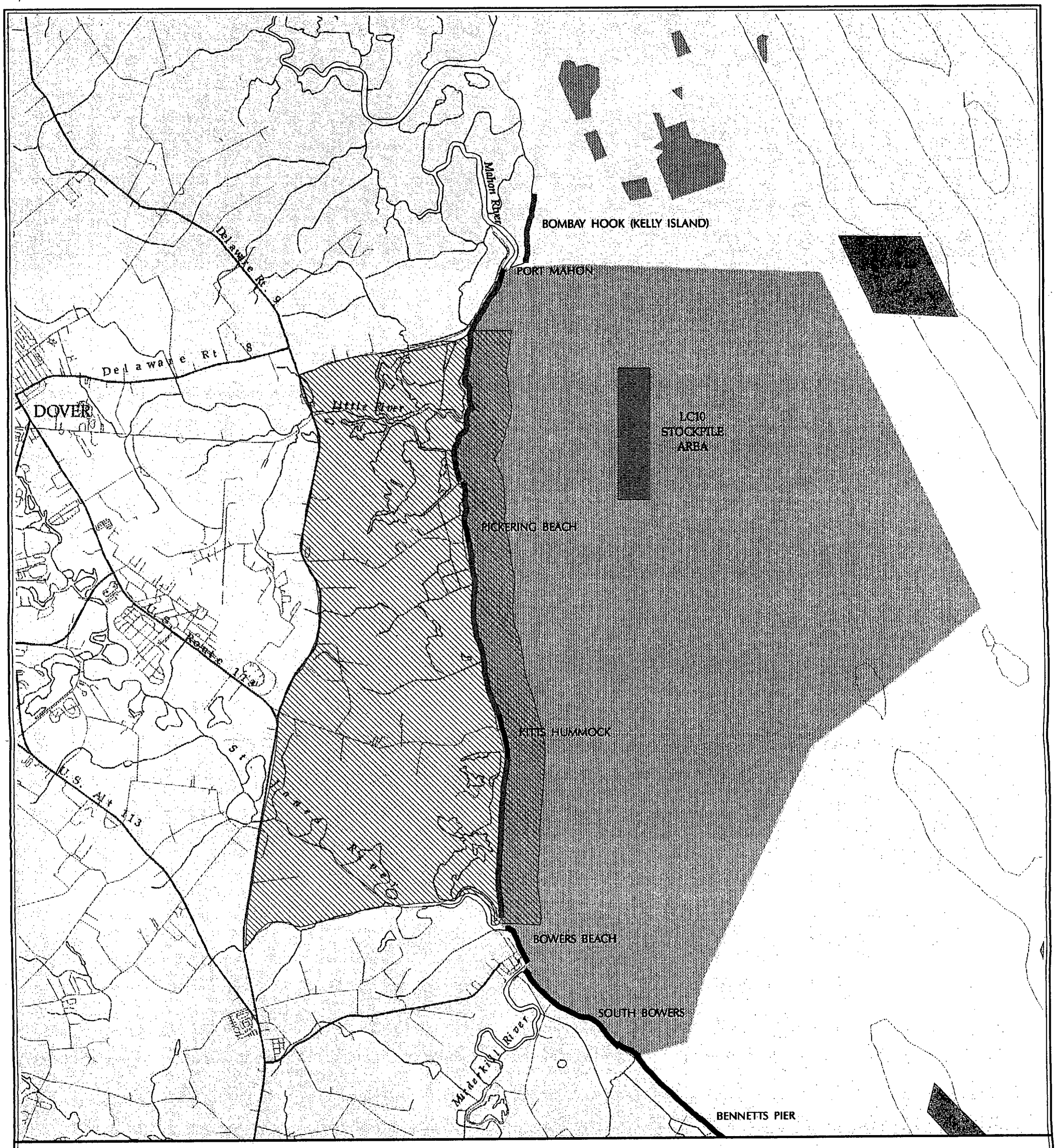


Figure 4b Kelly Island Vicinity

Notes to the User

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The Service compiled Delaware Bay natural resource data from federal and state agencies and other sources. Map scale limitations preclude the portrayal of all available information on species occurrence and distribution. This map should only be used in conjunction with the detailed report available through the Service or the U.S. Army Corps of Engineers. This map was developed, in part, using New Jersey Department of Environmental Protection (NJDEP) Geographic Information System digital data, in conjunction with the U.S. Fish and Wildlife Service's work, but this secondary product has not been verified by NJDEP and is not state-authorized.

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Sources

Delaware Department of Natural Resources, Division of Fish and Wildlife.
New Jersey Department of Environmental Protection, Division of Science and Research.
The College of William and Mary, Shuster Carl N. 1993-1994. Pers. comm.
U.S. Army Corps of Engineers, Philadelphia District.
U.S. Department of Commerce, Bureau of Census.

Legend

- Stockpile Areas
- Natural Oyster Beds
- Oyster Lease Area
- Waterfowl Concentration Areas
- State Proposed Artificial Reefs

HORSESHOE CRABS

- High Use Suitable Beach
- High Use Unsuitable Beach

3. Port Mahon to South Bowers Beach

Port Mahon receives heavy use by horseshoe crabs and shorebirds (Figure 4b). However, the high level of human disturbance and continued erosion threaten the area's continued suitability for horseshoe crabs and shorebirds. The sand strip to seaward of the rip-rap has been eroding noticeably each year, and the shorebirds and horseshoe crabs using this area are being forced closer to, and often onto, the road. Additionally, horseshoe crabs may be legally harvested by permit at Port Mahon.

The narrow (less than 30 feet wide) strip of sandy beach just north of the Dover Air Force Base Aviation Gas pipeline / barge unloading pier comprises the best spawning area for horseshoe crabs at Port Mahon. Although the sand along this 600-foot-long section of shoreline is covered by water at high tide, horseshoe crabs have been observed spawning on falling tides in this area. The viability of horseshoe crab eggs is probably minimal on beaches that are covered by high tides such as this area, but the value of eggs as food for shorebirds and juvenile fish remains high. Other small sections of shoreline, totalling approximately 300 feet in length are scattered among the rip-rap and bulkheads. These areas generally do not support favorable spawning conditions. Service field observations revealed that large numbers of horseshoe crabs become trapped in the rip-rap, and the normal 10 percent mortality from spawning activities on more natural beaches is probably exceeded substantially at this site.

Extensive oyster lease beds occupy the offshore area from Port Mahon to South Bowers Beach. Additionally, many species of marine fish, particularly weakfish, spawn in the offshore area from approximately 600 feet to 3,600 feet offshore of Port Mahon to the mouth of the Little River near Pickering Beach. Juvenile fish, particularly weakfish, also concentrate just offshore of Port Mahon in spring (R. Miller, pers. comm., 1995).

Port Mahon, especially near the mouth of Little Creek, supports large numbers of birds during all seasons. Numerous species of waterfowl and shorebirds use the area in fall, winter and spring (Clark *et al.*, 1993). Many species of gulls and terns use the area during the spring, summer and fall, and numerous wading birds are found here all year. Shorebirds have been observed feeding on inviable horseshoe crab eggs in the thick, unconsolidated peat deposits at the mouth of Little Creek in all seasons.

Pickering Beach receives high use by spawning horseshoe crabs, and migratory shorebirds. Site visits revealed that Kitts Hummock also supports large number of spawning horseshoe crabs and migrating shorebirds; however, the only suitable spawning habitat for horseshoe crabs at Kitts Hummock is the 0.5-mile-long sand and gravel beach.

The mud flats offshore of Kitts Hummock have accumulated since the three breakwaters were constructed. These mud flats contain benthic invertebrates that support large numbers of shorebirds in the spring. Blue crabs and hard clams are distributed throughout this area. Winter flounder *(Pleuronectes americanus)* and summer flounder are distributed throughout the area, along with numerous species of finfish (R. Miller, pers. comm., 1995).

Spawning horseshoe crabs and migrating shorebirds also occur in large numbers at Bowers Beach and South Bowers Beach. Additionally, blue crabs, hard clams, and oysters are distributed throughout the area, and numerous species of riverine, anadromous, and marine fish also use this area. Riverine and anadromous fish spawn in the Murderkill and Saint Jones Rivers.

4. Bennetts Pier to Big Stone Beach

Big Stone Beach experienced extraordinarily high horseshoe crab spawning in 1993, with light spawning activity in other years (Swan *et al.*, 1994). It appears that this area is not extensively used by spawning horseshoe crabs in most years, despite the presence of apparently suitable spawning habitat. Similarly, the area from Bennetts Pier to Big Stone Beach does not appear to be heavily used by shorebirds. Additionally, there are no oyster lease beds offshore of Bennetts Pier and Big Stone Beach (J. Tinsman, pers. comm., 1995).

5. Mispillion Jetty to Lewes Beach

Horseshoe crabs attempt to spawn at Cedar Beach in large numbers. However, due to the relatively flat beach slope, thousands of horseshoe crabs become stranded on the intertidal mud flats and die. The small sand deposit halfway along the south jetty is surrounded by soft mud, and is probably only marginally suitable for spawning horseshoe crabs; however, this area is heavily used by shorebirds. More than 50,000 shorebirds concentrate in the immediate vicinity of this sandy area (Niles *et al.*, 1994).

Hard clams and blue crabs are distributed throughout the offshore area in the vicinity of Cedar Beach. Additionally, marine, anadromous and riverine fish spawn in the Mispillion River. Fish species found here include striped bass, American shad, tautog, bluefish, black sea bass, spot, Atlantic croaker, weakfish, red hake, and white perch (R. Miller, pers. comm., 1995).

Numerous species of waterfowl, wading birds, and gulls and terns are distributed throughout the Cedar Beach area. Osprey *(Pandion haliaetus)* are also found here in spring, summer, and fall.

Slaughter Beach supports a moderate shorebird population during the spring and early summer. Historically, Slaughter Beach experienced heavy spawning by horseshoe crabs, and harvesting these animals here was a healthy industry during the 1800s (Shuster and Botton, 1985). Current use by horseshoe crabs is sporadic and unpredictable; although the large dune washover south of slaughter beach appears to receive heavy use by spawning horseshoe crabs, based on the large number of molts observed in this area during Service site inspections. Numerous species of gulls and terns, as well as waterfowl, wading birds, and raptors frequent the area. Similarly, Fowler beach currently supports low numbers of spawning horseshoe crabs and migratory shorebirds.

Broadkill beach appears to receive higher use by spawning horseshoe crabs and migratory shorebirds than other beaches in this section of the shoreline; although, the numbers of horseshoe crabs and shorebirds seen here are substantially lower than in the Port Mahon to South Bowers Beach section (L. Gelvin-Innvaer, pers. comm., 1995). Semipalmated sandpiper and red knot are the most common species of shorebirds at Broadkill Beach.

The peat area inside the mouth of the Roosevelt Inlet, although experiencing rapid erosion, is the only part of Roosevelt Inlet beach where horseshoe crabs have spawned recently in substantial numbers, according to the annual volunteer horseshoe crab survey (W. Hall, pers. comm., 1995). In 1990, 1,000 horseshoe crabs were counted during the annual survey. In 1991, 60,800 crabs were counted. Since 1991, spawning activity has been light.

Some riverine and anadromous fish may spawn in the mouth of the Broadkill River at Roosevelt Inlet. Distributed throughout are summer and winter flounder, bluefish, black sea bass, Atlantic menhaden (*Brevoortia tyrannus*), spot, Atlantic croaker, weakfish, scup, and northern kingfish (*Menticirrhus saxatilis*).

6. Sand Stockpile Areas

The most frequently occurring species of benthic macroinvertebrates in samples taken in the vicinity of Site L-5 area by Maurer *et al.* (1978) in 1972 and 1973 included polychaetes such as *Nephtys picta*, *Scoloplos fragilis*, *Glycera americana*, *Glycera capitata*, *Glycera dibranchiata*, *Aricidea cerruti*, and *Heteromastus filiformis*; mollusks such as *Tellina agilis*, *Nassarius trivittatus*, *Ensis directus*, and *Nucula proxima*; and, crustaceans including *Cancer irroratus*, *Paraphoxus spinosus*, *Protohaustorius wigleyi*, and *Pagurus longicarpus*.

The Greeley-Polhemus Group (1994) found 51 macroinvertebrate species at Site L-5 in 1993. Crustaceans (19 species) and polychaetes (18 species) dominated the samples. Dominant species included crustaceans such as *Ampelisca sp.*, and *Cerapus tubularis*; mollusks such as *Mulinia lateralis*, and *Nucula proxima*; and, polychaetes including *Glycera americana* and *Nephtys incisa*.

The most frequently occurring species of benthic macroinvertebrates found in samples taken in the vicinity of Site LC-10 by Maurer *et al.* (1978) in 1972 and 1973 included polychaetes such as *Heteromastus filiformis*, *Glycera dibranchiata*, *Glycera capitata*, and *Nephtys picta*; crustaceans including *Melita nitida*, *and Protohaustorius wigleyi*; and mollusks such as *Mulinia lateralis*, and *Tellina agilis*.

The Greeley-Polhemus Group (1994) found a total of 50 species, including 20 crustaceans and 16 polychaetes, at Site LC-10. Dominant species included the polychaetes, *Scoloplos sp.*; crustaceans such as *Ampelisca sp.*, and *Neomysis americana;* mollusks *Mulinia lateralis*, and *Ensis directus*; and, the nemertean *Cerebratulus lacteus*. This site contained more commercially or recreationally important species than other sites sampled, including the knobbed whelk (*Busycon carica*), the channeled whelk (*Busycon canaliculatum*), hard clams, blue crab, and horseshoe crab.

Site LC-10 is within an American oyster lease area. Sampling in this area by the Greeley-Polhemus Group (1994) did not detect oysters; however, this was likely due to the sampling techniques used in that study.

The area in the vicinity of Site MS-19 was sampled by Maurer *et al.* (1978) in 1972 and 1973. The dominant species included mollusks such as *Ensis directus*, *Tellina agilis*, and *Nucula proxima*; polychaetes including *Glycera americana*, *Glycera capitata*, *Glycera dibranchiata*, *Nereis succinea*, *Nephtys picta*, *Capitella capitata*, *Aricidea cerruti*, *Polydora ligni*, *Sabellaria vulgaris*, and *Heteromastus filiformis*; and, crustaceans including *Protohaustorius wigleyi*, *Paraphoxus spinosus*, *Pagurus longicarpus*, *Cancer irroratus*, *Melita nitida*, *Neopanope sayi*, *Corophium simile*, *Paracaprella tenuis*, and *Eurypanopeus depressus*.

The Greeley-Polhemus Group (1994) found a total of 62 species at Site MS-19 in samples collected in 1993. The mean density of individuals collected at this site (26,562.5 individuals per square meter) was much higher than that of any other proposed sand stockpile site. Most species were crustaceans (24 species) and polychaetes (20 species). Dominant species included crustaceans such as *Ampelisca sp.*, *Corophium sp.*, *Cerapus tubularis*, and *Eurypanopeus depressus*; and, mollusks such as *Crepidula fornicata*, and *Ensis directus*. Commercially and recreationally important species included knobbed whelk, horseshoe crab, blue crab, and hard clam.

The offshore areas in the vicinity of all three proposed stockpile sites support important fisheries for weakfish. Additionally, the offshore areas in the vicinity of Sites L-5 and MS-19 support summer flounder, black sea bass, and drum (Figley and McCloy, 1988).

VI. EFFECTS TO FISH AND WILDLIFE AND SUGGESTED MITIGATIVE MEASURES

A. SHORELINE PROTECTION / WETLAND RESTORATION

Estuarine emergent wetlands such as those on Egg Island Point and Kelly Island are among the most productive natural systems on earth. The detritus produced by the annual death and decay of saltmarsh vegetation and other wetland vegetation contributes to estuarine productivity and the aquatic food web. In some estuaries, the detrital material exported from salt marshes is more important than the phytoplankton-based production in the estuary (Mitsch and Gosselink, 1986). Additionally, salt marshes provide important spawning and nursery habitat for many species of marine and estuarine fish, shellfish and crustaceans, and provide feeding, resting and breeding habitat for a wide variety of migratory waterfowl, shorebirds, wading birds, raptors, and passerine birds.

The continual loss of estuarine wetlands through shoreline erosion not only eliminates habitat for marsh-dwelling organisms; but also reduces the productivity of the entire estuary. Therefore, measures designed to slow or reverse the erosion of Delaware Bay salt marshes, if successful, would be expected to produce many positive benefits for the Delaware Bay ecosystem as a whole.

Although erosion control has many desirable benefits, shoreline stabilization measures such as beach nourishment and the use of hard structures such as geotextile tubes may also have a number of site-specific adverse impacts that must be carefully weighed against the expected project benefits in order to determine the net effect. In particular, the effects of the proposed geotextile tube structures on spawning horseshoe crabs is unknown. While the Egg Island Point and Kelly Island sites do not currently support high quality breeding habitat, as discussed above, significant numbers of horseshoe crabs still spawn in these areas. Although most eggs deposited in these areas may be inviable, the eggs still provide a valuable food source for migratory shorebirds and other organisms.

It is almost certain that the geotextile tube structures would not provide suitable spawning habitat for horseshoe crabs, given the lack of open sandy area above mean low water. It is uncertain whether horseshoe crabs would continue to attempt to spawn along these structures. Additionally, horseshoe crabs may become trapped behind these structures, which could result in increased mortality.

1. Egg Island Point

The estuarine wetlands on Egg Island Point provide valuable habitat for a wide variety of fish and wildlife, particularly species of migratory shorebirds and waterfowl; therefore, carefully designed measures that slow or reverse erosional wetland loss would benefit these species. However, careful planning will be necessary to ensure that these shoreline protection measures are effective in controlling erosion without adversely affecting important fish and wildlife resources.

The initial construction of the proposed project, particularly the deposition of the sand foundation, would most likely create a temporary increase in turbidity in the vicinity of the oyster lease beds. Additionally, the initial construction of the proposed project could adversely effect spawning horseshoe crabs and migrating shorebirds, if construction occurred between April 15 and June 30. To avoid impacts to spawning horseshoe crabs and shorebirds, the Service recommends that no construction activities be scheduled to occur between April 15 and June 30.

The potential exists for substantial quantities of dredged material to migrate out of the project area, and smother nearby oyster beds; however, the completed project would likely reduce shoreline erosion and sediment transport onto the oyster beds. Insufficient information exists regarding sediment transport in the Egg Island Point area to accurately predict the movement of

deposited dredged material. The Corps is currently conducting modeling studies to assess sediment transport. The Service recommends that a meeting be held among interested parties upon completion of these modeling studies to review and discuss the results.

Depending on design, the proposed geotextile tube structure at Egg Island Point may alter the tidal flow over the adjacent salt marsh. Altered tidal flow may interrupt nutrient transport over the marsh; thereby decreasing the value of the tidal ponds to migratory shorebirds and potentially encouraging the spread of common reed. The Corps has stated that the proposed structure would be designed to maintain 100 percent of the current tidal flow over the salt marshes (J. Brady, pers. comm., 1995). The Service supports this design specification and recommends that the Corps take all necessary steps to ensure that tidal flow over the marsh is maintained.

The proposed shoreline protection at Egg Island Point would result in the elimination of all subtidal benthic habitat directly under the footprint of the proposed geotextile tubes, supporting scour blanket, and areas of dredged material placement for wetland restoration. The current plan to deposit up to 2.6 million cubic yards of dredged material landward of the geotextile tube structure along the southeastern shoreline would restore between 150 and 200 acres of estuarine emergent wetlands, while eliminating the same amount of open water and benthic habitat. The area in the proposed footprint of the structure does not appear to support a particularly diverse or unusual benthic community; however, care must be taken to avoid nearshore areas that support oyster lease beds. It should be noted that geotextile tubes used for similar projects in other parts of the country frequently become colonized by a variety of benthic invertebrates (M. Landin, pers. comm., 1995).

The proposed geotextile tube structure could also block access to the beach for spawning horseshoe crabs. This is a concern along the southwestern shoreline and at the tip of Egg Island Point, where the most productive horseshoe crab spawning habitat exists. A possible design under consideration by the Corps would provide spaces between sections of geotextile tube placed along the southwestern shoreline. Such spaces would provide access points to the beaches for spawning horseshoe crabs, while still providing protection of the shoreline. Specific design features, such as the exact configuration of the geotextile tubes or the width of the spaces between tubes have not yet been determined (J. Brady, pers. comm., 1995). The Service recommends that the Corps continue to coordinate with the Service and the NJDFGW to develop site plans that would provide shoreline protection while allowing beach access for spawning horseshoe crabs along the tip of Egg Island Point and along the southwestern shoreline.

2. Kelly Island

The environmental consequences resulting from the proposed Kelly Island project are in many respects similar to those mentioned above regarding Egg Island Point. The proposed wetland restoration at Kelly Island would use up to one million cubic yards of dredged material to convert approximately 80 to 125 acres of nearshore shallow water habitat to estuarine intertidal wetlands.

This conversion would result in a permanent loss of the benthic community in this area; however, the only commercially important species known to occur at this site is the horseshoe crab. It is also important to note that the project purpose is wetland restoration, and that the proposed project area was historically an emergent marsh.

The primary concerns regarding the proposed Kelly Island project are the avoidance of the ecologically sensitive area on the northern end of Kelly Island and the avoidance of potential effects on the oyster seed beds located offshore of Kelly Island. The wetlands on the northern end of Kelly Island, north of Deepwater Point, provide valuable waterfowl habitat. Additionally, the northern end of the island does not appear to be eroding as rapidly as the southern portion of Kelly Island. Therefore, the Service recommends that the proposed wetlands restoration project be limited to the area south of Deepwater Point.

The footprint of the proposed wetland restoration at Kelly Island would not directly affect oyster beds; however, increased sedimentation and turbidity resulting from the initial construction of the project could adversely affect oysters. Additionally, the movement of large volumes of dredged material from the proposed project site to the oyster beds due to storm events or structural failure of the geotextile tubes poses a significant threat to oyster seed beds. Adverse impacts to oysters through increased sedimentation is a greater threat at Kelly Island than at Egg Island Point due to the proposed deposition of fine-grained silt and clay material at the Kelly Island site.

Any benefits to fish and wildlife derived from the proposed wetland restoration at Kelly Island would be insufficient to offset the loss of oyster seed beds due to excessive sedimentation. As such, the over-riding design consideration for the Kelly Island site must be to minimize the risks of sediment transport from the project site to the oyster beds, both in terms of construction-related sedimentation and long-term sedimentation.

The concerns regarding sedimentation from the Kelly Island site would be substantially reduced or eliminated if the material deposited at the site were sand instead of silt and clay. Therefore, the Corps should carefully consider alternative disposal options for the fine-grained material, including upland disposal at one of the existing disposal sites along the Delaware River. If upland disposal of the fine-grained dredged material is not practicable, the Corps should investigate the feasibility of mixing or capping the fine-grained sediments with coarser-grained material.

It is important that the site be designed such that the dredged slurry is retained on site for sufficient time to allow suspended sediments to settle before water is discharged from the site. Additionally, the Service recommends water quality monitoring of the effluent from the site and the development of contingency plans to be implemented should monitoring indicate adverse impacts during site construction. Once the sediment deposited within the geotextile tube barrier settles and becomes vegetated, it is expected that less material would erode from the area than is currently eroding from the existing exposed marsh. Periodic water quality monitoring in the three to five year period following construction should be conducted to confirm that the site performs as expected.

Overall, it is the Service's view that wetland restoration / shoreline protection projects at Egg Island Point and Kelly Island, similar to those currently proposed, would have a net positive effect on fish and wildlife resources. However, considerable additional planning will be necessary to ensure maximum project benefits with minimal adverse effects. Therefore, the Service recommends that the Corps continue to work with the Service, DNREC, and NJDFGW to evaluate and refine project plans for these two areas.

As previously stated, Kelly Island is part of the Bombay Hook National Wildlife Refuge. As such, the Corps' use of the Kelly Island site for dredged material disposal will require a Special Use Permit from the Service, pursuant to the National Wildlife Refuge System Administration Act of 1966 (80 Stat. 927, 16 U.S.C. 668dd-668ee). Application for the Special Use Permit should be made to the Refuge Manager at the following address:

Paul Daly
Bombay Hook National Wildlife Refuge
R.D. 1, Box 147
Smyrna, Delaware 19977
(302) 653-0684

B. BEACH NOURISHMENT

In the absence of continued beach nourishment, the current shoreline recession that is already severely affecting the beach systems and adjacent salt marshes along the Delaware shoreline is expected to continue. The rate and degree of adverse impact on surrounding beaches and their biological processes is difficult to assess, but it is clear that without intervention some beaches will be lost and wetlands will be converted from vegetated to open water conditions.

Few studies have examined the effects of beach nourishment on beach infaunal communities (Reilly and Bellis, 1978; Naqvi and Pullen, 1982; Fenchel, 1969; Martore *et al.*, 1991). The results of these studies have indicated various effects depending on the compatibility of the beach substrate and replenishment material, time of year, magnitude of the project, and the benthic community composition. One Corps study (Reilly and Bellis, 1978) found that beach infauna was completely eliminated by beach nourishment in North Carolina, and that after 20 months, the infaunal community had still not recovered in any significant degree to its pre-disturbance composition or biomass. Naqvi and Pullen (1982) found that in most cases, initial infaunal recruitment was primarily by opportunistic species and that these species prevented the re-establishment of the original community. Additionally, because beach infaunal organisms are sensitive to even slight changes in sand grain-size distribution and substrate porosity, the species composition of the infaunal community prior to beach nourishment could differ from the post-project community (Fenchel, 1969; Martore *et al.*, 1991).

Beach nourishment conducted between mid-April and mid-July would adversely impact spawning horseshoe crabs, both through the potential disturbance or burial of spawning adults and through the burial of eggs and larvae. It is unlikely that eggs and larvae buried during beach nourishment activities would survive. Beach nourishment activity during this period would also disturb migrating shorebirds.

Aside from the above-mentioned dependency of migratory shorebirds on horseshoe crab eggs, the biomass and species composition of the infaunal community are also important for supplying the nutritional needs of shorebirds. Therefore, significant effects to spawning horseshoe crabs and / or the infaunal community would have congruent effects on migratory shorebirds.

There is little published information regarding the effects of beach nourishment on nearshore benthic and fish communities. A Florida study (Holland *et al.*, 1980) examined the effects of beach nourishment on nearshore species. This before-and-after-impact study found a temporary increase in fish abundance along the newly created beach, possibly due to the sudden and large-scale die-off of infaunal organisms resulting from the beach nourishment. However, long-term information is lacking. Beach nourishment activities could adversely effect offshore oyster beds through reduced water quality (i.e., higher turbidity and lower dissolved oxygen concentrations), and the deposition of fine-grained material.

The reduction in water quality that would likely occur adjacent to and down current from beach nourishment activities could also adversely effect anadromous fish. If water quality were reduced during the period in which anadromous fish make their spawning runs into inlets and up the Delaware River, their migration could be inhibited and their reproductive success compromised.

Not withstanding the above-mentioned potential adverse effects, properly conducted beach nourishment projects could produce a number of positive environmental effects, particularly in terms of retarding the above-mentioned adverse effects of shoreline erosion. The specific recommendations that follow should help the Corps select beach nourishment projects that would result in maximum benefits with minimum adverse effects.

1. Port Mahon to South Bowers Beach

This section of the Delaware shoreline is experiencing severe erosion that threatens existing wetlands and bayshore communities. The area between Port Mahon and South Bowers Beach is also an area of high biological sensitivity in terms of its value to spawning horseshoe crabs, migratory shorebirds, fish and shellfish. All beaches in this section of the shoreline receive high use by spawning horseshoe crabs; however, reproductive success is probably low at some of these beaches, particularly Port Mahon and Pickering Beach, due to unsuitable habitat conditions. Additionally, the offshore area of this section of shoreline supports commercially valuable oyster beds as well as important spawning areas for commercially and recreationally important fish species.

This section of the Delaware shoreline has the highest ecological value and the most severe erosion of the three sections analyzed for possible beach nourishment projects. Accordingly, the Service recommends that beaches in this section receive priority consideration for beach nourishment. Beach nourishment would have the greatest ecological benefits at Port Mahon and Pickering Beach; although all beaches in this section would benefit from nourishment. Beach nourishment projects should not be conducted between April 15 and June 30 in order to avoid potential adverse impacts to spawning horseshoe crabs, and migratory shorebirds.

2. Bennetts Pier to Big Stone Beach

This section of shoreline appears to have fewer biological constraints than the northern portion of the study area. Although high numbers of spawning horseshoe crabs have been observed in this section in some years, these beaches do not appear to receive consistently high use by horseshoe crabs. The reason for the lower use of this area by horseshoe crabs is not understood, because many of the beaches in this section appear to provide suitable spawning habitat. Factors other than beach habitat characteristics may limit the use of this section of the shoreline by spawning horseshoe crabs.

Significant numbers of shorebirds use the area in the spring, particularly Conch Bar Inlet; therefore, beach nourishment projects should not be conducted along this section of the shoreline during the spring migration period, April 15 through June 30. There are no significant American oyster lease or seed beds in the offshore area, with the exception of the offshore area north of Bennetts Pier; therefore, potential adverse impacts related to any beach nourishment project conducted outside the spring shorebird migration would be limited to temporary disturbances of the benthic infaunal community.

The Service recommends that beaches in this area be given lower priority for consideration as potential disposal sites. The rate of erosion in this section of shoreline is also slower than in the section between Port Mahon and South Bowers Beach. In addition, the potential ecological benefits of beach nourishment projects along the section of shoreline between Bennetts Pier and Big Stone Beach are generally less than could be realized from projects conducted between Port Mahon and South Bowers Beach.

3. Mispillion Jetty to Lewes Beach

This area receives the lowest use by spawning horseshoe crabs, despite the presence of apparently suitable spawning beaches. This area also receives proportionately less use by migratory shorebirds, with the exception of the mud flats adjacent to Cedar Beach. There are also no commercial oyster beds between Mispillion Jetty and Lewes Beach.

Nourishment of this section of the Delaware shoreline should receive the lowest priority in terms of providing beneficial uses for dredged material.

The anticipated effects of beach nourishment activities in this area would be short-term disturbance of the beach infaunal community. While beach nourishment projects would have positive economic benefits for local communities in terms of property protection, it is unlikely that beach nourishment in this area would greatly enhance habitat values for spawning horseshoe crabs or migratory shorebirds.

C. SAND STOCKPILES

It is unlikely that the habitat and aquatic resources in the vicinity of sites L-5, LC-10, and MS-19 would change significantly over time if sand deposition does not take place. Conversely, the use of these areas as dredged material disposal sites would have a number of environmental effects.

The environmental impacts of dredged material disposal in open water are similar in some ways to impacts resulting from sand dredging. Direct impacts include water quality degradation and temporary loss of the benthic community. Benthic community loss will in turn impact finfish species that feed on benthic organisms. Temporary water quality degradation is expected due to elevation of suspended sediments. Brief periods of elevated turbidity will occur as a result of sand placement. Extended periods of elevated turbidity would occur if wind or water currents cause sediments to remain in suspension. Water quality degradation would be more severe and widespread with unconfined open water disposal than if the sand were deposited behind containment devices such as geotextile tubes.

Placement of up to 9.5 million cubic yards of dredged material at the proposed sand stockpile sites would result in burial of the existing benthic community. Benthic recolonization depends upon a number of factors, which include substrate type, distance from similar habitat, and water currents. Recovery of the benthic community would be further hindered by future disturbance as the material is taken from the stockpiles for beach nourishment projects. Site LC-10, while not under consideration at this time, would have been placed directly on top of an economically important oyster lease bed. The Service supports the Corps decision to eliminate the Site LC-10 from further consideration as a sand stockpile area.

Deposition of large quantities of dredge spoil in sand stockpiles would decrease water depth at the sites from current depths to approximately 5 feet below mlw. This depth reduction could result in changes in the tidal regime and current patterns, which in turn could impact biological resources. Changes in the tidal regime may have some impact on biological resources associated with nearby rivers as well as resources associated with adjacent beaches.

Benthic recolonization is dependent upon recruitment from plankton dispersed by water currents. Changes in current patterns and velocities may alter dispersal of benthic larvae. The District is investigating the potential impacts to current patterns and velocities (J. Brady, pers. comm., 1995). When this information is available, the Service requests that it be provided for review.

Except for oysters, the loss of the benthic community due to dredged material disposal would be expected to be a short-term adverse impact. The Corps has constructed twenty-three underwater berms for storm attenuation or beach nourishment throughout the United States (Landin, 1992). For example, results of detailed studies of benthic recovery and fish use on a berm constructed at Dauphin Island, Alabama, indicated rapid benthic recovery. Fish use of the area also was reported as greater than in surrounding waters. The benthic recovery and greater fish use are related to slope, configuration, and orientation of the berm in the current (Landin, 1992).

Long-term impacts would likely result from the use of the sites as sand sources for future beach nourishment projects if the area is subjected to repeated disturbances. A regularly disturbed bottom would not necessarily provide the same abundance or species composition as the present site condition.

Placement of dredged material would result in some loss of finfish nursery and feeding areas. The loss of the food source would be expected to result in a temporary and localized reduction in recreationally and commercially important finfish species. As with effects to the benthic community, the repeated disturbance of the sand stockpile sites for future beach nourishment projects would likely result in long-term adverse impacts to local fisheries.

The above-described adverse impacts of the sand stockpiles would not be offset by any appreciable environmental benefits, as would be the case with the other projects under consideration. Therefore, the use of sand stockpiles for the disposal of dredged material cannot be considered "beneficial" in terms of its effects on fish and wildlife resources.

The Service recommends that the disposal of dredged material in sand stockpiles be considered the disposal option of last resort, and that dredged material be used for wetland restoration and direct beach nourishment to the maximum extent possible. Current plans for Egg Island Point and Kelly Island may accommodate over 3.5 million cubic yards of the estimated 10 million cubic yards of material to be generated by the Delaware Bay portion of the Main Channel Deepening Project. Beach nourishment projects in the above-recommended areas along the Delaware shoreline could accommodate substantial additional quantities of dredged sand; thereby minimizing or eliminating the need for sand stockpiles.

The Service recommends that the Corps coordinate with the State of Delaware to schedule dredging activities to coincide with State-sponsored beach nourishment efforts in order to minimize the costs of conducting beach nourishment as part of the Main Channel Deepening Project. Additionally, the Corps should re-evaluate the economic feasibility of using the dredged material for projects outside the area evaluated for the current study, such as the Maurice River Cove area and beaches in Cape May County, New Jersey.

VII. DATA GAPS AND RECOMMENDATIONS FOR FURTHER STUDIES

Significant concerns remain regarding the potential erosion of large quantities of dredged material from the Kelly Island and Egg Island Point wetland restoration sites, and the effects of such erosion on commercially important shellfish resources. Additionally, there are similar concerns regarding the movement of dredged material placed in sand stockpiles. As previously mentioned, the Service is aware that the Corps is currently conducting modeling studies of sediment transport patterns in these areas. The Service recommends that meetings be held between the Corps, Service, DNREC and NJDFGW upon the completion of these studies to review the results.

There is currently little information regarding the performance or effectiveness of geotextile tubes in areas with tidal regimes and wave patterns similar to Delaware Bay. It is also uncertain whether the peat substrate surrounding Kelly Island and Egg Island Point would support such structures or how much settling would likely occur. Additionally, the effect of shoreline hardening structures such as geotextile tubes on beach access to spawning horseshoe crabs is unknown. The Corps has discussed the possibility of conducting a pilot project for the use of geotextile tubes in Delaware Bay (J. Brady, pers comm., 1995). Such a pilot project would allow an assessment of the effectiveness of geotextile tubes in the Delaware Bay environment. The Service supports the proposal to conduct a pilot project using geotextile tubes, and recommends that the Corps coordinate with the Service, DNREC, and NJDFGW regarding the design of such a project, and related monitoring studies.

A direct correlation appears to exist between the area of sand available on a given beach and the number of horseshoe crabs that will spawn there; however, this remains to be quantified (C. Shuster, pers. comm., 1995). Additionally, it is believed that beach slope plays an important role in determining horseshoe crab spawning success. In order to better design beach nourishment projects to benefit spawning horseshoe crabs, additional information is needed regarding the relationships between these habitat parameters and horseshoe crab beach utilization and spawning success. The Service recommends that the Corps coordinate with the Service and other sources of expertise to design and implement a study of horseshoe crab spawning habitat requirements as a component of the above-mentioned pilot project.

Migratory shorebirds are one of the main species groups intended to benefit from the proposed beach nourishment and wetland restoration projects, yet information regarding shorebird use of Delaware Bay beaches and wetlands is incomplete. The lack of complete information makes a thorough assessment of the effects of the various proposed projects on migratory shorebirds difficult. Additionally, without sufficient baseline data, it will not be possible to determine whether the projects achieve the goal of improving shorebird habitat. The Service recommends that the Corps coordinate with the NJDFGW, Endangered and Nongame Species Program, to continue and expand the annual shorebird surveys. Additional studies should focus on the use of specific project sites by migratory shorebirds, before and after project construction.

VIII. CONCLUSIONS

Shoreline erosion poses a continuing threat to the diverse and abundant fish and wildlife resources of the Delaware Bay. The Service has evaluated three types of proposals by the Corps to use dredged material to combat shoreline erosion: wetland restoration using geotextile tubes, beach nourishment, and sand stockpiles. The Service concludes that the proposed wetland restoration projects at Egg Island Point and Kelly Island would provide positive benefits to fish and wildlife resources. The Service further concludes that beach nourishment would have the greatest positive effects on beaches between Port Mahon and South Bowers Beach, while nourishment of beaches in the more southern sections of the Delaware shoreline would be less beneficial, although still worthwhile. Finally, the Service concludes that the proposed disposal of dredged material in sand stockpiles would adversely affect fish and wildlife resources and that the use of sand stockpiles should be minimized or eliminated.

While the Service supports the proposed wetland restoration and beach nourishment plans, in concept, substantial additional coordination and planning are necessary to ensure maximum project benefits with minimal adverse effects. Therefore, the Service offers the following recommendations to assist the Corps in refining project plans.

In regard to protection of federally-listed threatened and endangered species, the Service recommends that the Corps:

1. coordinate with the NJDFGW, Endangered and Nongame Species Program, and the Service to incorporate relocation of the peregrine falcon nesting tower on Egg Island Point into the current project plans;

2. continue to consult with the Service and the NMFS in the preparation of the Biological Assessment necessary to address potential project-related effects to federally-listed species; and,

3. contact the NJDFGW, Endangered and Nongame Species Program for additional information regarding State-listed threatened and endangered species.

In regard to the proposed wetland restoration plans for Egg Island Point, New Jersey, and Kelly Island, Delaware, the Service recommends that the Corps:

1. avoid construction between April 15 and June 30 in order to minimize potential adverse impacts to spawning horseshoe crabs and migrating shorebirds;

2. continue modeling studies to determine the sediment transport patterns around Egg Island Point and Kelly Island, and coordinate with the Service, NJDFGW and DNREC to discuss the results of these studies;

3. design the proposed geotextile tube structure to ensure maintenance of existing tidal flow over adjacent salt marshes;

4. avoid impacts to oyster lease and seed beds adjacent to the proposed project sites by locating project features outside of areas known to support oysters;

5. design the Egg Island Point site to allow beach access for horseshoe crabs along the southwestern shoreline and the tip of Egg Island Point;

6. limit the proposed Kelly Island project to the area south of Deepwater Point, in order to avoid the ecologically sensitive area of northern Kelly Island;

7. evaluate alternative disposal options for the fine-grain dredged material, including upland disposal, in order to avoid adverse impacts to oyster beds;

8. investigate the feasibility of mixing or capping fine-grained material with coarser-grained material, in order to minimize adverse impacts to oyster beds;

9. retain dredged slurry on site long enough to allow sediments to settle before discharging water, in order to further minimize potential sedimentation impacts to oyster beds;

10. conduct water quality monitoring of effluent from the Kelly Island wetland restoration sites, and develop a contingency plan to be implemented should monitoring indicate adverse impacts during construction;

11. conduct periodic water quality monitoring for three to five years following construction to ensure that the wetland restoration projects are performing as planned;

12. continue to coordinate project planning with the Service, NJDFGW and DNREC; and,

13. coordinate with the refuge manager of the Bombay Hook National Wildlife Refuge regarding the need for a Special Use Permit for the Kelly Island project.

In regard to proposed beach nourishment projects along the Delaware shoreline, the Service recommends that the Corps:

1. give highest priority for beach nourishment to the beaches between Port Mahon and South Bowers Beach, followed next by the beaches between Bennetts Pier and Big Stone Beach, and last by the beaches between the Mispillion Jetty and Lewes Beach; and,

2. avoid beach nourishment between April 15 and June 30 in order to minimize potential adverse impacts to spawning horseshoe crabs and migrating shorebirds.

In regard to the proposed disposal of dredged material in sand stockpiles near the Delaware shoreline, the Service supports the Corps decision to eliminate Site LC-10 from further consideration as a dredged material disposal site. Additionally, the Service recommends that the Corps:

1. verify site conditions once a specific location is identified for a sand stockpile in the vicinity of Big Stone Beach;

2. minimize or eliminate the use of sand stockpiles for the disposal of dredged material by maximizing use of dredged material for beach nourishment and wetland restoration;

3. coordinate with the State of Delaware to identify cost-effective measures to use as much sand as possible to direct nourishment of Delaware beaches;

4. re-evaluate the potential for additional beach nourishment and wetland restoration projects outside the area evaluated for the current study including the Maurice River Cove area and beaches in Cape May County; and,

5. coordinate with the Service, NJDFGW, and DNREC regarding the results of the sediment transport modeling studies.

Finally, the Service recommends that the Corps proceed with plans to conduct a pilot project to study the effectiveness of geotextile tubes in Delaware Bay. Such a pilot project would greatly improve the prospects for successful implementation of the proposed Egg Island Point and Kelly Island wetland restoration projects. Such a pilot project should also include expanded horseshoe crab and shorebird surveys, and assessments of horseshoe crab spawning habitat requirements. The Service recommends that the Corps coordinate with the Service, DNREC, and NJDFGW regarding the design of the pilot project, and related monitoring studies.

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APPENDIX A

Federally-listed endangered and threatened species
and candidate species in New Jersey and Delaware

Revised 5/95

FEDERALLY-LISTED ENDANGERED AND THREATENED SPECIES IN NEW JERSEY

An **ENDANGERED SPECIES** is any species that is in danger of extinction throughout all or a significant portion of its range.

A **THREATENED SPECIES** is any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

FISHES

Sturgeon, shortnose*	Acipenser brevirostrum	E

REPTILES

Turtle, Atl. Ridley*	Lepidochelys kempii	E
Turtle, green*	Chelonia mydas	T
Turtle, hawksbill*	Eretmochelys imbricata	E
Turtle, leatherback*	Dermochelys coriacea	E
Turtle, loggerhead*	Caretta caretta	T

BIRDS

Eagle, bald	Haliaeetus leucocephalus	PT
Falcon, Am. peregrine	Falco peregrinus anatum	E
Plover, piping	Charadrius melodus	T
Tern, roseate	Sterna dougallii dougallii	E

MAMMALS

Bat, Indiana	Myotis sodalis	E
Cougar, eastern	Felis concolor couguar	E+
Whale, blue*	Balaenoptera musculus	E
Whale, finback*	Balaenoptera physalus	E
Whale, humpback*	Megaptera novaeangliae	E
Whale, right*	Balaena glacialis	E
Whale, sei*	Balaenoptera borealis	E
Whale, sperm*	Physeter catodon	E
Wolf, gray	Canis lupus	E+

INVERTEBRATES

Dwarf wedge mussel	Alasmidonta heterodon	E+
Beetle, northeastern beach tiger	Cicindela dorsalis dorsalis	T
Butterfly, Mitchell satyr	Neonympha m. mitchellii	E+
American burying beetle	Nicrophorus americanus	E+

PLANTS

Pogonia, small whorled	Isotria medeoloides	E
Swamp pink	Helonias bullata	T
Orchid, eastern prairie fringed	Platanthera leucophaea	T+
Knieskern's beaked-rush	Rhynchospora knieskernii	T
American chaffseed	Schwalbea americana	E
Joint-vetch, sensitive	Aeschynomene virginica	T
Pigweed, sea-beach	Amaranthus pumilus	T+

STATUS:

E: endangered species
T: threatened species
+: presumed extirpated
PE: proposed endangered
PT: proposed threatened

* Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service.

Note: for a complete listing of Endangered and Threatened Wildlife and Plants refer to 50 CFR 17.11 & 17.12, August 20, 1994

FEDERAL CANDIDATE SPECIES IN NEW JERSEY

CANDIDATE SPECIES in categories 1 and 2 are species that appear to warrant consideration for addition to the federal List of Endangered and Threatened Wildlife and Plants. Although these species receive no substantive or procedural protection under the Endangered Species Act, the U.S. Fish and Wildlife Service encourages federal agencies and other planners to give consideration to these species in the environmental planning process.

VERTEBRATES

Turtle, bog	Clemmys muhlenbergii	1
Terrapin, northern diamondback	Malaclemys terrapin terrapin	2
Snake, northern pine	Pituophis melanoleucus melanoleucus	2
Duck, harlequin	Histrionicus histrionicus	2
Goshawk, northern	Accipiter gentilis	2
Rail, Black	Laterallus jamaicensis	2
Shrike, migrant loggerhead	Lanius ludovicianus migrans	2
Sparrow, Henslow's	Ammodramus henslowii	2
Warbler, cerulean	Dendroica cerulea	2
Bat, eastern small-footed	Myotis leibii	2
Rabbit, New England cottontail	Sylvilagus transitionalis	2
Shrew, Tuckahoe masked	Sorex cinereus nigriculus	2
Woodrat, Alleghany	Neotoma magister	2

INVERTEBRATES

Mussel, brook floater	Alasmidonta varicosa	2
Mussel, yellow lamp	Lampsilis cariosa	2
Mussel, green floater	Lasmigona subviridis	2
Damselfly, lateral bluet	Enallagma laterale	2
Dragonfly, extra-striped snaketail	Ophiogomphus anomalus	2*
Dragonfly, banded bog skimmer	Williamsonia lintneri	2*
Beetle, cobblestone tiger	Cicindela marginipennis	2
Moth, Albarufan dagger	Acronicta albarufa	2
Moth, Buchholz' dart	Agrotis buchholzi	2
Skipper, eastern beard grass	Atrytone arogos arogos	2
Moth, precious underwing	Catocala pretiosa pretiosa	2
Moth, Daecke's pyralid	Crambus daeckeellus	2
Moth, Hebard's noctuid	Erythroecia hebardi	2
Moth, buck	Hemileuca sp.	2
Moth, Lemmer's pinion	Lithophane lemmeri	3C
Moth, Doll's merolonche	Merolonche dolli	2
Moth, noctuid	Papaipema aerata	2
Butterfly, tawny crescent	Phyciodes batesi	2*
Skipper, rare	Problema bulenta	2
Moth, annointed sallow	Pyreferra ceromatica	2*
Skipper, grizzled	Pyrgus wyandot	2*
Moth, Carter's noctuid	Spartiniphaga carterae	2
Butterfly, regal fritillary	Speyeria idalia	2*

PLANTS

Lakecress	Armoracia lacustris	3C
Bur-marigold	Bidens bidentoides var. bidentoides	2
Sedge, handsome	Carex formosa	2
Sedge, variable	Carex polymorpha	2
Sedge, Schweinitz's	Carex schweinitzii	2
Spring beauty yellow	Claytonia virginica var. hammondiae	2
Tick-trefoil, ground-spreading	Desmodium humifusum	2
Boneset, pine barrens	Eupatorium resinosum	2
Spurge, Darlington's	Euphorbia purpurea	2
Everlasting, clammy	Gnaphalium macounii	3B
St. Johnswort, Barton's	Hypericum adpressum	2
Butternut	Juglans cinerea	2
Rush, New Jersey	Juncus caesariensis	2
Blazingstar	Liatris borealis	2
Lobelia, Boykin's	Lobelia boykinii	2
Micranthemum, Nuttall's	Micranthemum micranthemoides	2*
Bog asphodel	Narthecium americanum	1
Panic grass, Hirst's	Panicum hirstii	2
Pondweed, algae-like	Potamogeton confervoides	2
Plum, Alleghany	Prunus alleghaniensis	2
Meadowbeauty, awned	Rhexia aristosa	2
Bulrush, Long's	Scirpus longii	2
Morning-glory, Pickering's	Stylisma pickeringii	2
Sea blite	Suaeda rolandii	2
False-foxglove, auriculate	Tomanthera auriculata	2*
Verbena	Verbena riparia	2*

Categories:

1: Taxa for which the U.S. Fish and Wildlife Service (Service) currently has substantial information to support the appropriateness of proposing to list the species as threatened or endangered. Development and publication of proposed rules on these species is anticipated.

2: Taxa for which information now in possession of the Service indicates that proposing to list the species as threatened or endangered is possibly appropriate, but for which conclusive data are not available to support proposed rules at this time.

3B: Names that, on the basis of current taxonomic understanding, do not represent distinct taxa meeting the Act's definition of "species." Such supposed taxa could be reevaluated in the future on the basis of new information.

3C: Taxa that have proven to be more abundant than previously believed and/or those that are not subject to any identifiable threat. If further research or changes in habitat indicate a significant decline in any of these taxa, they may be reevaluated for possible inclusion in categories 1 or 2.

PE: Proposed Endangered species

PT: Proposed Threatened species

* Signifies a lack of sightings, to the Service's knowledge, since 1963 for New Jersey.

Note: For complete listings of taxa under review, refer to Federal Register Vol. 59, No. 219, Nov. 15, 1994 (Animal) and Vol. 58, No. 188, September 30, 1993 (Plants).

FEDERALLY-LISTED ENDANGERED AND THREATENED SPECIES IN DELAWARE

FISHES

Sturgeon, shortnose*	Acipenser brevirostrum	E

REPTILES

Turtle, Alt. Ridley*	Lepidochelys kempii	E
Turtle, green*	Chelonia mydas	T
Turtle, hawksbill*	Eretmochelys imbricata	E
Turtle, leatherback	Dermochelys coriacea	E
Turtle, loggerhead*	Caretta caretta	T

BIRDS

Eagle, bald	Haliaeetus leucocephalus	T
Falcon, Am. peregrine	Falco peregrinus anatum	E
Plover, piping	Charadrius melodus	T
Tern, roseate	Sterna dougallii dougallii	E

MAMMALS

Squirrel, Delmarva peninsula fox	Sciurus niger cinereus	+
Whale, blue*	Balaenoptera musculus	E+
Whale, finback*	Balaenoptera physalus	E
Whale, humpback*	Megaptera novaeangliae	E
Whale, right*	Balaena glacialis	E
Whale, sperm*	Physeter catodon	E

FEDERAL CANDIDATE SPECIES IN DELAWARE

VERTEBRATES

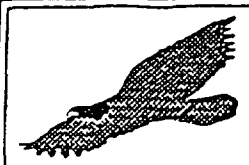
Turtle, bog	Clemmys muhlenbergii	1
Terrapin, northern diamondback	Malaclemys terrapin terrapin	2
Duck, fulvous whistling	Dendrocygna bicolor	2
Duck, harlequin	Histrionicus histrionicus	2
Goshawk, northern	Accipiter gentilis	2
Rail, black	Laterallus jamaicensis	2
Tern, black	Chlidonias niger	2
Shrike, loggerhead	Lanius ludovicianus	2
Warbler, cerulean	Dendroica cerulea	2

INVERTEBRATES

Skipper, rare	Problema bulenta	2
Butterfly, regal fritillary	Speyeria idalia	2+
Floater, brook	Alasmidonta varicosa	2+

APPENDIX B

State-listed endangered and threatened species in New Jersey



ENDANGERED AND THREATENED WILDLIFE OF NEW JERSEY

Endangered Species are those whose prospects for survival in New Jersey are in immediate danger because of a loss or change in habitat, over-exploitation, predation, competition, disease, disturbance or contamination. Assistance is needed to prevent future extinction in New Jersey.

Threatened Species are those who may become endangered if conditions surrounding them begin to or continue to deteriorate.

BIRDS

Endangered

Pied-billed Grebe,* *Podilymbus podiceps*
Bald Eagle, *Haliaeetus leucocephalus***
Northern Harrier,* *Circus cyaneus*
Cooper's Hawk, *Accipiter cooperii*
Red-shouldered Hawk, *Buteo lineatus* (Breeding)
Peregrine Falcon, *Falco peregrinus***
Piping Plover, *Charadrius melodus***
Upland Sandpiper, *Bartramia longicauda*
Roseate Tern, *Sterna dougallii*
Least Tern, *Sterna antillarum*
Black Skimmer, *Rynchops niger*
Short-eared Owl,* *Asio flammeus*
Sedge Wren, *Cistothorus platensis*
Loggerhead Shrike, *Lanius ludovicianus*
Vesper Sparrow, *Pooecetes gramineus*
Henslow's Sparrow, *Ammodramus henslowii*

Threatened

American Bittern*, *Botaurus lentiginosos*
Great Blue Heron*, *Ardea herodias*
Little Blue Heron, *Egretta caerulea**
Yellow-crowned Night Heron, *Nyctanassa violaceus*
Osprey, *Pandion haliaetus*
Northern Goshawk, *Accipiter gentilis*
Red-shouldered Hawk, *Buteo lineatus* (Non-breeding)
Black Rail, *Laterallus jamaicensis*
Long-eared Owl, *Asio otus*
Barred Owl, *Strix varia*
Red-headed Woodpecker, *Melanerpes erythrocephalus*
Cliff Swallow,* *Hirundo pyrrhonota*
Savannah Sparrow, *Passerculus sandwichensis*
Ipswich Sparrow, *Passerculus sandwichensis princeps*
Grasshopper Sparrow, *Ammodramus savannarum*
Bobolink, *Dolichonyx oryzivorus*

*Only breeding population considered endangered or threatened
**Federally endangered or threatened

REPTILES

Endangered

Bog Turtle, *Clemmys muhlenbergi*
Atlantic Hawksbill, *Eretmochelys imbricata***
Atlantic Loggerhead, *Caretta caretta***
Atlantic Ridley, *Lepidochelys kempi***
Atlantic Leatherback, *Dermochelys coriacea***
Corn Snake, *Elaphe g. guttata*
Timber Rattlesnake, *Crotalus h. horridus*

Threatened

Wood Turtle, *Clemmys insculpta*
Atlantic Green Turtle, *Chelonia mydas***
Northern Pine Snake, *Pituophis m. melanoleucus*

**Federally endangered or threatened

ENDANGERED AND NONGAME SPECIES PROGRAM

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION AND ENERGY
DIVISION OF FISH, GAME AND WILDLIFE

AMPHIBIANS

Endangered

Tremblay's Salamander, *Ambystoma tremblayi*
Blue-spotted Salamander, *Ambystoma laterale*
Eastern Tiger Salamander, *Ambystoma t. tigrinum*
Pine Barrens Treefrog, *Hyla andersonii*
Southern Gray Treefrog, *Hyla chrysoscelis*

Threatened

Long-tailed Salamander, *Eurycea longicauda*
Eastern Mud Salamander, *Pseudotriton montanus*

MAMMALS

Endangered

Bobcat, *Lynx rufus*
Eastern Woodrat, *Neotoma floridana*
Sperm Whale *Physeter, macrocephalus***
Fin Whale, *Balaenoptera physalus***
Sei Whale, *Balaenoptera borealis***
Blue Whale, *Balaenoptera musculus***
Humpback Whale, *Megaptera novaeangliae***
Black Right Whale, *Balaena glacialis***

INVERTEBRATES

Endangered

Mitchell's Satyr (butterfly), *Neonympha m. mitchellii***
Northeastern Beach Tiger Beetle, *Cicindela d. dorsalis*
American Burying Beetle, *Nicrophorus americanus***
Dwarf Wedge Mussel, *Alasmidonta heterodon***

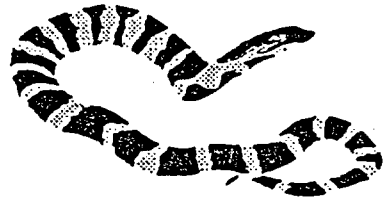
**Federally endangered

FISH

Endangered

Shortnose Sturgeon, *Acipenser brevirostrum***

List revisions: March 29, 1979
January 17, 1984
May 6, 1985
July 20, 1987
June 3, 1991



The lists of New Jersey's endangered and nongame wildlife species are maintained by the DEP&E's Division of Fish, Game and Wildlife's, Endangered and Nongame Species Program. These lists are used to determine protection and management actions necessary to insure the survival of the State's endangered and nongame wildlife. This work is made possible only through voluntary contributions received through the Wildlife Check-off on the New Jersey State Tax Form. The Wildlife Check-off is the only major funding source for the protection and management of the State's endangered and nongame wildlife resource. For more information about the Endangered and Nongame Species Program or to report a sighting of endangered or threatened wildlife contact: Endangered and Nongame Species Program, Northern District Office, Box 383 R.D. 1, Hampton, N.J. 08827 or call (908) 735-8975.