

# **Ocean City, Maryland & Vicinity Water Resources Feasibility Study**

## **Impacts to Piping Plover and Seabeach Amaranth from Long-Term Sand Management Component BIOLOGICAL ASSESSMENT**

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## EXECUTIVE SUMMARY

Prior to 1933, Assateague Island was an open, sparsely vegetated, barrier beach, connected to Fenwick Island. A major storm during 1933 created a breach in the area of the Ocean City Inlet. Since its formation more than 60 years ago, the maintained Ocean City Inlet has provided for navigation between the ocean and coastal bays. However, stabilization of the Ocean City Inlet through construction of jetties during 1933-35 greatly altered the sand supply and transport mechanisms to Assateague Island in Maryland. Prior to the inlet formation and stabilization, sand generally traveled from Ocean City to Assateague Island. The jetty system reduced the sand volume delivered to the island from the north via long shore transport, rerouted a large portion of sand that would have otherwise reached northern Assateague, and resulted in increased erosion rates and an accelerated retreat of the northern 11 km (6.8 miles) of the island. The disruption of sand flow between Ocean City and Assateague Island has resulted in numerous physical and biological impacts to the area. Immediately following inlet stabilization, ebb and flood tidal shoals began forming at the expense of downdrift Assateague Island. The ebb shoal's volume has currently reached 10 million cubic meters (13 million cubic yards). The ebb shoal has acted as a sink for 60 years, depriving Assateague Island of the sediment needed to sustain the island.

During 1995 and 1996, the degradation of Assateague Island was determined to be an urgent problem. This resulted in development of a plan for a short-term beach restoration project by the US Army Corps of Engineers Baltimore District (USACE) recommending the placement of 1.4 million cubic meters (1.8 million cubic yards) of sand along much of northern Assateague Island's shoreline beach. This short-term project, a one-time nourishment of the island, serves to partially mitigate for past sediment starvation due to jetty construction. Implementation for the beach restoration component, the short-term project, is planned for the year 1999. A separate biological assessment was prepared for this short-term restoration project in 1996.

It is believed that Assateague Island has been deprived of a volume of sand in the magnitude of 6.6 million cubic meters (8.6 million cubic yards) since the 1933 jetty construction (USACE 1997a). A thorough analysis of the sediment budget during development of the short-term restoration project indicated an annual sediment shortfall of approximately 145,000 cubic meters (189,000 cubic yards) to Assateague Island due to the presence of the jetties. A long-term sand management program was proposed to compensate for this sediment shortfall but is not expected to change the island's historic transgressive condition. This long-term program will continually supply sand to sediment-starved northern Assateague Island for at least 25 years through a mobile bypassing of 145,000 cubic meters per year of sand to the island. With this long-term sand management program in place, it is assumed that natural forces will be allowed to prevail to shape the island's geomorphological character on the majority of the island. Implementation for the long-term sand management component is planned to immediately follow the short-term project.

The attached biological assessment refers to the long-term sand management component. This document will address potential effects that this project may have on piping plovers (*Charadrius melodus*) and seabeach amaranth (*Amaranthus pumilus*), both federally threatened species.

The long-term sand management component of the project may adversely affect piping plovers and/or seabeach amaranth. However, no known direct adverse impacts are expected to piping plovers or seabeach amaranth as a result of the proposed long-term sand management project if considered on its own. This assumes that the same time-of-year restrictions apply as in the short-term restoration plan, placement of sediment is restricted to the nearshore water zone and will not occur on emergent upland portions of the island, and the quantity of dredged material to be released is significantly less than the short-term project.

Consideration of the indirect effects likely to result from the proposed action is more difficult. Since monitoring began on Assateague Island, piping plovers have been observed responding to a wide range of habitat types in different ways, including fluctuations of breeding pairs and productivity numbers. By restoring the sediment deficit and allowing natural processes to drive the islands physical character, as proposed in this project, it is expected that there will be available habitat types that are suitable for piping plovers. This assumes that the island will continue to be erosional, retreating, and experience enough overwash that results in a range of habitats that are favorable to piping plovers.

Based on what is known historically for habitat characteristics along Assateague Island prior to jetty construction, it appears that the island supported conditions that were favorable to breeding piping plovers. The proposed long-term sand management project may provide some benefits to piping plovers, including favorable nesting conditions by elevating some areas that have lost significant amounts of sand due to recent storms. These areas are currently no longer suitable for nesting plovers. Depending on frequency, duration, and intensity of storms, which will always be an unpredictable factor, piping plovers will likely respond accordingly with fluctuations of numbers and successes. Likewise, conditions resulting from the long-term project may provide suitable habitat for seabeach amaranth reintroduction opportunities.

Indirect effects of the long-term sand management project will also be dependent at least initially (several years perhaps) on those of the more intensive short-term restoration effort. It will likely be difficult to sort out effects of one project over the other since implementation of the long-term so closely follows the short-term.

If the short-term project results in unfavorable habitat conditions that can not be corrected by the monitoring and mitigation plan, the long-term project is likely to exacerbate these effects and may adversely affect piping plovers.

Monitoring and mitigation measures would lessen the severity of potential cumulative impacts on piping plovers and seabeach amaranth. Some measures would include ecological monitoring of piping plovers, red fox populations, vegetation cover, island topography, and implementing corrective management actions as needed.

## 1.0 INTRODUCTION

Sand supply and transport mechanisms on Assateague Island were greatly altered by the construction of jetties at the Ocean City Inlet, in Maryland, by the U.S. Army Corps of Engineers (USACE) in 1933-1935. The jetty system was constructed to stabilize the Ocean City Inlet, which was formed by the hurricane of 1933. The jetties were designed and built to provide navigation through the inlet between the coastal bays and the Atlantic Ocean. The Ocean City jetty system has acted as a sand trap, disrupting the natural movement of sand along the coast to Assateague Island for more than 60 years. The primary effect of the jetty-induced interruption of sand to Assateague is that the island has been deprived of a volume of sand in the magnitude of 6.6 million cubic meters (8.6 million cubic yards). Because of its diminished sediment volume, the island no longer functions as an effective barrier island. The recent storms in January and February 1998, resulted in severe erosion on Assateague Island and will likely continue to deteriorate due to increased overwash. Overwash effects are expected to create conditions more susceptible to breach formation along the island's northern section.

Conditions at Assateague Island are being evaluated comprehensively in conjunction with evaluation of coastal bays navigation and environmental restoration needs by the U.S. Army Corps of Engineers (USACE) Ocean City and vicinity feasibility study with the following components: (1) the short-term, immediate restoration of Assateague Island, (2) long-term sand management, (3) navigation improvements, and (4) environmental restoration in the coastal bays. The overall project goal is to restore the coastal bay ecosystem by restoring coastal functions and wildlife habitat, while protecting and improving the economic resources (USACE, 1997b).

The proposed long-term sand management program will continually supply sand for a 25 year period to sediment-starved northern Assateague Island without changing the historic transgressive condition of eroding at a rate of 150,000 cubic meters per year. The stated goal of the long-term project is that natural forces will dictate the condition of the island following project implementation. The exception to this is in the developed area of both the State of Maryland's Assateague State Park and National Seashore immediately south of the state park. It is expected that this long-term sand management program will be implemented in the year 2001. This will immediately follow a beach nourishment effort along northern Assateague which is expected to be implemented in two seasons during the Fall 1999 and Fall 2000. A description of the short-term beach nourishment project and its separate Biological Assessment can be found in the May 1997 report *Restoration of Assateague Island Draft Environmental Impact Statement*.

Assateague Island National Seashore (ASIS), provides nesting and foraging habitats for piping plovers (a shorebird, federally-listed as threatened, state-listed as endangered). Assateague Island is one of several sites along the Atlantic coast that is being considered for the reintroduction of seabeach amaranth (a beach plant, federally-listed as threatened, state-listed

as extirpated). The long-term sand management component of the project may have effect on the current population of piping plovers along Assateague Island. Since no seabeach amaranth populations are currently known to occur on Assateague Island, and there is no official reintroduction proposal, potential impacts that are discussed within this Biological Assessment are speculative and primarily based on extrapolation from populations that occur in other states. Both species are protected by the 1973 Endangered Species Act (ESA), as amended which is administered by the U.S. Fish and Wildlife Service (USFWS).

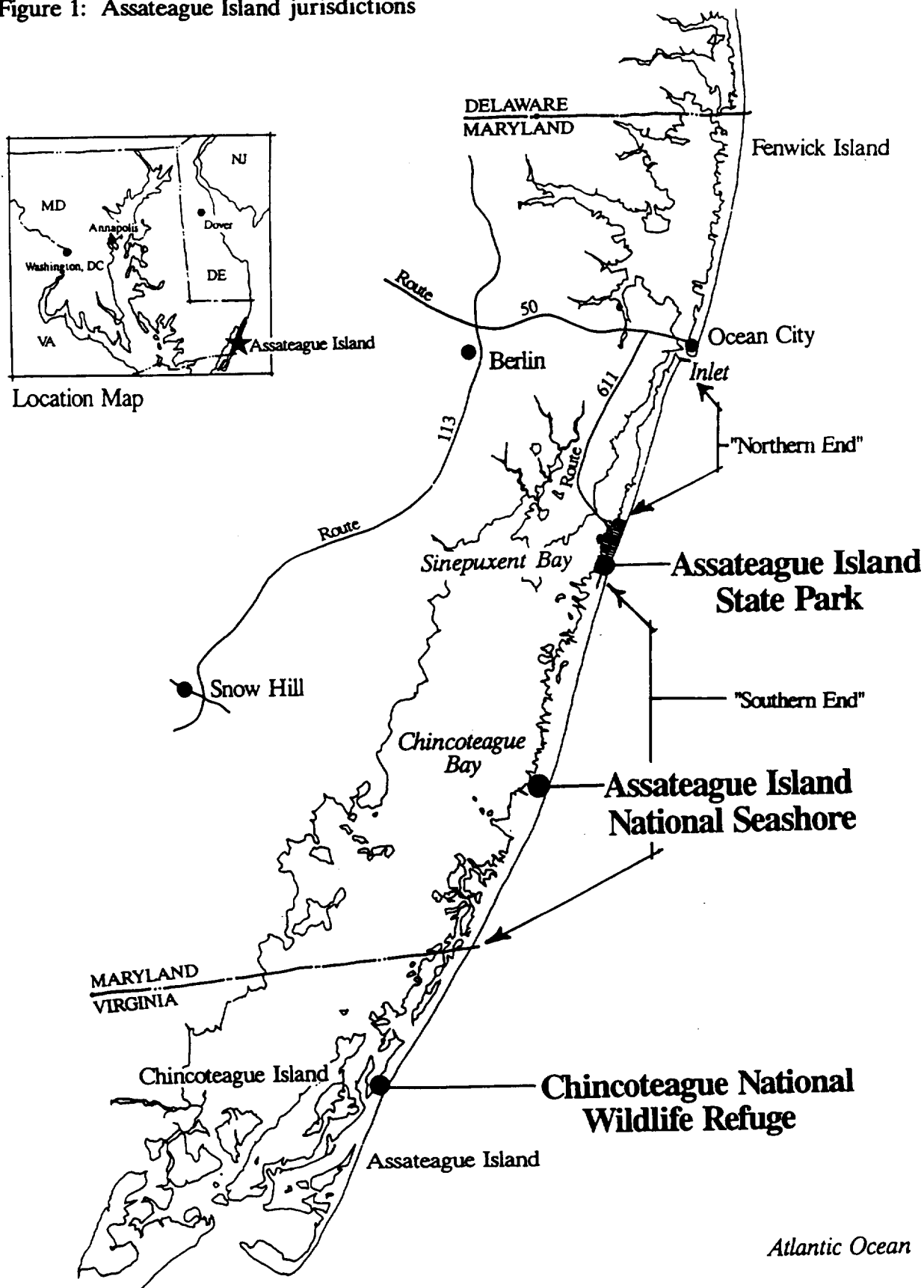
Pursuant to Section 7 of the ESA, the USACE has prepared this Biological Assessment to evaluate the potential effects of the long-term sand management project on piping plovers and seabeach amaranth. The results of this assessment will be used by USACE and the USFWS to determine if formal consultation is necessary (Federal Register/Vol. 51, No. 106, Rules and Regulations 1986). If the USACE initiates formal consultation, the USFWS may use the assessment in formulating its biological opinion (50 CFR, Part 402.12(k)(2)).

## **2.0 SPECIES AND PROJECT AREA DESCRIPTION**

Assateague Island is located on the Delaware-Maryland-Virginia (Delmarva) peninsula along the Atlantic coastline (Figure 1) and is the longest unbroken coastal barrier along the peninsula (Geotlle 1978). Prior to 1933, what is now known as northern Assateague Island was called Assateague Spit. Although Assateague was part of the same land mass as Fenwick island, neither were actually islands and were instead extensions of the Bethany Beach, Delaware headland (Underwood and Hiland 1995). Assateague Island extends from the Ocean City Inlet, Maryland, southward to the Chincoteague Inlet, Virginia. The majority of Maryland's 35-km portion of the island is federal property managed by the National Park Service (NPS) as Assateague Island National Seashore. The national park's boundary also includes the waters surrounding the island to one-half mile offshore, except where adjoining land masses restrict that distance and jurisdiction is reduced to half the distance to the adjacent shore (NPS 1993). The State of Maryland owns a 3.2-km section of the island that is managed as Assateague State Park. The Virginia portion of the island is under jurisdiction of the USFWS and managed as Chincoteague National Wildlife Refuge.

For the purpose of this report, we define the "northern end" of Assateague Island as that portion of ASIS north of the state park northern boundary and the "southern end" as the area south of the state park southern boundary (Figure 1). The northern and southern ends of Assateague Island will be discussed in detail in Section 2 of this report because the areas are distinct in their physical character, history, human use, and habitat potential for piping plover and seabeach amaranth.

Figure 1: Assateague Island jurisdictions



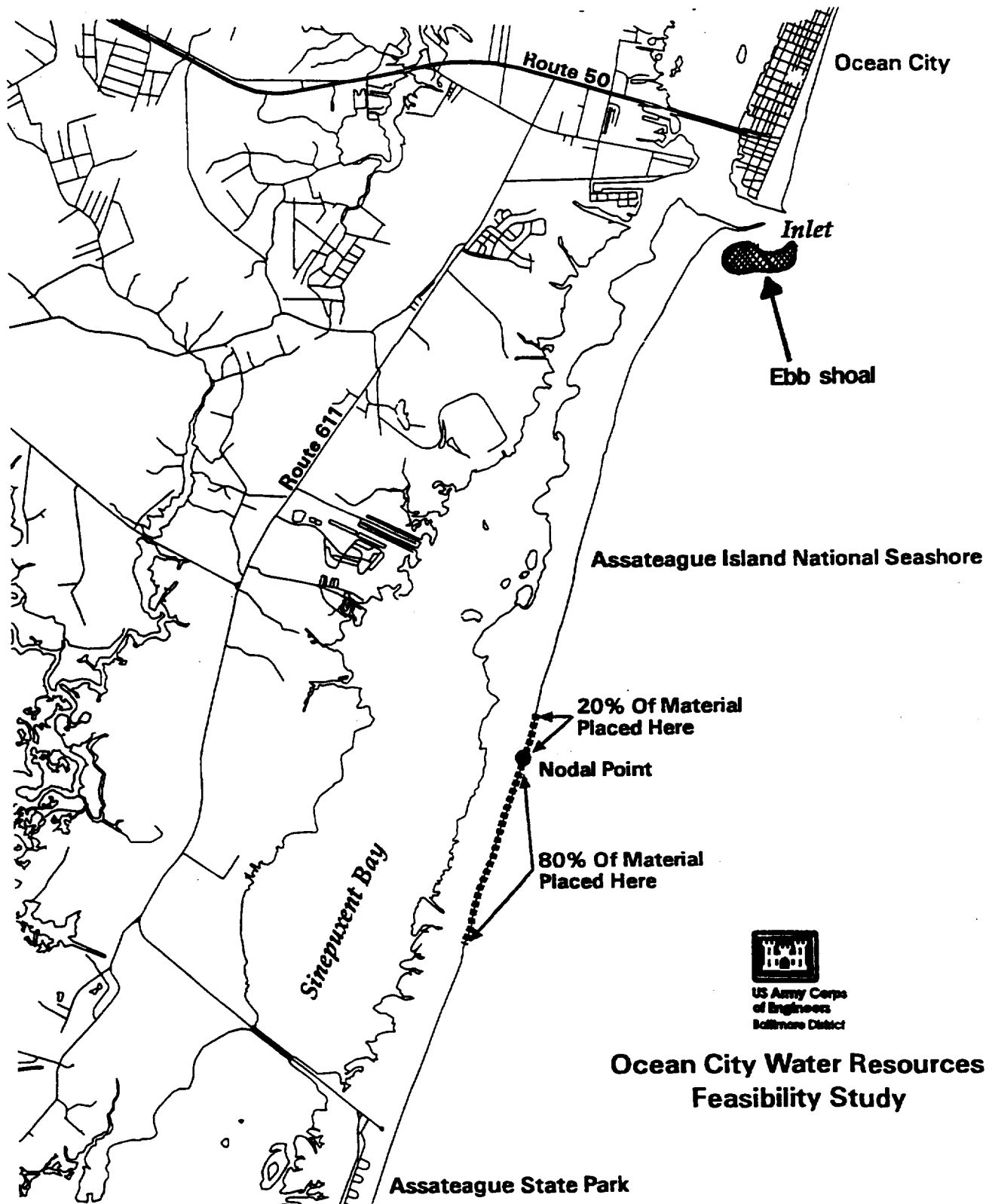
The Maryland and Virginia island is approximately 61 km (38 miles) long and is separated from the Eastern Shore mainland by Sinepuxent and Chincoteague Bays. Assateague Island is naturally much narrower at its Maryland end than at the Virginia southern end, with island widths ranging from about 270 m (900 feet) along northern Assateague Island to about 1.6 km (one mile) in Virginia. This configuration appears to be due to systematic distribution of offshore steepness and curvature, and resultant distribution of wave energy (Hayden and Dolan 1979).

Along Assateague Island, the ocean berm is a natural wave-built feature which, along most of the island's northern end, is the point of maximum island elevation except where isolated mid-island dunes and remnant dredged materials occur (USACE 1997). Berm elevations along the island may vary greatly depending on the duration, frequency, and intensity of storm events and the ambient sediment budget. Recent beach profile data taken along northern Assateague during 1995 and 1996 indicate surface elevations ranging from 0.0 m (bay shoreline) to approximately 3.0 m above the 1929 National Geodetic Vertical Datum (NGVD) (Hulslander 1996).

The area that may be directly affected by the proposed long-term sand management project includes approximately a 3.4 km nearshore area located between 5 to 8.4 km south of the Ocean City Inlet (Figure 2). This placement area lies within the reach of northern Assateague Island that will be restored under the beach nourishment action where the island will be widened and a storm berm averaging 0.8 m in height will be constructed. This northern end of the island has experienced the highest rates of erosion, and relatively frequent overwash events make it more vulnerable to breaching than portions of the island to the south (Dean and Division of Beaches 1986).

A series of northeaster storms, during January and February 1998, flattened and inundated portions of the northern end of the island. Based on post-storm breach profile surveys conducted by NPS up to 1.5 meters (5 feet) of elevation were lost along a 2.4 km (1.5 mile ) reach in the area of the project nodal point (between 6.5 and 7.0 km markers) (USACE 1998).

Figure 2: USACE long-term sand management project area



For the purposes of this assessment, working definitions are provided for habitat types potentially used by piping plover and seabeach amaranth (Table 1). These habitats are defined and described by physical position on the barrier beach and plant community associations. They are referred to throughout sections 2.1 and 2.2. The relative proportion of available habitat could not be calculated by existing data for this report. Rough estimates of coverage can be made from sequence of vegetation maps completed each spring by NPS. The southern end has more shrub and tree vegetation cover as compared to the northern end, mostly a factor of island width. The relative proportion of habitats historically is difficult to determine from available reference materials.

**Table 1.** Definition of habitat types important for piping plover and seabeach amaranth on Assateague Island.

[Where two or more **bold** terms are indicated, they are used interchangeably]

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**Ocean intertidal zone, Sand intertidal:** Ocean bare sand between high and low tides with damp to saturated sand.

**Ocean fresh wrack:** Fresh, wet lines of organic materials deposited on seaward edge of the ocean berm or throughout intertidal zone. Commonly occur at the peak of last high tide, and are associated with the mean high water line.

**Ocean berm, Berm:** A bare sand habitat zone landward of high tide line. This wave-formed feature is usually sparsely vegetated.

**Dredge material dune, Spoil pile:** Human created or stabilized feature. Remnants on Assateague have advanced successional vegetation.

**Open sand, Upper beach:** Wind blown sand, usually unvegetated or sparsely vegetated, occurring above high tide and landward of the ocean berm.

**Dune sparse vegetation, Beach dune herbaceous zone, Dune grass:** American beachgrass often dominant, and characteristic of early succession found on wind-deposited dune features landward of ocean berm. Includes community alliance *Scirpus pungens-Spartina patens*: (Split of The Nature Conservancy *Scirpus americanus-Spartina patens* Community Alliance) Diversity low, lack of dense cover, water table near surface, on water deposited dunes. *Polygonum glaucum* found here.

**Shrub, Shrubland:** Dominated by *Myrica pensylvanica*, occurs in stable, xeric higher elevations landward of beach-dune herbaceous zone.

**Overwash corridor, Overwash flats, Wash zone:** Zone of overwash swash uprush activity. A bare or sparsely vegetated habitat that occurs in areas adjacent to dune breaks or in areas where ocean or bay overwashing or breaching has occurred. Often connected to links between bayside and ocean side.

**Ephemeral pools, Ponds, Salt pan, Exposed groundwater:** Seasonally or storm flooded low lying areas or interdunal corridors. Wetland type with sparse vegetation on sandy or muddy substrates which fluctuates with changes in overwash and groundwater changes.

**Bay intertidal, Mud flats, Tidal flats, Mudflat intertidal:** Bayside bare sand and mud zone between low and high tides. Unvegetated intertidal sand or mudflat. Sometimes has sparse vegetation.

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## 2.1 Piping Plovers

In 1986, piping plover populations were listed as endangered or threatened under provisions of the ESA (USFWS 1985). The Atlantic Coast population, which is considered threatened under the ESA, breeds and nests on sandy beaches along the east coast of North America from Newfoundland to South Carolina. The nesting and brood-foraging habitats are particular importance. Piping plovers typically nest above the high tide line along ocean shorelines, along gently-sloping foredunes, in blowout areas behind primary dunes, overwash fans and sandflats at inlets or ends of barrier islands, and in washover areas where high tides or storm overwash activity has provided open, sparsely vegetated habitats. Preferred foraging areas include intertidal zones along ocean beaches, washover areas that remain moist throughout the summer, mud and sandflats, wrack lines, and shorelines of ponds and salt marshes (USFWS 1995a). Following storm-related breach activity or the formation of inlets along barrier island systems, plovers will often use recurved spits and delta fans for foraging (Houghton *et al.* 1997a). One of the primary objectives of the Atlantic Coast piping plover recovery effort includes achieving well-distributed increases in numbers and productivity of breeding pairs. In recent years, the Assateague Island population of piping plovers has contributed dramatically to this goal with breeding pairs and productivity numbers reaching record highs.

Four recovery units have been established by the Revised Recovery Plan (USFWS 1996a), including the Southern recovery unit (Delaware, Maryland, Virginia and North Carolina). Piping plover populations have been increasing more slowly in the southern unit than most of the other recovery units. Assateague Island National Seashore has taken on a particularly critical role in recovery of the southern recovery unit. It is one of the few areas within this unit that has experienced a significant population increase. Piping plover number on ASIS have increased from 9 percent in 1991, comprising nearly a third of the Southern Recovery Unit sub-population in 1996 (Anne Hecht. 1998. In press.). The Southern Recovery Unit's population goal is 400 pairs. Attainment of sub population goals are especially important for the Atlantic Canada and Southern Recovery Units due to their small numbers, sparse distribution over relatively large geographic areas, and potential to substantially contribute to the viability of the entire Atlantic coast population. By maintaining robust, well-distributed sub populations, variances in survival and productivity of the Atlantic coast population are reduced, interchange of genetic material between sub populations is easier, and sites that have suffered declines due to low productivity and/or habitat degradation are more likely to be recolonized.

Piping plovers typically return to the mid-Atlantic region in mid-March, but have been observed as early as February 24 in Virginia (Cross 1991). Males begin to establish territories by early April. First nests on northern Assateague Island have been found as early as the third week of April (NPS reports), but eggs may be present on the beach from mid-April to late July (USFWS 1996a). Southward migration to the wintering grounds peaks during the last week of July and extends until September. However, piping plovers have been occasionally sighted on Assateague during winter months (NPS reports, Hoffman. unpublished report).

Although piping plovers depend on habitats that may change between years, they typically exhibit great site tenacity within and between years (Haig and Oring 1988, Wiens and Cuthbert 1988, MacIvor 1990). Over a six-year period, approximately 70 percent of surviving adult plovers were site faithful in Manitoba, Canada. At four breeding localities in Minnesota, 84 percent of all breeding birds nested within 200 m of their nest site of the previous year. At ten breeding localities over a five year period along Cape Cod, Massachusetts, up to 80 percent of banded surviving adults returned to the same breeding area to nest, and site fidelity was greater in males than females (same authors as above).

In New York, Wilcox (1959) recaptured 39 percent of the 744 adult plovers that he banded in prior years. Only 4.7 percent of 979 plovers that he banded as chicks were recaptured. Of 92 adults banded on Assateague Island, Maryland, and re-sighted the following year, 91 were seen at the same site, as were 8 of 12 first-year birds (Loefering 1992). Ten of 12 juveniles banded on Assateague Island, Virginia and re-sighted on and/or two years later were observed on the Virginia or Maryland portions of Assateague Island. The remaining two were observed on other Virginia barrier islands. Nearly all observations of inter-year movements of piping plovers along the Atlantic Coast have been within the same or adjacent states. Two of 121 plovers banded on Assateague Island were re-sighted breeding in New Jersey.

In some years, frequent clutch failures due to predators and storms provide opportunities for birds to change mates within the breeding season. Piping plovers are known to exhibit high mate-retention within the nesting season, but do not typically retain the same mate between years even if both birds return the following year (Haig and Oring 1988, MacIvor 1990). During studies in Manitoba, Canada, adults typically kept mates after nest destruction, but changed territories (Haig and Oring 1988). Birds changed territories more often following nest destruction by storms than following destruction by predation.

Shoreline stabilization and development along the Atlantic seaboard have been major contributors to the piping plover's decline through degradation and direct loss of habitat (Wilcox 1959). Predation and disturbance by humans and pets are also major factors that have limited reproductive success at many Atlantic Coast sites (Cairns and McLaren 1980, Flemming *et al.* 1988, MacIvor 1990, Patterson *et al.* 1991).

During 1986-97, Maryland's portion of Assateague Island has supported between 14 and 61 breeding pairs of piping plovers (Table 2). Reproductive success, measured as the number of chicks fledged per breeding pair, has varied greatly between years due to a variety of biological and meteorological influences during all phases of breeding activity. Nests may be impacted by flooding, high winds, predation, and human disturbance. Chicks may be affected by these same influences in addition to prey availability, disease, injury, and extreme weather conditions. Low chick survival can be caused by restricted access to bayside foraging areas due to vegetation blockage from lack of sufficient overwash or disturbance processes to reduce vegetation. During this monitoring period on Assateague Island, actual chick mortality was rarely verified (less than 1 percent).

**Table 2.** Summary of Piping Plover Reproductive Success on Assateague Island National Seashore, 1986-1997

| Year | Breeding Pairs | Nest Attempts | Nests Hatched | Chicks Hatched | Chicks Fledged | Number. Fledged / Breeding Pair |
|------|----------------|---------------|---------------|----------------|----------------|---------------------------------|
| 1986 | 17             | 23            | 14            | 38             | 18             | 1.06                            |
| 1987 | 23             | 33            | 16            | 46             | 27             | 1.17                            |
| 1988 | 25a            | 34            | 13            | 37             | 13             | 0.52                            |
| 1989 | 20a            | 27            | 11            | 36             | 18             | 0.90                            |
| 1990 | 14a            | 20            | 8             | 25             | 11             | 0.78                            |
| 1991 | 18             | 20            | 14            | 47             | 7              | 0.41                            |
| 1992 | 24             | 30            | 14            | 43             | 24             | 1.00                            |
| 1993 | 20             | 30            | 11            | 39             | 34             | 1.7                             |
| 1994 | 32             | 42            | 31            | 104            | 77             | 2.41                            |
| 1995 | 44             | 45            | 41            | 148            | 76             | 1.73                            |
| 1996 | 61             | 72            | 50            | 173            | 91             | 1.49                            |
| 1997 | 60             | 100           | 54            | 177            | 60b            | 1.00                            |

a Calculated from nesting pair (Loefering 1992)

b 1997 fledging predicted from a 15 day monitoring period

Table adapted from NPS report, 1997

In the early 1990's, chick survival was declining due to restricted access to bayside foraging areas (Loefering & Fraser 1995). During that time, nesting activity primarily occurred along the northern 8 km of the island and vegetation cover was substantial. In 1997, piping plover nest sites were mapped along with vegetation type (Figure 3) and shrub dominated habitats occurred far less than prior to the 1991/92 storms.

Figure 3: Northern end piping plover nest sites, 1997

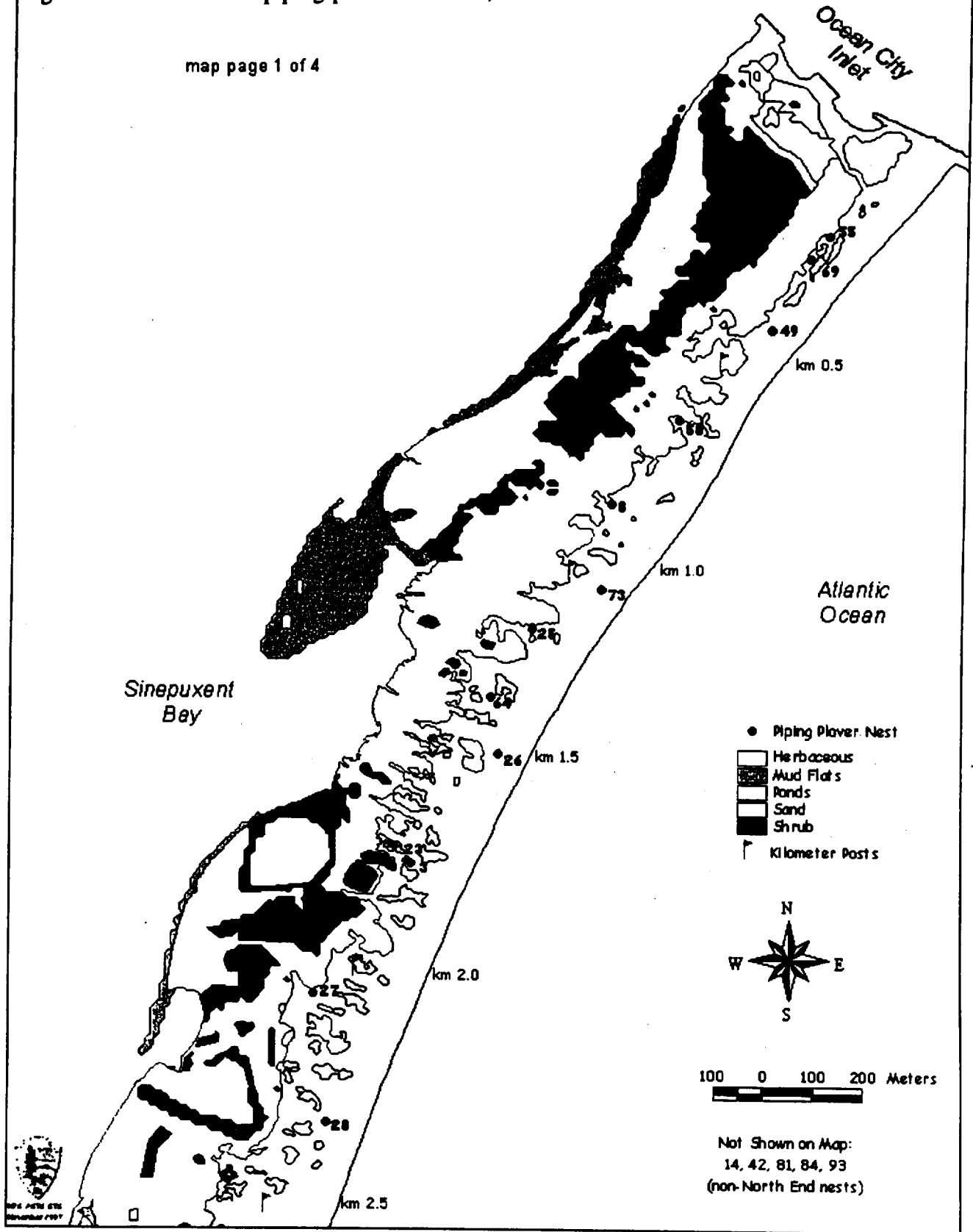


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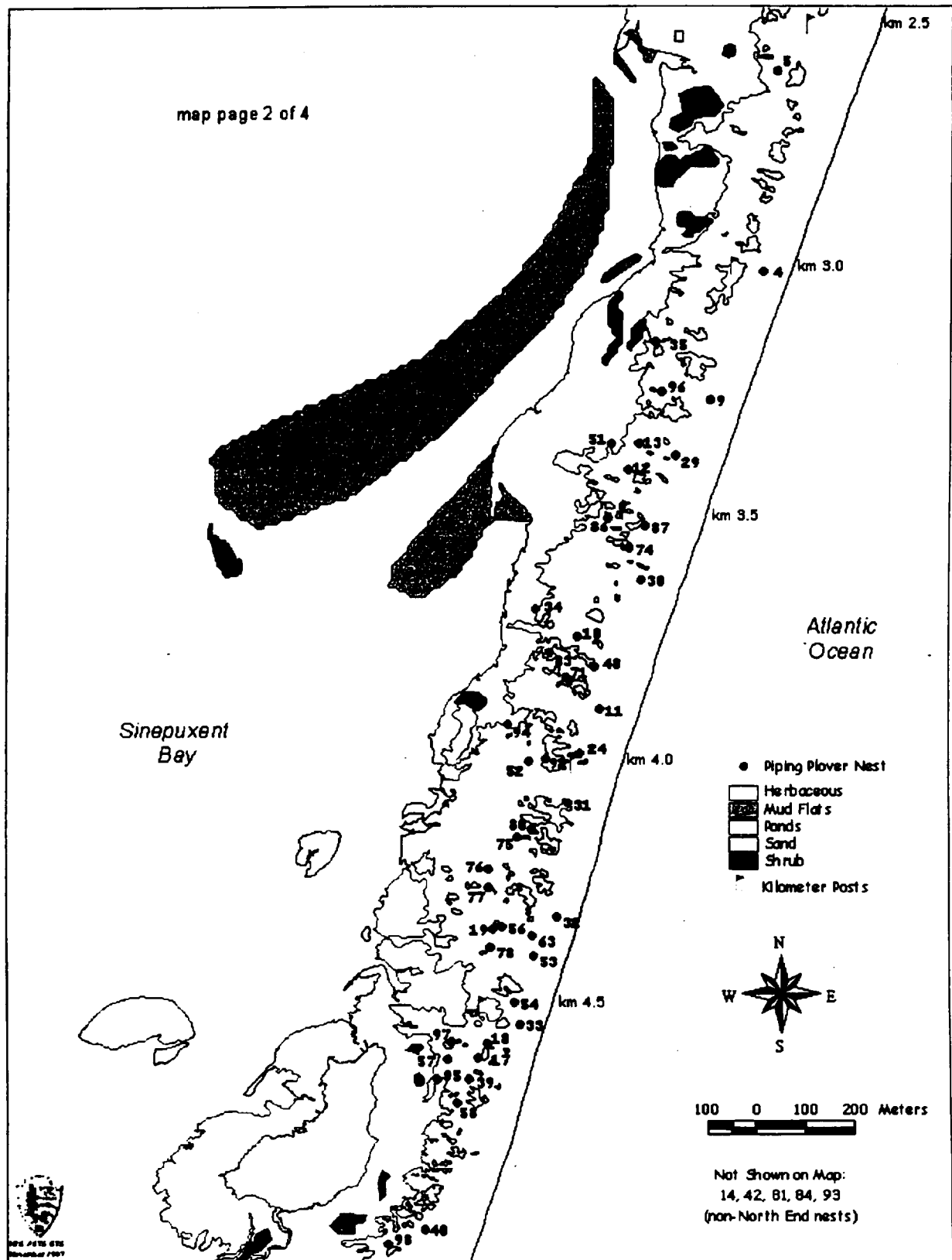


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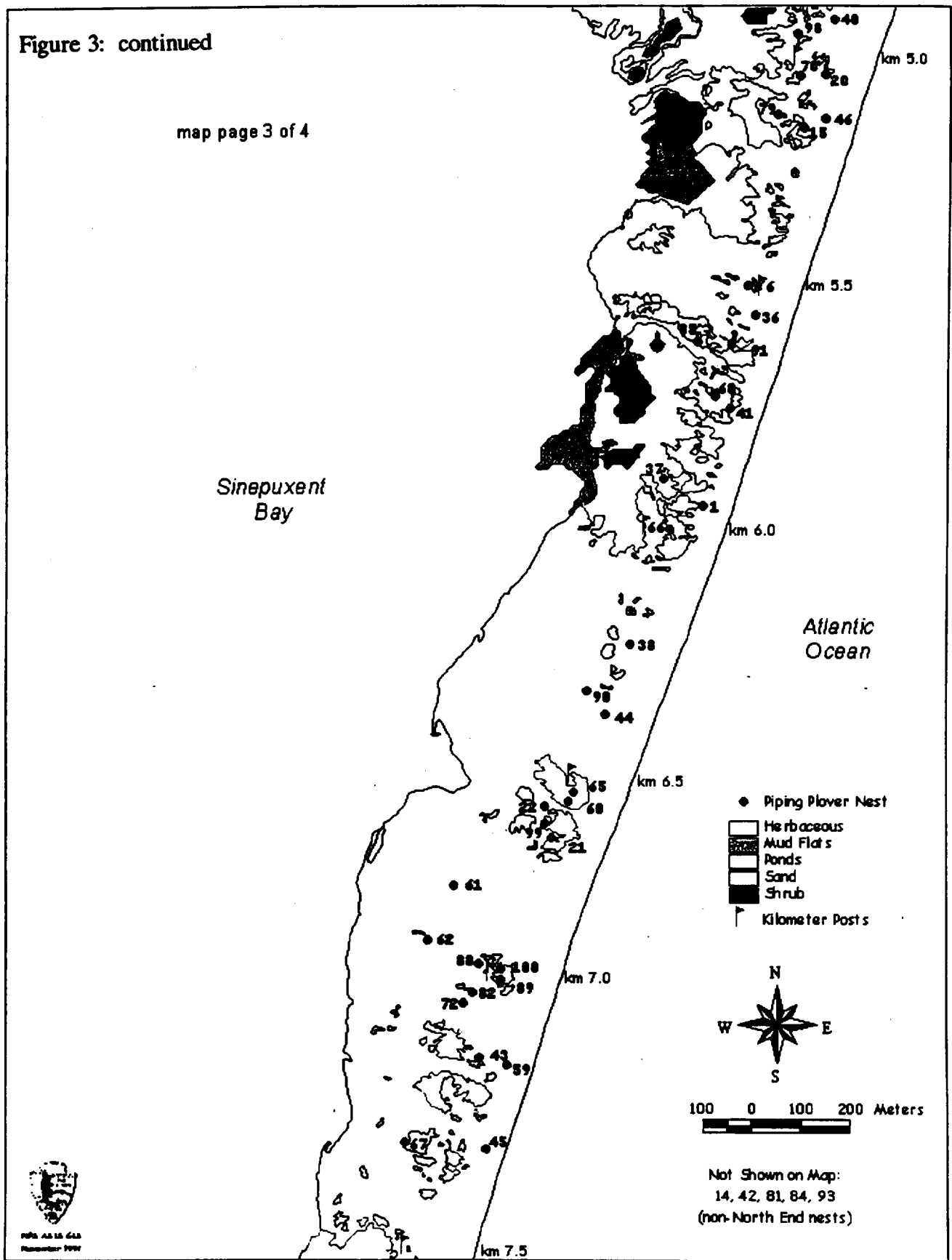
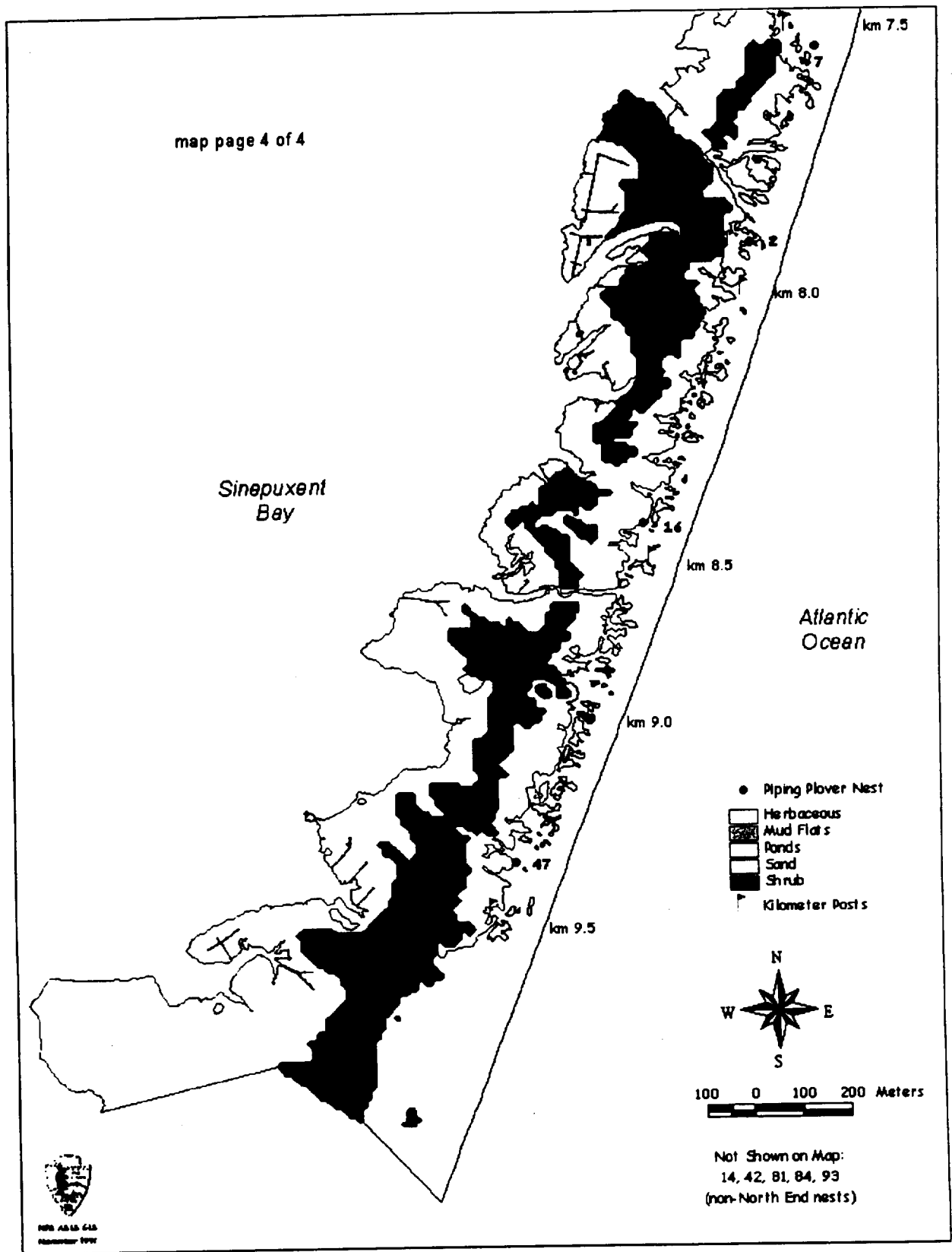


Figure 3: continued

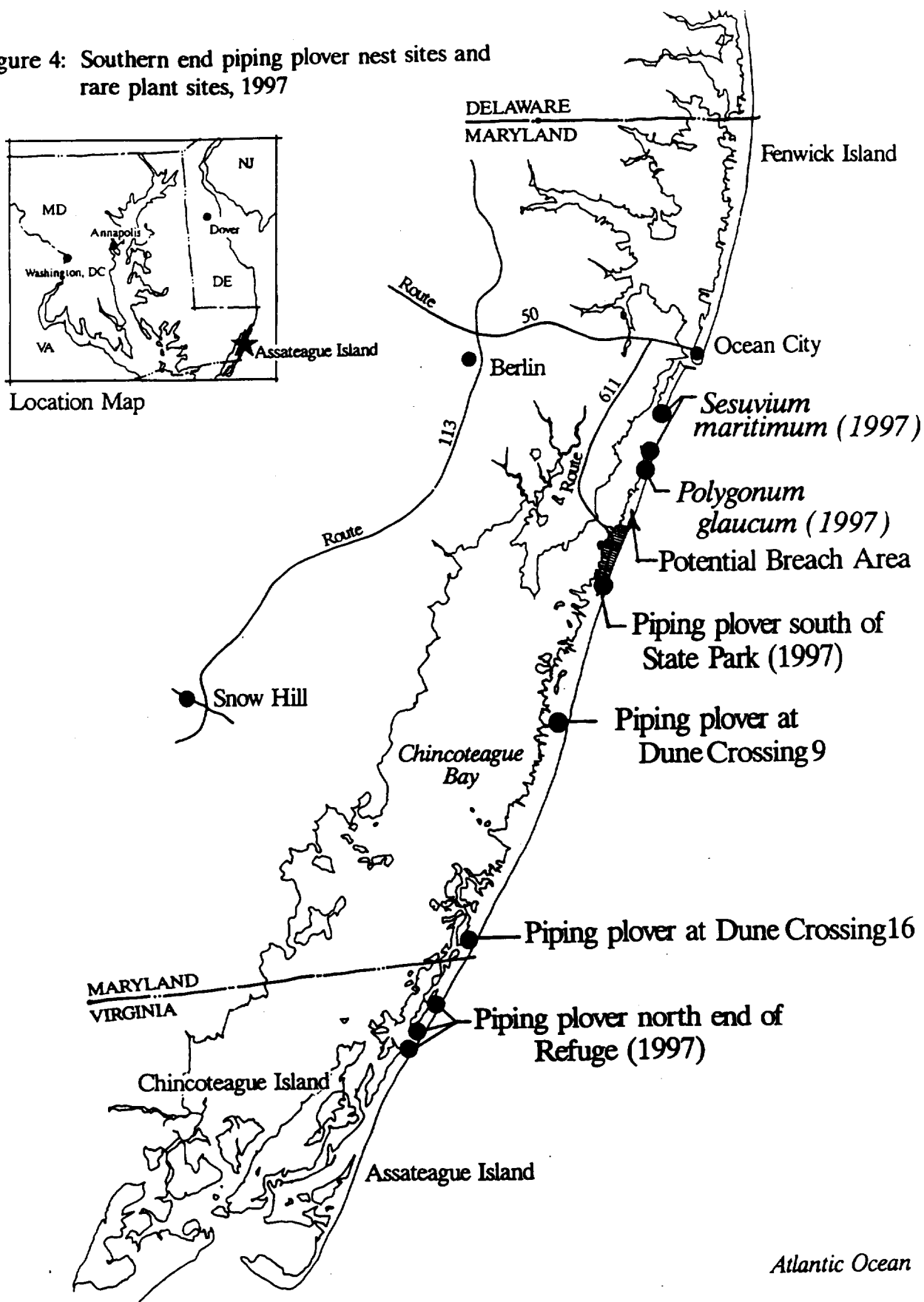


Between 1986 and 1997, piping plovers were occasionally observed engaged in courtship and pair bonding behaviors along the southern end of Assateague Island Seashore. Between 1994-97, nine nests were found south of the primary plover nesting area, including the first known record of nesting piping plovers just south (40 m) of the Assateague State Park boundary (Figure 4). The birds did not use the state park dune to access the ocean beach, rather appeared to do most of their foraging in a swale south of the state park (Carl Zimmerman, Pers. Comm., 1998). During 1996 and 1997, a nest was observed just south of dune crossing number nine. A male and female were observed in 1992 and a lone male in 1994, but breeding activity was not observed prior to 1996. A re-nest was also found in 1997 just north of dune crossing number nine. At another site north of dune crossing number sixteen, an area just north of the Maryland/Virginia state line, there has been active breeding from 1986-91 and from 1995-97 (Figure 4). A pair was located at the start of the 1992 and 1993 breeding seasons, but nests were not observed from 1992-94. During 1997, piping plovers nested at three locations within the most northern 6,000 meters of Virginia's Chincoteague National Wildlife Refuge for the first time since monitoring has been done (Figure 4). In most years, additional sightings of single piping plovers were observed at the southern end of the Seashore and the northern end of the Refuge but no territories were established.

On Assateague Island in Maryland, piping plovers typically nest in open sandy areas that are frequently mixed with shell and cobble and have little or no vegetation. During a three-year study on Assateague Island by Loegering (1992), 81 percent of 46 plover nests had no vegetation near the nest. Between 1992-95, 68 percent (98 of 145) of total nests occurred in open habitats without vegetation. During 1997, 80 percent (80 of 100) of total piping plover nests were located in predominantly unvegetated habitat types and averaged 20 meters from vegetated habitats. Twenty percent (20 of 100) of total piping plover nests were placed in herbaceous vegetated habitats and averaged 9 meters to unvegetated habitats (NPS Annual Reports 1992-97).

Piping plovers on Assateague rear their broods on the bay beach, in the island interior, and on the ocean beach (Loegering and Fraser 1995). In certain years, vegetation blocked access between nest sites and the bay side, causing chicks to be restricted to ocean side foraging. Survival rates of chicks raised on the ocean beach were found to be lower than those of chicks reared on the bay beach (Patterson *et al.* 1991). During 1988-90, chicks with access to the bay side had higher daily survival rates than those without access (Loegering and Fraser 1995). Further, they found that piping plover chicks that occupied bay beach and island interior habitats had higher daily survival rates than chicks in ocean beach habitat. For chicks less than 20 days old, foraging rates on ocean beach were lower than on bay beach and island interior habitats. Findings from this study on northern Assateague indicated that ocean beaches had fewer insects, chicks foraged at a lower rate along the ocean beach, chicks weighed less, and exhibited higher mortality than chicks elsewhere. Quality foraging habitats and access to them are critical to supporting healthy populations of piping plovers.

Figure 4: Southern end piping plover nest sites and rare plant sites, 1997



Overwash has played an important role in maintaining suitable piping plover habitat on Assateague Island. Overwash was defined by Leatherman (1988) as any swash uprush that crosses the dune line or, if no dunes are present, the storm berm. Storm overwash can occur in a variety of situations, including through narrow dune gaps, over wide sections of the barrier with low dune topography, or over an entire stretch of the barrier island. Depending on storm magnitude and island width, the flow of water may or may not carry sand to the barrier flats and/or marsh on the bayside. An overwash fan was defined by Elias-Gerken (1994) as a break in a continuous dune or vegetation line where storm tides carry sand from ocean side to bayside, often clearing a vegetation-free path from ocean to bay. Usually overwashes occur during coastal storms, but a marginal event can occur during extremely high spring tide conditions at lower elevation areas. On northern Assateague Island storm overwashes typically occur over wide sections of the barrier with low dune topography. During some storm events, overwashes have occurred over entire stretches of the island. The recent February 1998 northeaster overwashed much of the northern end and inundated approximately 1.5 miles (2.4 km) along a low lying section of island. During overwash, if scour of the barrier gets to an elevation below mean sea level, an inlet may be created (Leatherman 1988).

On the northern end of Assateague Island, overwash activity has played an important role in maintaining high quality piping plover nesting and brood rearing habitat by keeping vegetation sparse (Loefering and Fraser 1995). Depending on the island elevation, width, and wave energy, sediment can be laid on top of existing sand, or the overwash energy can scour the underlying sediment and lower the elevation, resulting in a new surface. In the recent storm (February 1998) along Assateague a section of the island has been lowered to the point where that portion is at risk of breaching. Wave and overwash activity has scoured the sediment down to the peat layer on much of the northern end. This area will most likely not be available to plovers for nesting during the 1998 breeding season due to its low elevation.

Overwash action has the potential to create or destroy favorable nesting habitats for piping plovers. If island elevations fall below a certain level where normal high tides are washing over nesting areas, piping plover nests may be lost and adults are likely to move elsewhere to higher ground for re-nesting. Although nests sites may be lost due to flooding, plovers will typically re-nest nearby, if habitat is available. Piping plovers will likely use the recently inundated section of Assateague Island (from February 1998 storm) for foraging. Although there is no known optimal proximity to foraging sites, piping plovers will often select nesting sites adjacent to foraging areas. Adult plovers have been known to fly across water to forage on islands. Further, adults have been known to travel 1-2 miles with broods to reach foraging sites, often with very high attendant chick mortality (Strauss 1990). Fledged chicks can and will move greater distances than young chicks, even splitting off from the brood.

It is likely that piping plovers historically relied on winter storm events to create and maintain suitable nesting and foraging habitats by scouring and covering up vegetation (Loefering 1992). Overall vegetation cover along the northern 8 km of Assateague Island between 1985 and 1997 underwent great changes in the distribution of the island's plant communities. In

just a two season vegetation sampling of plant communities, 1996-97, a change towards succeeding community types was statistically significant in a year with no big storms (Lea 1997).

Over the last eleven years, biologists have witnessed piping plovers responding to a wide range of habitats driven by a cycle of events that becomes a repeating process. These responses of plovers have provided us with some insight as to how piping plovers might be affected by the long-term project if the island is restored to its pre-jetty condition.

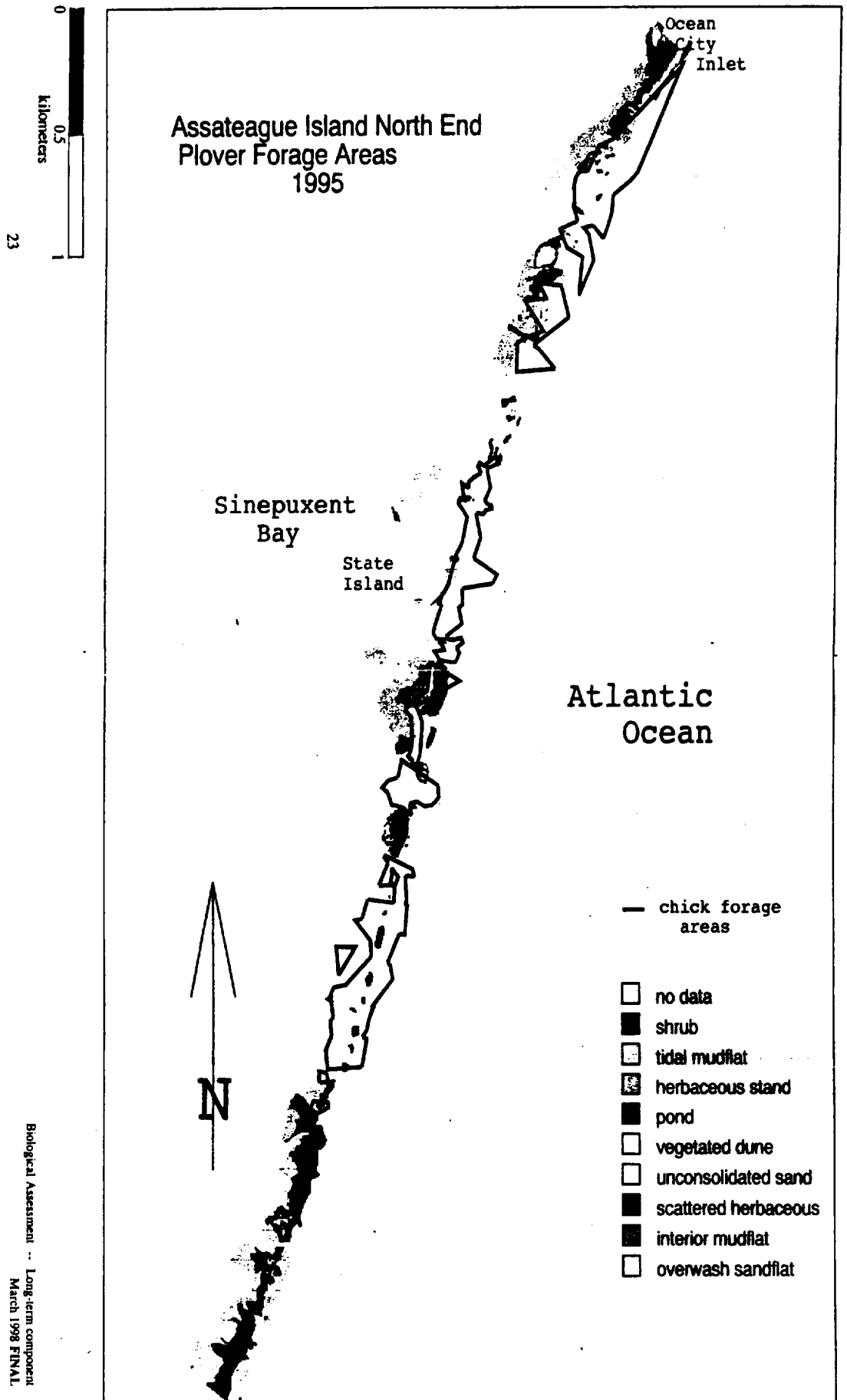
During Loegering's study, from 1988-90, there were no cross-island overwashing storm events and dramatic vegetative succession occurred within two years (Loegering, Pers. Comm. 1996). Loegering believed that the lack of overwash activity resulted in vegetation encroachment, which reduced foraging opportunities for plovers and was a major factor in the decline of reproductive success on northern Assateague Island during those three years. During this time, plover broods restricted to the ocean beach by either dunes or vegetation had adequate nest success but nearly all chicks died. A relationship between the presence of overwash corridors and piping plover productivity was documented during this study (Loegering and Fraser 1995). Loegering also predicted that a piping plover population increase would follow major storm events because habitats supporting suitable sites for nesting would increase.

Following the January 1992 storm, much of the northern portion of Assateague Island experienced cross-island overwash that scoured or covered vegetation. Large expanses of vegetation-free areas were created, increasing the areas available for nesting and improving access to the bay side for foraging chicks. Data collected between 1992-95 also showed a preference for interior and bay habitats by chicks. During these four years, 91 percent (1,621 of 1,775) of all chick observations along the northern 8 km of the island were chicks using interior and bayside habitats and 9 percent (154 of 1,775) were chicks using ocean beach habitats (NPS reports 1992-95).

Based on a visual examination of aerial photographs between 1992 and 1997, it appears that there has been very little change in the amount of overall vegetation and sand cover, but there actually has been a gradual change in extent of dunes and swale vegetation. The shift has been documented in NPS vegetation studies for the past two years (Lea 1997). Without major storms, portions of the island may experience rapid invasions of opportunistic vegetation. Currently, large areas of open sand with low-lying dunes remain and areas that allow cross-island overwash are common. Nesting and foraging habitats have been favorable to piping plovers during the last five years.

In 1996 and 1997, the piping plover population increased to 61 and 60 breeding pairs, respectively, the highest number of pairs since monitoring began eleven years ago (Kumer *et al.* 1997). Much of the open sand areas within the northern 8 km has been used by piping plovers for nesting and/or foraging over the years (Figure 5). One of the two areas considered in this project as vulnerable to breaching consists of a large, mostly flat and unvegetated

Figure 5: Piping plover brood foraging territories, 1995



overwash area (now inundated by February 1998 northeaster). This low-lying area supported the highest concentrations of nesting plovers during 1995-97. "Clumping" of piping plover nest sites in an open, largely unvegetated area is typical behavior when there are a large number of breeding pairs and most of the available habitat is being used. However, reproductive success was lower in this area compared to other areas during 1995 and 1996, potentially due to exposure to predators and weather because vegetation was completely lacking (Brady *et al.* 1995, Kumer *et al.* 1997). For the 1998 breeding season, the area between 6.5 and 7 km markers may not be available to piping plovers for nesting due to the inundation from overwash.

#### **2.1.1 Evaluation of probable historic (pre-jetty) habitat suitability of northern and southern Assateague Island for piping plovers**

Although piping plovers have historically nested along Atlantic Coast beaches from North Carolina to the Atlantic Provinces of Canada (Bent 1929), there has been little published information available prior to 1980. Historical population trends for piping plovers have been reconstructed from scattered, largely qualitative records. Nineteenth-century naturalists, such as Audubon and Wilson, described the piping plover as a common summer resident along Atlantic Coast beaches (Haig and Oring 1987). By the beginning of the 20th century uncontrolled hunting and egg collecting had greatly reduced the population, and in some areas along the Atlantic coast the piping plover was close to extirpation (USFWS 1996a). Following passage of the Migratory Bird Treaty Act in 1918 along with fashion industry changes, piping plover populations began to recover (Haig and Oring 1985).

Prior to the 1980's, even fewer historical records are known for piping plovers on Assateague Island, Maryland. However, given what we know about the topographical and geomorphological character of this section of the Delmarva peninsula since the early 1900's, it is highly likely that piping plovers have long used this barrier system for nesting, foraging, and migratory stopovers. Assateague Island's morphology was described by Shreve (1910) as a series of low and comparatively stable dunes that were discontinuous along the ocean side. He also mentions the presence of low shrub thickets and other low vegetation along the lee side of a continuous dunefield, including American beach grass as being the predominant dune plant. These habitat characteristics are certainly within the range of suitable habitat types for nesting piping plovers.

Although populations of piping plovers most likely nested on what was historically called Fenwick Spit, which included Ocean City and Assateague Island, there are no known records of piping plover observations prior to 1935. Worcester County records indicate an observation of one downy chick on June 16, 1935 (Tyrrell 1935). Between the mid 1930's and 1986, when intensive monitoring of piping plovers began on Assateague Island, there are 91 records of piping plover observations in Maryland (M. L. Hoffman, unpublished report). Although the majority of observations were during the breeding season, some were during the winter months. Further, a few observations occurred outside of Assateague Island, including

north of Ocean City, mud flats under the Ocean City bridge, dredged piles in W. Ocean City, and Pocomoke Swamp. One of the more striking records is a count of 138 piping plovers on May 5, 1973 (Maryland Birdlife 29:39-51). These historical data also indicate year to year fluctuations of piping plovers along coastal Maryland.

Based on historic literature and photographs, the northern portion of Assateague Island has maintained erosional and retreating characteristics. However, since the 1933 inlet formation and stabilization efforts, erosion rates have significantly increased due to the jetty-induced interruption of sand. This has resulted in a sediment starved island that has lost much of its natural character, including a reduced ability to recover from major storms.

Due to the dynamics of a barrier system, it is likely that Assateague Island has experienced fluctuations of piping plover numbers as major storms washed over the island, scouring or covering vegetation, and resulting in significant habitat changes. In years where data was available prior to the 1933 stabilization of the Ocean City inlet, Assateague Island supported habitats that fall within the range of nesting and foraging habitats for piping plovers. Based on early accounts and photographs, it appears that in some years there was more shrub and woody vegetation along the northern end, but the northern portion of the island continued to maintain a somewhat low, open topography with various amounts of vegetative cover. The amount and type of vegetation likely changed depending on frequency, duration, and intensity of storms. Following long periods of time that lacked heavy storm activity, smaller amounts of piping plovers habitat was likely available for nesting. There is no evidence that suggests that the northern portion of the island did not support habitats that would be suitable to piping plovers for nesting and foraging. Numbers of piping plovers likely vacillated greatly depending on storm activity.

In the last decade, significant habitat changes have been observed and correlated with piping plover biology. Between 1985-91, data showed a steady increase in vegetation invasion along much of northern Assateague Island (Patterson 1988, Loegering 1992) due to the lack of overwash activity. Nearly all overwash corridors that piping plover chicks used to access bayside feeding areas were eventually blocked with vegetation. Numbers of breeding pairs and reproductive success declined dramatically. The 1991/92 storms resulted in major physical changes to this area. Vegetation was scoured resulting in open, very sparsely vegetated habitats along the majority of northern Assateague Island. Between 1992 to present, there has been a steady decline in vegetation cover. Piping plovers have responded accordingly, with numbers increasing to record highs. However, due to the sand budget deficit, data suggests that piping plovers may begin to experience declines due to too much overwash and inundation of habitats resulting in unsuitable nesting habitats.

Other studies have also shown relationships between storm-related habitat changes and fluctuations of piping plovers numbers. Following the 1938 hurricane, Raithel (1984) showed that Rhode Island piping plover numbers reached a 20th-century peak when dunes were flattened and shoreline developments were destroyed. Following World War II, beach habitat was lost to dune stabilization and summer home construction and piping plovers numbers

declined. Piping plovers partially recovered following another severe hurricane in 1954 before beginning a steady decline which continued through the early 1980's.

Wilcox (1959) conducted a 20 year study along Long Island, New York, documenting major fluctuations in piping plover numbers, which he correlated with habitat changes. Number of breeding pairs tripled from before the 1938 hurricane to 1941, attesting to the piping plover's ability to rapidly colonize newly available habitat. As habitat was lost to dune stabilization, summer homes, and road construction, the population declined.

Historically, the southern portion of Assateague Island has been wider, more vegetated, and more stable than the northern end. The presence of an artificial dune helped further to stabilize this portion of the island. However, since the early 1970's there has not been any systematic dune building or stabilization efforts with the exception of approximately a two mile Park section that is zoned as a development area. The artificial dune remained mostly intact until the 1991 and 1992 major storms when the dune was essentially eliminated as a significant beach feature. Since then, much of the southern end has experienced significant overwash several times per year, reverting to more natural conditions, including overwash, blowout, and interior habitats. Due to the greater width of this portion of the island, the overwash activity has not yet resulted in corridors extending entirely to the bayside. With the exception of potential effects of off-road vehicle activity, no human influences are scheduled that would impede the natural coastal processes from allowing this portion of the island to evolve naturally and exhibit the full range of natural habitat characteristics of Assateague Island.

Since plover monitoring began in 1986, much less plover nesting activity has occurred along the southern end compared to the northern end of the island. Periodic courtship and nesting activity has been recorded primarily around areas that are more open and contain sparsely vegetated low-lying habitats along the foredune and interior habitats. Since 1992, suitable nesting habitats for plovers have greatly increased with a concurrent increase in nesting activity in these areas. It is likely that without human perturbations that the amount of suitable nesting habitat for plovers will continue to increase along portions of the southern end. However, the abundance and quality of foraging habitat is not known for these areas, which is as important as suitable nesting habitats for piping plovers.

## 2.2 Seabeach amaranth

Seabeach amaranth (*Amaranthus pumilus*) historically occurred along Atlantic coast barrier island beaches in nine states from Massachusetts to South Carolina. Seabeach amaranth was federally-listed as threatened by the USFWS in 1993 due to its vulnerability to threats and its extirpation from two-thirds of its historic range (USFWS 1993). This species has been eliminated from six of these States, including Maryland, at 41 sites due primarily to habitat alteration, shoreline stabilization, storm-related erosion, heavy off-road vehicle use and herbivory. By 1990, only 55 populations were known to occur, which included 34 in North Carolina, 8 in South Carolina, and 13 in New York (USFWS 1996b). Proposed recovery objectives outlined in the *Recovery Plan for Seabeach Amaranth* calls for re-establishment of the species in at least six of the nine states in its historic range (USFWS 1996b).

Habitat requirements for seabeach amaranth are similar to those of piping plovers. Just like plovers, habitats are maintained by overwash actions which prevent establishment of competing vegetation. Seabeach amaranth appears to be intolerant of competition and does not survive on well-vegetated beaches. This species is a pioneer, or fugitive, on dynamic barrier island habitats. The plant is also intolerant of storm tides during the early growing season which causes mortality of nearly all plants. This mortality does not necessarily result in population extirpation, but does reduce seed production, especially if the disturbance occurs during the growing season. For example, in 1989 Hurricane Hugo ended the amaranth season from Cape Fear south. However, amaranth populations that had been absent for several decades, reappeared in New York following Hurricane Hugo (USFWS 1996b).

Although they may be killed by summer inundation, it seems that amaranth requires winter overwash to keep its habitat open. Primary habitats consist of overwash flats at accreting ends of islands, lower foredunes, and upper strands of ocean beaches (USFWS 1996b). Seabeach amaranth can be found in small populations in other habitats including bayside beaches, dune blowouts, or on sand and shell dredge material. No vascular plant occurs at a lower topographic position on beaches than seabeach amaranth, though other annuals like saltwort (*Salsola australis*), sea rocket (*Cakile edentula*), and some grasses can occur with amaranth. Many of these species are salt-tolerant and have life-histories that allow them to invade suitable habitat when it becomes available. Seabeach amaranth typically occupies elevations from 0.2 to 1.5 meters (8 inches to 5 feet) above mean high tide and is usually found growing on nearly pure silica sand substrates, occasionally with a few shell fragments mixed in.

Seabeach amaranth is likely wind pollinated and its seeds are dispersed by wind and water. There is possible requirement for seabeach amaranth to have an obstacle for trapping seeds (i.e. lower elevation, lee side of dune) or they are easily blown across the flat beach. Some proportion of the seeds are probably blown into the water. Germination takes place over a relatively long period of time, generally from April to July (USFWS 1996b). Flowering can occur as early as June, but typically begins in July, and continues until the death of the plant in late fall. Seed production begins in late summer and continues until the death of the plant. Seeds are regularly produced by nearly all adult plants and fertility is assumed to be high.

Under favorable conditions (without extreme weather events or webworm predation), the reproductive season may extend until January, or sometimes later in the south (Weakley and Bucher 1992). Presence of plants in any given year is evidence of reproduction in the former year, or even earlier reproduction and seed-banking.

Seed dispersal is one of the most important characteristics of the biology of an annual plant such as seabeach amaranth. Lincoln *et al.* (1982) describe this species as a classic example of a fugitive species -- "...an inferior competitor which is always excluded locally under inter-specific competition, but which persists in newly disturbed habitats by virtue of its high dispersal ability: a species of temporary habitats."

Seeds may remain viable after decades of being buried when exposed as a result of overwash and breach events. The instability of the sand makes the adaptation to wait out better conditions a good long term survival strategy, but this is based on observations alone and very speculative (Bill Adams, Pers. Comm. 1997). There has not been much research done on the seed bank for seabeach amaranth. However, Ehrenfeld (1990) states that seed-banking in dune soils is not likely due to the instability of the soil. Continual disturbance through deposition and erosion could either bury seeds too deeply for emergence or remove them entirely. The effect of storms uncovering sand layers need to be investigated (USFWS 1996b). It is not known if the re-occurrence in New York was caused by the exposure of the seed bank or if storm currents and surf brought up seeds from North Carolina populations.

The regular, annual disturbance accomplished by USACE sand bypassing projects at North Carolina sites may encourage survival of seabeach amaranth populations. The site is annually replenished with new sand, keeping the habitat disturbed and open during the winter, which retains favorable conditions for amaranth. Strong populations are noted in areas of bypassing projects (Bill Adams, Pers. Comm. 1997).

In Maryland, seabeach amaranth was last reported during botanical surveys on Assateague Island in 1967 (Higgins *et al.* 1971) (Figure 4). This was the only recorded occurrence of seabeach amaranth and it was on the southern end of ASIS at a former inlet area known as Green Run Inlet. Hill (1986) returned to the reported location in 1984, but after extensive searches did not find it. The Maryland Natural Heritage Program conducted intensive searches in 1991, 1992, and 1993 and did not locate it (Bartgis 1994).

Although there is currently no proposal to reintroduce seabeach amaranth to Assateague Island, this report outlines considerations to take into account in the event that reintroduction efforts are initiated.

### 2.2.1 Evaluation of probable historic habitat suitability of northern and southern Assateague Island for seabeach amaranth

From a review of historic photos, aerial photographs and series of shoreline changes, overwash-maintained habitat has occurred over many years on northern Assateague Island. This overwash activity prevented establishment of woody vegetation and perennial dominance in the overwash corridors. Although seabeach amaranth requires primarily unvegetated habitats, it is intolerant of any flooding during its growing season, especially between May and November. Complete mortality from high tides was recorded in North Carolina and New York populations. Seabeach amaranth requires extensive areas of barrier beaches and inlets, functioning in a relatively natural and dynamic manner. This allows populations to move around in the landscape to occupy suitable habitat as it becomes available.

Responses of seabeach amaranth to different situations on Assateague Island could perhaps be predicted by its behavior in nearby areas, like North Carolina and New York. The near absence of seabeach amaranth in northern North Carolina corresponds closely with the artificial construction of a continuous barrier dune and high erosion (USFWS 1996b). There are fewer and more scattered plants occurring on beaches that are east-facing and receive greater wave energy and higher erosion processes (USFWS 1996b). When comparing areas that represent artificial and natural states of barrier islands in North Carolina, the most striking contrast is a large difference in beach width. The unaltered islands, which are more likely to have seabeach amaranth, have much wider beaches than the stabilized ones. Many physical factors are similar on North Carolina to Maryland (e.g., tidal range, history of constructed dunes), however, differences include the presence of the Gulf Stream in close proximity to the North Carolina coast south of about Cape Lookout and the lower erosion factor. Comparisons related to seabeach amaranth are limited to the response of the plant to altered conditions. Seabeach amaranth was not seen after a series of dune maintenance projects on the southern end of Assateague in the late 1960's.

Seabeach amaranth is typically found along less eroded south and southeast facing shorelines throughout its range (Dolan & Lins 1987). Therefore, directly east-facing shorelines of Assateague may be subject to erosional processes and wave energy too extreme to support populations of seabeach amaranth. Rather, the more important Assateague Island habitats may be the low sand spits or washover edge types. These habitats occur on both the northern and southern ends of ASIS. The southern end habitats are perhaps "safer sites" with more protection from flooding.

The Nature Conservancy (TNC) classifies the habitat community association suited for seabeach amaranth as *Cakile edentula-Salsola kali* herbaceous vegetation community (Sneddon & Berdine 1995). Lea (1997) further refines the community to a specific subset he found on Assateague Island during vegetation sampling: a *Scirpus pungens-Spartina patens* (wispy form) community association where he has located the seabeach smartweed (*Polygonum glaucum*). This community was found in greater proportion on the northern end compared to the southern end in 1996-97.

Seabeach amaranth can be found in beach habitats that may also support other state rare vascular plant species. Some of these other species, including seaside knotweed (*Polygonum glaucum*) (Ranked as "very rare throughout its range and highly rare in Maryland"), seabeach purslane, (*Sesuvium maritimum*) (Ranked as "demonstrably secure globally and highly rare in Maryland") occur on ASIS (Maryland Department of Natural Resources 1994). Their distribution may be useful in determining habitat suitability for seabeach amaranth. Seaside knotweed was found in a 1984 survey (Hill 1986) on the northern end of Assateague Island in two places, between the parking lot and coastal dunes off the end of paved portion of Route 611, and near north beach and a small number of plants on the north end of the state park. In 1992, a single plant of seaside knotweed was found on the ocean berm adjacent to a dune crossing within the OSV zone on the southern end. Seaside knotweed was not found again until 1997, when it was very abundant in a sheltered site near the old McCabe House site on the northern end (Figure 4). Rare plants occur in areas where they are afforded some protection from directly being killed by overwash processes, off-road vehicles and grazing.

Due to a lowering elevation and degradation of the old constructed dunes on the southern end since the 1991-92 series of storms and the most recent 1998 storm there are suitable habitats that would support seabeach amaranth populations. The southern end contains substantial openings in the former dune line and substantial interior habitats that are kept open by overwash. These would be suitable locations for seabeach amaranth reintroductions. The southern end may receive less flooding (especially during the growing season) than the northern end and be a more protected site for seabeach amaranth.

Although overwash habitats are currently available on a substantial portion northern Assateague Island at a few locations, an increase in overwash activity may actually reduce the suitability for seabeach amaranth. Many pioneer plants, like seabeach amaranth, grow on the edges of overwash and high tide lines, along the slightly elevated banks but not in the active wash zone itself. Results of the February 1998 storm demonstrate the limiting factors of overwash activity. A large section of the northern end is inundated and sand is lost. The storm also leveled that portion of the island to such a low elevation that it has become unsuitable for seabeach amaranth, because of its intolerance to flooding. Although there may be some favorable re-introduction sites on the northern end, much of the habitat is currently lost from the 1998 storm.

Without the reintroduction of seabeach amaranth in Maryland, it is unlikely that the recovery objective will be met to establish populations in six of the nine states where it historically occurred. ASIS is a suitable site for reintroduction due to its large size, favorable NPS management and restoration intents, NPS willingness to manage seabeach amaranth, and natural physical processes that maintain the necessary dynamic habitats.

The slight possibility that seabeach amaranth will spontaneously re-appear on Assateague Island following a storm event or the repositioning of buried substrates should be stated here. Seabeach amaranth re-appeared in New York in 1990 after many years of absence (USFWS 1996b). Although the chances of a finding it are very slim, NPS surveys continue each growing season (C. Lea, Pers. comm. 1997).

## **2.3 Review of island characteristics and changes**

Assateague Island can be characterized as a naturally low-lying, narrow barrier island with a history of human manipulations that has left its influence for decades. The history of the island reveals ongoing dynamics of shifting sands, washover fans, opened and closed inlets, an accelerated and a landward retreat of entire island. High storm surges have been a dominant force to re-configure the barrier island, change the size and shape of dune formations, and drive island ecological processes.

Due to changing coastal dynamics and past impacts by Ocean City jetties to the coastal bays and natural movement of sand along the Atlantic coast, the geomorphology of Assateague Island has been influenced. Numerous shoals occur off shore due to the interrupted flow of sand and the stability of the island is threatened. Assateague Island has been characterized as a barrier island of diminished function (USACE 1997b).

### **2.3.1 Historical (pre-1933; pre-jetty) conditions**

Prior to 1933, what is currently known as northern Assateague Island was called Assateague Spit. Although Ocean City and Assateague Island were a part of Fenwick Island spit, Assateague Island was considered distinct from Fenwick Island. However, neither were actually islands and were instead extensions of the Bethany Beach, Delaware headland (Underwood and Hiland 1995). A 1686 account of the area described Assateague as, "A certain Isthmus or Peninsula of marsh and Piney Hummocks called Asseateague [*sic*] Island..." and a 1700 reference called Assateague an "island with some trees on it near oyster creek" (Bearss 1968).

In 1837, Ducatel described the barrier island feature of Assateague as "that part of Maryland which lies on the Atlantic Ocean...the main land of which is separated and protected from surf, by a sand beach, at present, extending unbroken the whole length of the Maryland sea-coast... the inlets of the ocean have become obstructed."

From the earliest colonial days the island was used to graze horses, sheep, goats, hogs and cattle (Perkins 1928). The losses of cows were great since the winters were difficult, but the secure island made it a very popular place for communal grazing lands. Farmers imported horses to Assateague beginning in the mid-1600's to avoid tax payments and grazing limits on the mainland. Over the centuries feral horses became naturalized to the island. Known as Assateague ponies, the feral horses are maintained and managed by the National Seashore as a regionally significant tourist attraction. Overpopulation of Assateague ponies has led to concern over damage to native plant populations and limits have been placed on herd sizes. As early as 1649 to 1669 horses became so crowded on the island, farmers were prohibited from bringing more ashore. Currently, there are approximately 160 ponies roaming the Maryland portion of Assateague Island. The NPS utilizes contraceptive injections and monitors the effect of grazing on barrier beach ecology.

Shreve *et al.* (1910) described the island's morphology as a series of low and comparatively stable dunes that were discontinuous along the ocean side. The predominant plant along the dunes was American beach grass (*Ammophila breviligulata*). Shreve described a small grove of loblolly pines (*Pinus taeda*) near Fenwick Light, at the extreme northern end of the sand bar, as being the only trees on the island's northern end, suggesting that maritime forest was absent. There was also indication of low shrub thickets and other low vegetation along the lee side of a continuous dunefield (Shreve *et al.* 1910).

From historic references in the literature and old photographs the general nature of the pre-jetty Assateague island can be interpreted, although most photographs were taken to document the effects of big storms. We found that photo collections (including aerial photos taken by NPS) are biased towards the periods following major 'destructive' events and tend to show breaches, blowouts, and new inlet formations.

A few photographs document the typical beach landscape prior to the Ocean City jetty construction (Figures 6.1, 6.2, 7.1, 7.2 and Figures 1.1, 1.2, 2 in Annex). A *ca.* 1930 photograph (Figure 6.1) of a dune crossing for off-road vehicles and cabins in the background is probably taken south of the current state park on Assateague Island. Telephone poles are seen in the distance, which are still present along the southern end of Assateague. The photo shows a gentle sloping beach and position of the ocean berm. Very sparse, scattered American beach grass and evidence of sculpted berm are seen. The American beach grass is not growing in thick mats as it does on planted dune situations.

A *ca.* 1930 photograph (Figure 6.2) illustrates Assateague during the summer with a wide open beach and the North Beach life saving station in the background. American beach grass appears sparse and patchy and growing on low dunes. A treeline across the bay on the mainland can be seen in the background. The dunes appear sculpted and occur as mounds and swales with variable elevation. The general beach topography appears low and flat with a patchy dune system marked by wind and overwash. For the most part the beach appears flat. This photograph epitomizes the pre-jetty condition of Assateague Island at this period in history.

Two of the earliest landscape photos reviewed were published in 1910 (Shreve *et al.* 1910) and show a low dune with scattered American beachgrass and an example of island interior shrub thickets (Figures 7.1 and 7.2).

An aerial photo of Ocean City (*ca.* 1928) shows an open sand beach with some shrubby patches in an area that would eventually become the Ocean City inlet (Figure 8). Parallel structures, probably seawalls (appear to be constructed of wood), are seen in the photo. The area appears to have active overwash beyond the seawalls and only low vegetation growth is seen.

Figure 6.1: *ca.* 1930 Dune crossing and cabins, near northern end of Assateague Island.

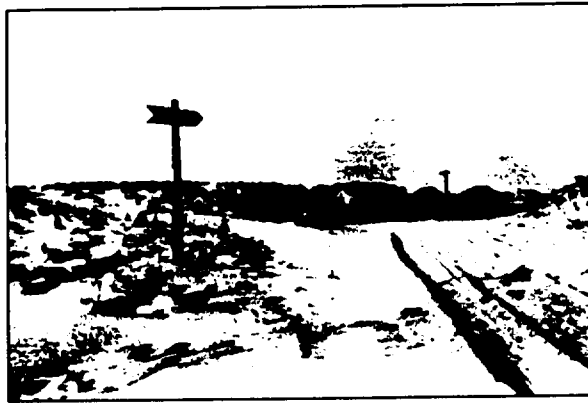


Figure 6.2: *ca.* 1930 General beach condition with "North Beach" cabins and lifesaving station in background.

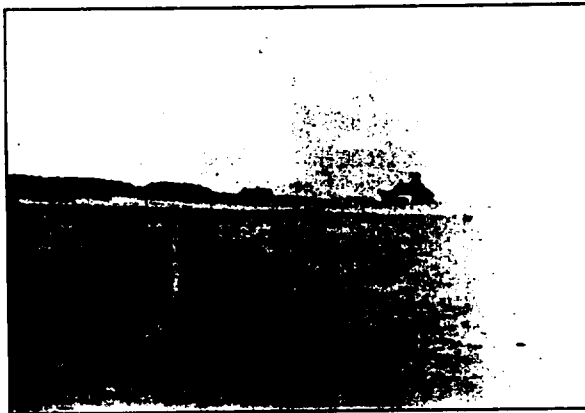
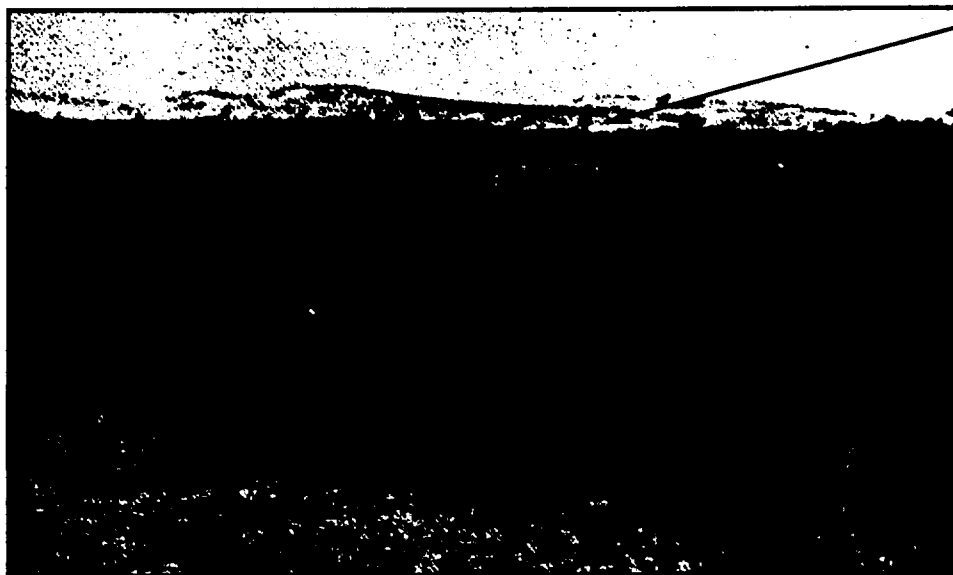


Figure 7.1: View showing a small sand dune near Ocean City, Worcester County,  
from Shreve *et al.*, 1910

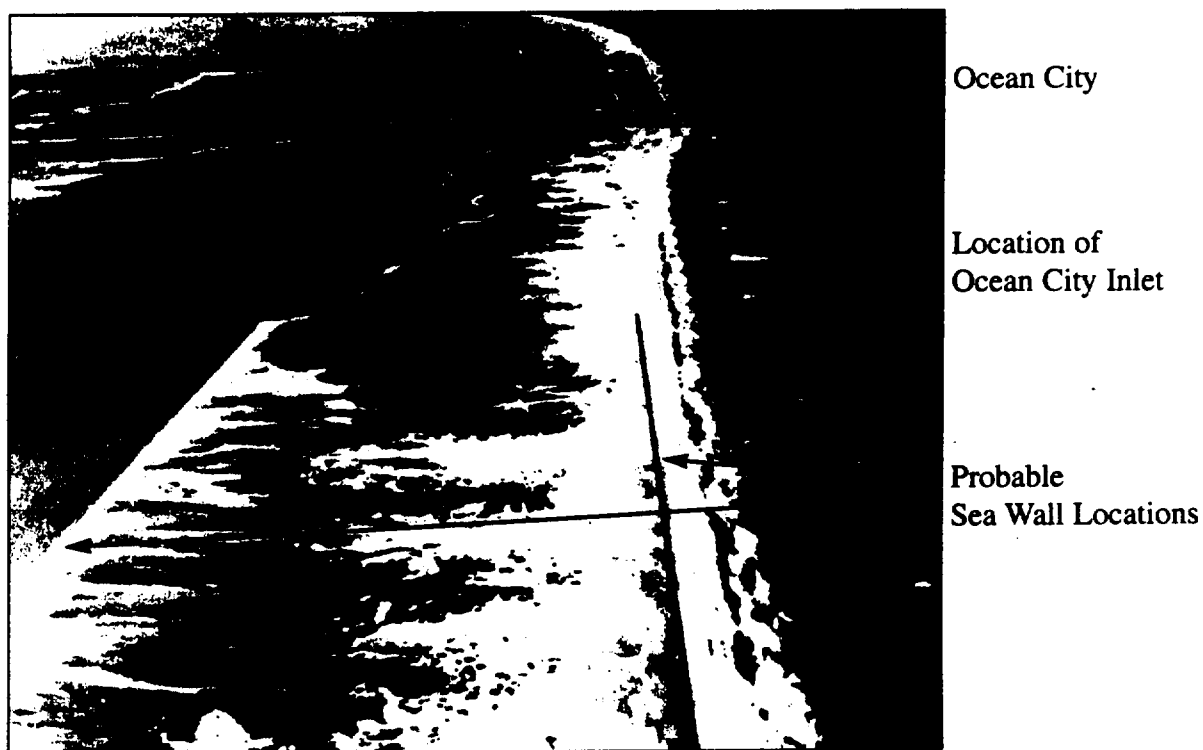


Figure 7.2: View showing the sand dunes along the Atlantic, near Ocean City, Worcester County,  
from Shreve *et al.*, 1910



Note Scale  
Figure

Figure 8: *ca.* 1928 Northern Assateague Island, view to the north, showing location of inlet area.



Before 1933, inlets were mapped and sometimes large enough to navigate (Bearss 1968). The opening and closing of inlets across the island have been recorded and their traces are discernible in aerial photographs. Green run inlet, located four miles north of the Virginia line, was formed in 1855 and closed over 30 years later (McLaughlin 1992). This area remains susceptible to overwash activity because of its low elevation position. Sinepuxent inlet, approximately 3 miles south of the Ocean City Inlet, was another important navigational outlet shown on an 1800 map and was also open most recently in 1920 (Annex Figure 3). Sinepuxent Inlet closed naturally during 1928 (Underwood and Hiland 1995).

From 1875 to early 1900's there were lifesaving stations positioned on the southern end of Assateague Island at 'Green Run', 'Pope Island' and 'Assateague Beach' and near the current State Park at 'North Beach' (Figure 9). Small communities of fishermen and lumbermen were built in the 1800's at Green Run and south on the Virginia portion of the island. Effects of lumbering loblolly pine on the island have not been determined. Lumbering and grazing activity may have contributed to the formation of blowouts by reducing vegetation, resulting in later inlet formation (Higgins *et al.* 1971) There may have been more extensive loblolly pine forests in the eighteenth century before human habitation.

During 1849-50, island widths ranged from about 235 m to 527 m (770-1730 ft) (USACE 1994) and northern Assateague Island was thought to be migrating landward at the rate of approximately 2 m/yr. (Underwood and Hiland 1995) (Figure 10). During this time, an equilibrium existed between sand erosion and deposition due to a somewhat balanced sand budget. Sand lost during oceanside erosion processes was compensated for by sand deposition, resulting in a relatively balanced sand budget (USACE 1997c).

Assateague island was used for grazing and hunting until 1930 when the island's recreational potential grew. Summer cottages and hunting cabins increased during the late 1920's and 1930's as the appeal of an accessible, yet remote, recreational hunting and clamming area became popular with mainland residents. The area this report refers to as the southern end of the island was used far more for cabins and hunting, while the northern end was used more for bayside clamming and grazing areas. Upland plants and salt marsh were both grazed, and there are accounts that American beachgrass and salt hay were preferred by domestic animals.

The evidence of exactly how Assateague Island looked pre-1933 is limited. Many photo collections were reviewed and little usable material was located. Most photographs showed an open, sparsely vegetated barrier beach. There were perhaps certain periods and years that did not have storms where upland growth was more extensive. However, we did not find any photographs or evidence of this habitat. Additional historical photographs and descriptions are found in the Annex of this report.

In summary, from the review of historic information the known ranges of habitats on northern Assateague Island before 1933 were not much different than they are now. The storm-influenced ranges of habitat types have been similar in the last 60 years or so.

Figure 9: Historic features on Assateague Island, Maryland

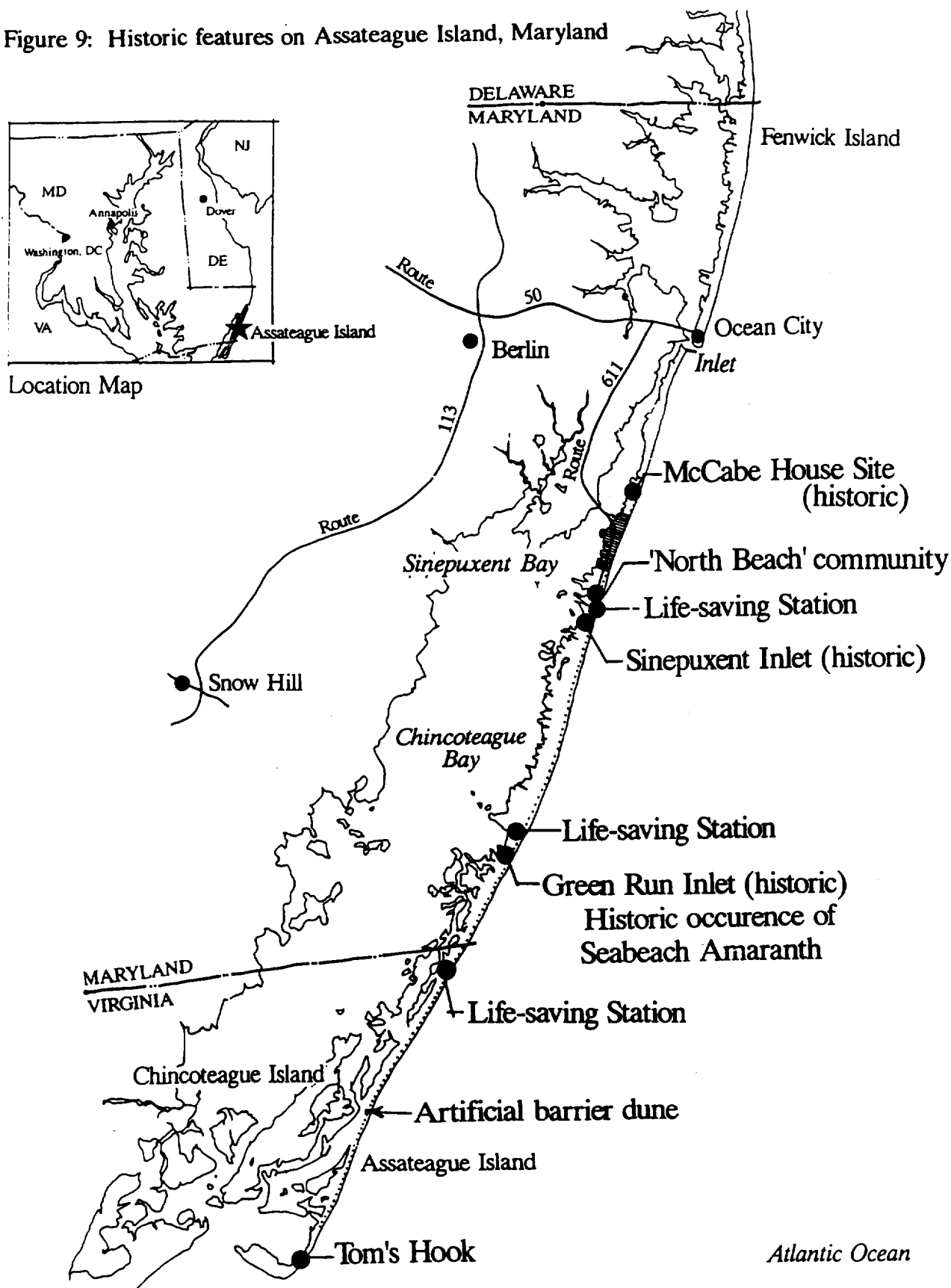
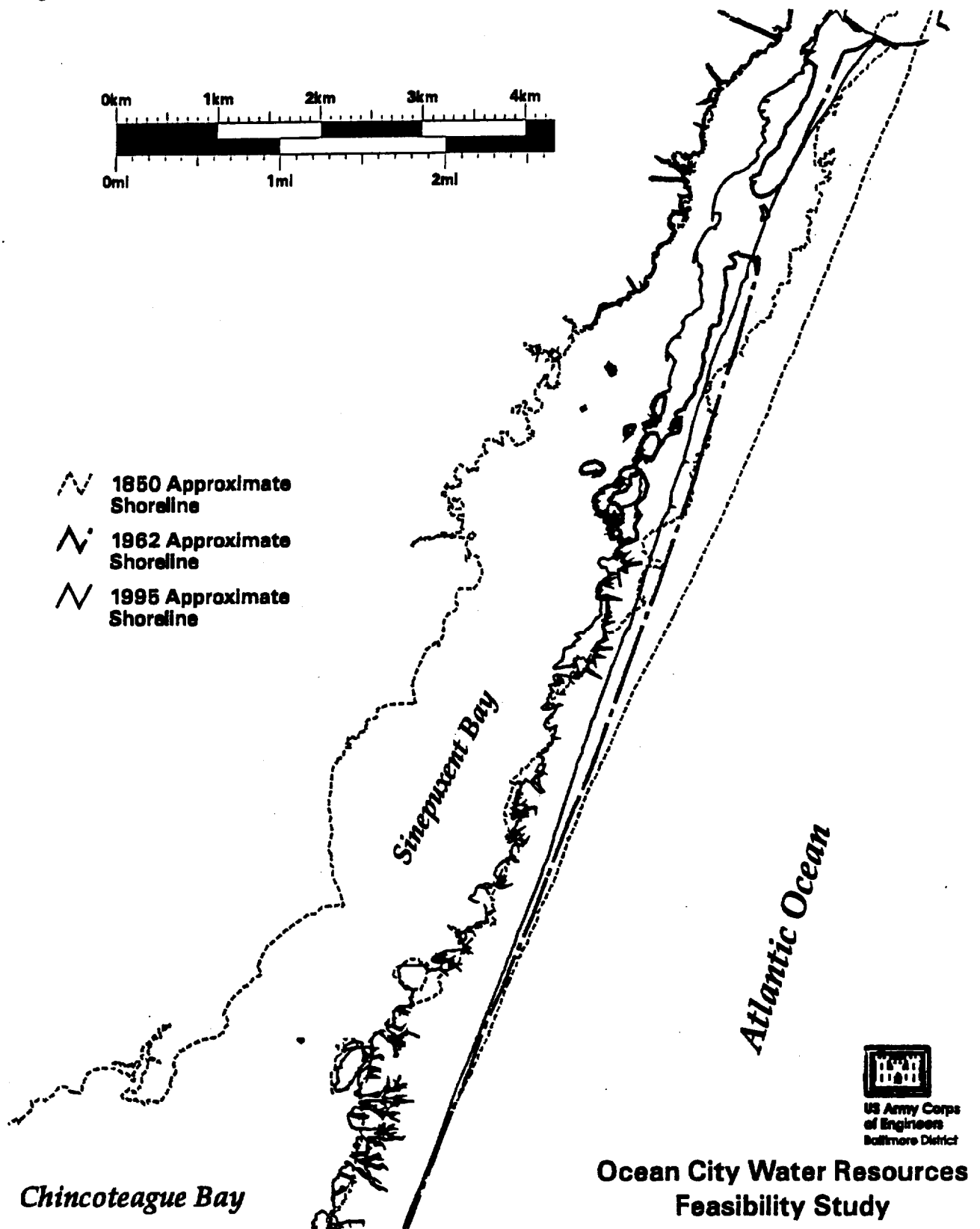


Figure 10: Historic shoreline changes on Assateague Island



### **2.3.2. Discussion of changes in island character 1933 to 1992**

On August 23, 1933, hurricane forces caused a major breach in the area now known as Ocean City Inlet, separating Fenwick Island to the north from Assateague Island to the south (Truitt 1967). Prior to stabilization, this inlet was approximately 3 m deep and 76 m wide (Underwood and Hiland 1995). One month later, the USACE began to stabilize the inlet through construction of stone jetties. Construction of the jetties was initiated in September 1933 and completed by May 1935 (USACE 1997). Since that time, Ocean City Inlet has been maintained by dredging and the jetties have been structurally modified to better protect the jetties and inlet.

The Ocean City Inlet and jetties, resulting from the 1933 breach, interrupted the longshore transport of sand and caused sand accumulation on Ocean City beaches on the north side of Ocean City Inlet. Offshore ebb-tidal and bay flood tidal shoals developed, trapping littoral materials before they reached Assateague Island. As early as 1935, only 1-2 years after jetty construction, it was evident that inlet processes were already forming an ebb tidal shoal at the expense of the downdrift beaches. Sediment starvation on the south side of the inlet resulted in erosion on the ocean side of Assateague Island at a rate that outpaced formation of new land on the bayside. Impacts along the northern-most 8.5 km were severe, with shoreline erosion and recession rates increasing to 9-12 m/yr. (30 to 40 ft/yr.) (USACE 1997a) (Figure 10).

Although the 1933-34 jetty construction resulted in an almost immediate stealing of sand from Assateague Island, the tendency for sediment transport over, through, and around these structures was impressive, and occurred for a majority of the post-inlet time period. Several times throughout a time period of 52 years post-inlet, repairs were needed, including a continual increase in elevation of the north and south jetties primarily due to the inability of the structures to retain sediment. Even as recent as 1984-85, the south jetty was increased in elevation to 2.3 NGVD, and three headland breakwaters were constructed on northern Assateague Island (USACE 1997a).

Assateague Island's topography has been impacted both by accelerated shoreline retreat and by artificial dune-building. Beginning in the 1930's, extensive sand dunes were built along all of the southern end of Assateague Island (Figure 9). In 1962, USACE erected snow fences to facilitate dune building along northern Assateague. Dunes were also repaired and rebuilt by NPS in the late 1960's and early 1970's. However, since that time dunes have not been maintained in most areas. No dunes were ever constructed north of the McCabe house on northern Assateague, although snowfence was used. Four areas on northern Assateague periodically received deposits of dredged material (piled and resembling a dune remnant) until the late 1970's. Remnant deposit features, now vegetated, remain on northern Assateague.

Although accelerated retreat of the shoreline decreased the width along some island sections and acreage of Assateague Island after 1934 (Figure 10), it has been determined that net erosion (loss of volume) was occurring on northern Assateague Island even prior to inlet stabilization (USACE 1996). This indicates that the natural condition of the north end of the

island was typically narrow, had low topography with frequent overwash. However, the rate of loss was much greater after the placement of the jetties. For example, between 1850-1933, the average net volume loss prior to inlet construction was 150,000 cubic meters per year, and between 1933-1995 was 255,000 cubic meters per year (USACE 1996). By the early 1950s, overwash deposition on the bayside appeared to reach a dynamic equilibrium with ocean-side erosion (USACE 1994), and by 1962 island widths ranged from about 161 m to 311 m (530-1020 ft). Although island width in some sections has actually increased since that year, partially due to routine and emergency placement of dredge material by USACE on northern Assateague, average island width is similar to pre-jetty condition.

Strong northeasterly storms in November 1961 and March 1962 caused an additional two breaches on Assateague, one located at the inshore end of the south jetty (northern breach), and the other approximately 1.5 km south of Ocean City Inlet (Dean and Division of Beaches 1986). On March 9, 1962 the northeaster, known as the "Ash Wednesday Storm", was of unusually long duration, spanning five high tides, which was responsible for exceptionally high water levels in the back bays. The northern breach was calculated at mean low water (MLW) to be 122 m (400 ft) wide and 1.2 m (4 ft) deep. Since the southern breach was not affecting the navigation channel, it was not eligible for repair by the USACE. However, while construction activities were underway to fill the northern breach, some of the newly-deposited sand drifted to the southern breach and closed it off (Dean and Division of Beaches 1986). It is important to note that approximately 1.5 million cubic yards of fill were used to fill the northern breach from 1962 to 1965. The Assateague Island breach persisted despite closure attempts until 1966, when the breaches were closed and the south jetty extended landward to prevent flanking as the southern shoreline continued to erode (USACE 1997).

Attempts to develop housing were made after 1933 when development ventures such as North Beach, Green Run, Shelby's Venture, Cold Harbor, Atlantic Ocean Estates, South Ocean Beach and Maryland Beach City were planned. Streets and some 6,000 lots were laid out along the spine of Assateague Island. During the 1962 northeastern storm, 32 of the 50 dwellings located on Assateague were lost and the road network damaged. Federal assistance to implement shoreline protection measures was requested by private citizens, but was rejected by the federal government. As federally-protected coastal recreation areas became more and more desirable interests grew for creating a National Seashore. Finally in 1965, the Assateague Island National Seashore was officially authorized.

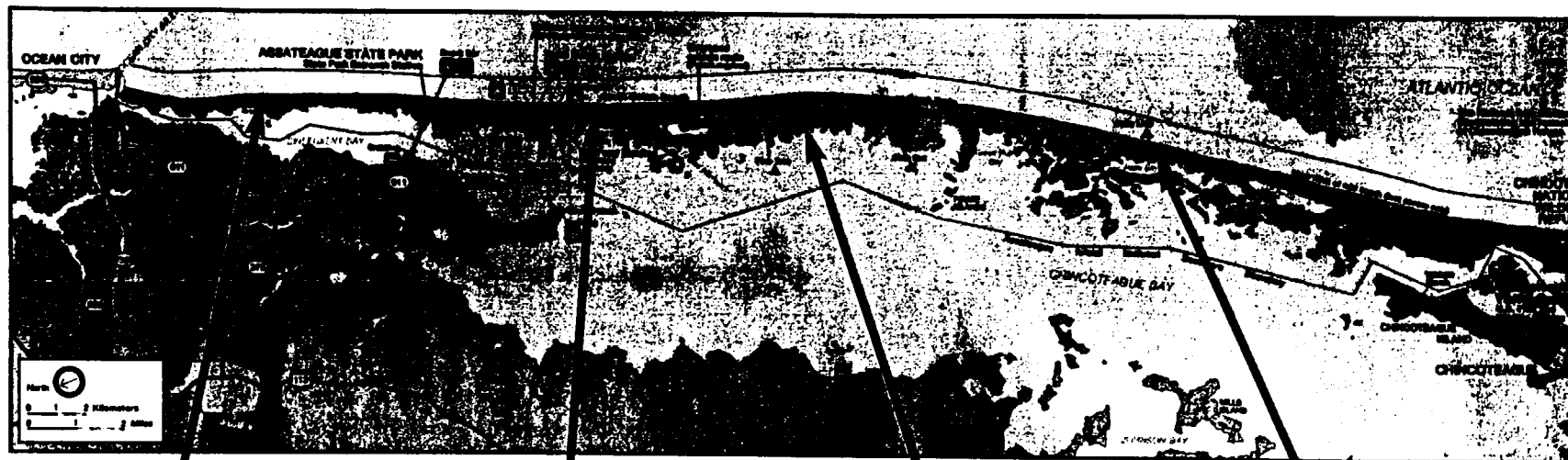
### 2.3.3. Discussion of changes in island character 1992 to present

During late 1991 and early 1992, three northeasters occurred within a three month period along the Atlantic coast resulting in significant morphological and topographical changes to northern Assateague Island. These were the first significant storms since the "Ash Wednesday" storm, an tropical cyclone, breached Assateague Island during March 1962. A significant increase in vegetation cover was documented during piping plover studies between 1986-1991, primarily due to a lack of cross-island overwash activity along northern Assateague (Patterson 1988, Loegering 1992). These data provide comparisons between post-storm island character studies following the 1992 northeaster, which scoured much of the vegetation and resulted in significant habitat changes. A direct correlation between vegetative cover in piping plover habitats and chick survival was documented on Assateague Island (Loegering and Fraser 1995). This study supports that the lack of overwash activity resulted in vegetation encroachment and reduced foraging opportunities for adult plovers and their chicks. It is believed that this habitat change was a major factor in the plover population decline on northern Assateague Island during these pre-storm conditions. Further, plover broods restricted to the ocean beach either by dunes or vegetation suffered high mortality. A relationship between the presence of overwash corridors and piping plover productivity was documented in this study.

Numerous changes, including morphological and ecological, occurred as the result of the 1991 and 1992 storms that were concentrated within a short period of time. The northern portion of the island has maintained an open, sparsely vegetated, and mostly low topography character since the 1992 storm. The presence of State rare early successional plant species have been recorded for the first time since the 1960's. Other beach nesting birds, including least terns and American oyster catcher have also been recorded nesting on the island during this period, primarily due to habitat changes and a decrease in predation pressures by red foxes (due to population contracting mange and rabies). Higher breeding numbers of these species occurred on Assateague than what is historically known. For as long as biological features have been recorded on Assateague Island, this has been a successful period for species adapted to early successional habitats in the mid-Atlantic barrier beach ecosystem.

Since 1992, the southern portion of the National Seashore has also incurred habitat changes. Photographs taken after the 1992 storm shows increased open areas, such as blowouts and interdune areas. There is no more maintenance or dune construction along most of the southern end, except for 2 miles zoned as a developed area located south of the state park. Recent photographs taken in the winter of 1997 (just prior to the early February, 1998 northeaster) indicates more sparsely vegetated areas and lower dunes than just a few years ago (Figure 11). Piping plover activity has been periodically recorded during the breeding season at the southern end, but during 1994, 1995, and 1997 piping plover nests were found at the southern end. This is likely due to the presence of more suitable habitat, higher productivity, and the significant increase in the state's population of piping plovers as well as the Atlantic Coast.

Figure 11: Habitat character at four piping plover nesting sites in 1997.



(National Park Service Map)



Nest site at 4.5 kilometer marker facing West.



Nest site South of Assateague State Park Facing West.



Nest site South of Dune Crossing 9 facing East.



Nest site North of Dune Crossing 16 facing Northeast.

#### **2.3.4 Southern end of Assateague Island**

For the purpose of this report, we define the "southern end" of Assateague as ASIS south of the state park's southern boundary (Figure 1). The maintained, artificial dune along the state park continues onto the NPS developed zone for 2 miles. South of this, the artificial dune has not been maintained since the early 1970's, and remained largely intact until the 1991, 1992 and 1998 storms eliminated most of it. Some sections of the old constructed dune are still intact, and degradation of the artificial dune will greatly depend on the frequency, duration, and severity of storms.

The southern end is an approximately 12 mile (19 km) long section of the National Seashore open to the public, including surf fisherman, recreationalists, and off-road vehicle use. The 'Over Sand Vehicle' (OSV) zone includes the ocean beach below the winter storm berm line, a mid-island trail ('Back Trail') that runs parallel to the beach, and dune cross-overs linking the two routes and connecting with several bay-side access points. The OSV Back trail is entirely located in the island interior and experiences regular overwash from the ocean side.

For the past several decades, and most dramatically since the 1992 storm, the southern end of Assateague Island National Seashore has continued to be altered by storms eroding the remaining artificial dune system, increasing the process of overwash, and creating extensive overwash fans that extend inland up to 1000 feet (C. Zimmerman, Pers. Comm. 1998). A substantive difference between the southern end and the northern end is island width and the erosional conditions brought on by the sediment deficit. The southern end had always been more expansive and wider.

Many inlets and dune cuts repeatedly occurred across southern Assateague Island through history. Most were temporary in nature, naturally filling in with sand over weeks or months. Based on historic maps, storm cut openings on the southern end tended to reoccur in the same location for example, at Green Run and Sandy Point inlet (Figure 9).

The amount of vegetation cover has varied over time due to storm-induced changes. The area of open, sparsely vegetated habitats may be equal to, if not greater along the southern end. Although the historic record of seabeach amaranth is from the southern end next to Green Run (Higgins *et al.* 1971), no early successional plant species (indicative of the same type of habitat seabeach amaranth favors) have been found in numerous southern end surveys. A range of physical parameters needs to be assessed to determine what quality differences, if any, there are between the northern and southern ends of Assateague Island. Parameters to assess should include the hydrology, including depth to water table, and off-road vehicle influences.

Conditions for plovers could be improving on the southern end of Assateague Island due to natural resources management plans. The artificial dune last maintained in the 1970's is disappearing as a feature as a result of several storms. Management planning with regard to the southern end of the island includes allowing the area to evolve under as natural conditions

as possible. The interior portion of the OSV route, the "backtrail", is in the process of being permanently closed to public use and is expected to be abandoned in fewer than 5 years. The backtrail is expected to fade, giving way to overwash and vegetation succession processes effectively reclaiming the old road bed. The NPS is committed to managing OSV use to minimize potential adverse effects on park natural resources, including threatened and endangered species (C. Zimmerman, Pers. Comm. 1998). The location where the park provides OSV opportunities may change over time if piping plover distribution changes to have more breeding pairs at the southern end.

In 1997, more pairs of piping plovers nested on the southern end than had previously been recorded. During the same 1997 breeding season, the northern portion of Chincoteague National Wildlife Refuge supported a higher number of breeding pairs compared to previous years. The ASIS implemented a vehicle closure 200 m from nests in the OSV zone. Broods from these nests tended to forage on either the ocean side or on the interior flats, but didn't use both areas as broods do on the north end do. Not many broods use both areas for foraging along the northern end.

Known plover nesting attempts have always been at dune crossings 9 and 16 (with the new state park nest in 1997 a new location). Plover nests have not been found between dune crossing 2 through 9. The habitat appears similar in a subjective view but there may be differences in recreational disturbances, foraging resources and ground water differences. The water table may be lower because ephemeral pools seem to dry out more quickly than they do on the northern end (J. Kumer, Pers. Comm. 1997). Soil moisture may also be an important variable to consider with regard to piping plover foraging ecology on the southern end. There are no features to match the extent of overwash habitat and flooding as is seen on the northern end because island width and elevation is very different.

### **3.0 PURPOSE AND NEED FOR PROJECT**

Although shoreline retreat rates have been evident along northern Assateague Island between 1850 to 1933 (Figure 10), the recession and erosion rates have noticeably increased along the northern 8.5 km since 1933. The natural opening of the Ocean City Inlet by the 1933 hurricane, and subsequent stabilization and maintenance of the Inlet, has resulted in sediment starvation at the north end of Assateague Island. This has resulted in a very low-profile barrier island with increased vulnerability to breaching, a reduction of the island's buffering effect of the mainland during storm events, and altering of ecological character. Due to the accelerated erosion and landward migration of the island, as well as the potential impacts on natural resources and visitor use, the NPS identified the erosion problem as a priority management concern. If erosion continues at its present rate, the island is likely to breach by the formation of a new inlet at any time and is expected before the year 2020 (Dean and Division of Beaches 1986).

The proposed long-term sand management program will result in a continual placement of sand along sections of northern Assateague Island to compensate for the sediment shortfall that has occurred since inlet stabilization. With the long-term program in place, natural forces will be allowed to prevail to shape the island geomorphological character on the majority of Assateague Island, except in the developed areas of both the State Park and the National Seashore immediately south of the State Park.

#### **3.1 Project history**

In February 1986, the NPS sponsored a workshop with the purpose of identifying appropriate management alternatives for addressing the erosion problem and its impact on island geomorphology, estuarine biology, and socioeconomic factors (Dean and Division of Beaches 1986). In July 1990, staff from NPS met with the U.S. Army Corps of Engineers Waterways Experiment Station's Coastal Engineering Research Center (CERC) to discuss physical and ecological changes occurring along northern Assateague Island. By 1992 a contract was in place to continue work on analyzing historical shoreline erosion trends along northern Assateague Island and evaluate how they may correlate with the Ocean City Inlet ebb-shoal growth (Underwood and Hiland 1995).

In 1994, the USACE completed a comprehensive study of navigation, storm damage, environmental quality, and water resources of Maryland's Atlantic coastal watershed and evaluated how they are impacted by the dynamic processes associated with Assateague barrier island and bays (USACE 1994). The reconnaissance surveys defined the general scope of the problems within the study area and determined federal interests (USACE 1994). The impacts of the long term restoration on endangered, threatened, and rare species were briefly considered in the May 1997 Draft EIS for the short term project (USACE 1997a).

### 3.2 Current problems and proposed project description

Northern Assateague Island is sediment starved as a result of interruption in the southerly longshore flow of sand caused by the Ocean City Inlet jetty trapping significant quantities of sediment since the 1930's. The annual sediment shortfall has been estimated at 145,000 cubic meters (189,000 cubic yards). The purpose of the proposed project is to mitigate the sediment shortfall caused by the jetty effects, but not to change the natural, historic conditions found on the northern portion of the island. The historic transgressive shore change rate was 1-2 meters/year and this condition is factored in the calculations for the sediment budget.

Sections within the northern 8 km portion of the island appear to be highly vulnerable to breaching. The destruction of the primary dune system on the northern end of the island has diminished the ability of northern Assateague to buffer the mainland from coastal storms. The goal of the proposed long-term sand management program is to compensate for this sediment shortfall, but is not expected to change the islands historic transgressive condition. The current plan includes a "mobile bypassing" of sand that would have naturally reached the island had the jetties never been built. The recommended alternative for accomplishing this is the use of a shallow mobile hopper dredge to bypass sand to northern Assateague Island. The hopper dredge will deposit sand in the surf zone of the waters adjacent to the island. Sand will be placed in relation to a nodal point on northern Assateague Island north of which longshore transport of materials is generally in a northerly direction, and south of which longshore transport is generally to the south. The nodal point lies approximately 6.8 km south of Ocean City Inlet (Figure 2). Normal wave processes are expected to gradually move the material onto and along the island. Dredging and sand placement is proposed to occur in a manner which best simulates natural processes. Work will occur during the periods of February/March and October/November. Several sand sources, including the updrift fillet, ebb shoal, navigation channels and flood shoals, will be used to provide sediment (Figure 2). When placed semi-annually, 14,500 cubic meters will be placed north of the nodal point, and 58,000 cubic meters will be placed south of the nodal point, for a total sediment budget of 145,000 cubic meters/year. The long-term project is proposed to be in place for at least 25 years.

The total volume of sand calculated to restore Assateague Island to its more natural pre-jetty condition was derived in the following way: Volume entering inlet from Fenwick Island (115,000 cubic meters/year) *minus* Volume reaching northern Assateague from ebb shoal (53,000 cubic meters/year) *plus* Volume moving into inlet from the south via south jetty (83,000 cu m/year) *equals* 145,000 cubic meters/year. This total volume accounts for all the inlet-induced processes calculated to deprive Assateague Island of sand (USACE 1997c).

## **4.0 PIPING PLOVER IMPACT ASSESSMENT**

This section includes an assessment and discussion of potential effects on piping plovers from the proposed long-term sand management project, which is designed to restore sediment to sand-starved Assateague Island over a period of approximately 25 years. Restoration is predicted to result in geomorphological conditions, processes, and habitats similar to the island's known historic pre-jetty character (USACE 1998).

### **4.1 Effects of proposed long-term sand management program**

When considered on its own, no known detrimental impacts to piping plovers are expected as a result of the long-term sand management project. Assuming that time of year restrictions are similar to those for the short-term effort, bypassed sand is deposited in adjacent waters and not on emergent uplands, and the volume amount of dredged material is significantly less than in the short-term project, piping plovers may in fact benefit from potential island elevation in the area that has recently become unsuitable for nesting plovers due to the sand deficit.

To determine project effectiveness and potential effects on plovers, a monitoring plan should be in place for at least the first several years following project implementation. Monitoring must include measure of shoreline changes, erosion and retreating rates, and beach profile data to determine if changes along this portion of the island are different than adjacent areas. It is expected the proposed project will result in an overwash frequency that falls within the normal range of variability. The project will likely reduce the frequency of overwash in the area targeted for placement, but not to an unnaturally low condition. If sediment is restored to Assateague Island in as natural manner as possible and natural processes are allowed to prevail, the island is expected to remain erosional, retreating, and maintain low elevations, all potentially favorable conditions for piping plovers. Assuming that pre-jetty conditions of the island supported nesting piping plovers and conditions that are going to be monitored fall within the historic range, impacts to piping plovers may not be adverse.

The abundance, quality, and availability of invertebrates is critical to plovers during the nesting and brood rearing seasons. It is not known how invertebrate abundance will be affected by the project. There is no data to compare with historic invertebrate conditions. However, comparisons should be made between the project area and areas outside of the affected section, including the southern nesting areas to determine potential project effects.

It is essential to continue monitoring the project, collecting biological data on piping plovers and monitoring physical changes on Assateague Island. Although the proposed project is expected to advance Assateague Island towards a condition where somewhat natural barrier island processes are the dominate forces shaping the landscape, our understanding of current sand budgets is imperfect. We cannot predict the amount of variation that may occur as a

result of the project or how closely it mimics the natural movement of sand that occurred pre-jetty construction.

If for any reason the proposed project results in changes in habitat that are undesirable for piping plovers, volumes and/or placement locations of sediment may need to be adjusted. Other onsite adaptive management measures cannot be ruled out.

#### **4.2 Information gaps and studies needed**

One of the most important key indicators that may determine habitat suitability for piping plovers is the quality of foraging habitats. In a 1988-90 study of piping plovers along Assateague Island, Loegering and Fraser (1995) concluded that foraging resources, particularly marine invertebrate abundance and access to, are the key determinants of plover reproductive success. There are also currently efforts by the USACE along Long Island, New York to look at invertebrate availability as the primary indicator of suitable plover habitat. Studies have shown that plovers may select foraging habitats where invertebrates are most dense. Further, chicks that feed in these areas have the highest survival rates. These data are likely to aid in determining habitat quality for piping plovers and predicting changes in suitability of plover habitat due to beach restoration or stabilization projects, or changes due to natural processes.

Direct correlations between open, sparsely vegetated corridors, providing access to foraging sites, and reproductive success has been documented on Assateague Island. Encroachment of vegetation, due to lack of sufficient overwash activity along northern Assateague Island, resulted in poor habitat quality and a decrease in number of breeding pairs and productivity. Monitoring increase or decrease in percent vegetation cover and abundance, and habitat types as they relate to piping plovers is essential in detecting potential impacts from the long-term sand management project, especially if it follows implementation of the short-term restoration project. There is currently a vegetation monitoring study, conducted annually by NPS along the northern end to determine changes between years of community types. This may provide useful data to aid in detecting plover responses to the proposed projects if community types can correspond to habitat types that plovers use for nesting and/or foraging.

Recommended studies are as follows:

- 1) Determine and compare foraging habitat availability and invertebrate abundance prior to and during, implementation of short and long-term projects between northern and southern portions of ASIS. This would greatly help determine direct suitability of plover habitats in the OSV zone as well as provide indices to changes following project implementation.
- 2) Continuation of beach profile study (NPS) to determine cross-island elevational changes between years along the entire Maryland portion of the island. Topographical changes,

particularly along northern Assateague should be mapped to document seasonal changes due to storm activity.

3) The current vegetation monitoring study should be evaluated to determine if the community alliance habitat types that are being used will be useful in detecting potential changes in nesting and foraging habitats for piping plover.

#### **4.3 Actions to avoid or minimize adverse impacts to piping plover**

The Monitoring and Action Plan developed for the short-term restoration project is a key component to avoid, minimize, or mitigate for adverse impacts to piping plovers on Assateague Island for the initial years following the short-term restoration project. The monitoring team should discuss assessment of specific indicators to determine deficiencies in overall performance.

#### **4.4 Summary of potential impacts**

Effects of the long-term project will depend, in part, on effects of the more intensive short-term project. If the short-term project results in adverse effects (excessive sand elevations or vegetation growth which is not, or cannot, be corrected by the "corrective actions" called for in the short-term monitoring and mitigation plan), then the long-term project is likely to maintain or exacerbate these effects.

No direct adverse effects are expected as a result of the long-term sand management project alone. However, adverse cumulative impacts for the short-term and long-term projects combined may occur, including too much increase in elevational change, and reduced access to bayside foraging areas. Impacts to piping plovers as well as the effectiveness of the projects will depend primarily on the unpredictable frequency, duration, and intensity of coastal storms during the years following project implementation.

Although some indirect effects to piping plovers are unknown due to the uncertainty of storm activity and the response of sand movement to the projects, effects will occur as natural processes modify the dredged areas of the ebb and tidal shoals, navigation channels, and Ocean City fillet and result in different habitats on northern Assateague. As sand becomes redistributed along the island, portions of the island become elevated and potentially more vegetated, and changes to mudflats and salt marsh occurs, indirect effects are likely to occur. These may include a redistribution of nesting pairs, increase and decrease of plover numbers, and reproductive success as the behavior of plovers respond accordingly from year to year in island changes.

#### **4.5 Summary of cumulative impacts**

Increased development, shoreline stabilization and navigation projects, large-scale agricultural operations, and extensive human use of the area continue to jeopardize the quality of biological resources in the coastal bay watershed around and on Assateague Island. These problems include the loss of nesting habitat for waterbirds, excessive erosion along ASIS, and increased storm damage. This combined with current ongoing projects such as beach nourishment and dune maintenance projects that periodically occur along Fenwick Island's shoreline, any future projects, and the current proposed projects on Assateague Island may result in cumulative impacts to piping plovers.

Certain management measures recently adopted by ASIS, which includes no more construction or maintenance of dunes along southern portions of the National Seashore, will likely have cumulative effects on populations of piping plovers. As natural processes are allowed to prevail and high dunes continue to degrade in this area, overwash areas will likely become more extensive, low lying topography with increased blowout areas will likely be created, and increased numbers of piping plovers will begin to use the area. This assumes that foraging quality and availability is high enough to support increased plover numbers.

Cumulative impacts of both the short-term and long-term projects may result in a reduction in overwash frequency that could potentially have adverse impacts on piping plovers. Vegetation encroachment, a stabilized dune system, and increased woody vegetation may result in a variety of conditions unsuitable for nesting plovers, including decreased nesting sites, blocked access to bayside foraging areas, and increased habitat availability for denning foxes.

If the sand deficit at Assateague has been calculated incorrectly or the movement of sand following deposition does not follow project patterns, the long-term project in conjunction with the short-term project may result in excessive elevations or dune-building. Thus, without further adaptive management by the USACE, the long-term project could well adversely affect the piping plover.

## **5.0 SEABEACH AMARANTH IMPACT ASSESSMENT**

Under the proposed long-term project the potential effects on seabeach amaranth apply if reintroduced or rediscovered on Assateague Island. Analysis of impacts on seabeach amaranth is speculative because no populations are known to occur on Assateague Island. There is currently no proposal to reintroduce seabeach amaranth to Assateague Island but what follows are the project effects to take into account in the event that reintroduction efforts are implemented and successful or if the plant is rediscovered in surveys.

### **5.1 Effects of proposed long-term sand management program**

There are four main potential effects that the long-term project may have on seabeach amaranth,

1) reduction in overwash frequency reducing open habitat (but possible maintenance of other disturbed habitat types); 2) increased elevation of the island allowing for vegetation to succeed reducing amaranth habitat; 3) increasing likelihood for breaches to be repaired, thereby reducing amaranth habitat; and 4) elevating the island on northern end reducing summer overwash, thereby providing more habitat. Another effect -- although a remote possibility -- is that the project may recover seed banks potentially occurring in dredged material brought up from shoals.

Fugitive plants such as seabeach amaranth have favorable habitat on the edges of overwash areas and in dune blowouts, as are found on the southern end of Assateague Island. Overwash edges and inlet spits are localized areas of accreting sand where seabeach amaranth does well. If a disturbance habitat is provided by the long-term bypassing project along the shoreline, it may expand the habitat for seabeach amaranth. In simulating natural processes, the new sand deposited along the shoreline adjusts and may create disturbed habitats, which may be beneficial to seabeach amaranth populations. Disturbed habitats created by sand being bypassed off-shore and melding with the island may not be a substantial disturbance when compared to other deposit methods, like placing sediment on the beach.

If the long-term project results in the formation of low dunes that become stabilized by American beachgrass and other perennials suitable habitat for seabeach amaranth may be limited. Reproductive output of annuals, like seabeach amaranth, is affected by proximity to and species of nearest neighbors and can be constrained by the presence of certain other species (Clark, 1990). Perennials and shrubs found in former seabeach amaranth habitat may indicate a successional trend toward stabilization. Although Fahrig (1994) states that the presence of "guerrilla" perennials (that act like annuals) need not indicate advancing succession on beach areas, NPS and TNC vegetation surveys have shown a close association of dominance of perennials (other than grasses) and advanced successional communities.

If, following implementation of the long-term project storm-induced breaches are repaired, effects on populations of seabeach amaranth will depend on their location and distribution in relation to the breaches. Filling of a new inlet may eliminate some of the best potential habitats for seabeach amaranth re-establishment. Allowing natural processes to prevail following formation of breaches may expand potential amaranth habitat on Assateague Island.

Beach erosion represents a severe threat to seabeach amaranth populations. According to the Recovery Plan (USFWS, 1996b) "this plant is never found where the foredune is scarped by undermining water at high (or storm) tides. Seabeach amaranth grows above high tide line and is intolerant of even occasional flooding during its growing season. It does not, however, grow more than a meter or so above the beach elevation on the foredune and is not often found anywhere behind the foredune (except in overwash areas)." Due to the sand budget deficit the high erosion rates along northern Assateague Island without a project may result in a continually overwashed area where seabeach amaranth could not survive.

A remote possibility exists for the long-term project to add material to Assateague that contains amaranth seeds. In North Carolina, an increase in populations of seabeach amaranth occurred following a USACE winter season bypassing project at Masonboro Inlet. During years when the bypassing project could not be completed because of budget restrictions very few plants were seen. However, numerous plants were found during surveys following a bypass action (Bill Adams, Pers. Comm. 1998). Bypassing may improve the chances for seabeach amaranth seeds that have blown into the water by conceivably dredging them up on shore. This may indicate that the seed bank, and not the vegetative structures, needs to be managed. Although there is no experimental evidence to suggest that seeds can survive underwater for long periods of time, these applied observations are noteworthy. However, Ehrenfeld (1990) expects seeds of fugitive plants to be distributed on or above the water surface (being carried over water to islands).

In North Carolina, Adams feels the USACE needs to bypass faithfully so the seed bank is not lost to the water and to create an ongoing disturbance regime. The North Carolina situation can provide helpful indicators for assessing a bypassing project at Assateague Island. There are difference in calculated east-facing shoreline erosion rates between the the two locations. Twenty percent of the shorelines measured in North Carolina eroded 0.91 m-1.52m (3 - 5 feet) per year, and the erosion rate at Assateague is 5 m (16.4 feet) per year on the north end (USACE 1997c). Differences in habitat preferences for seabeach amaranth also exist, however, there is some common ground with regard to conservation of this species.

## **5.2 Information gaps and studies needed**

The biology and ecology of this plant is not well understood, therefore much needs to be done with answering basic biological questions, but this discussion is not meant to outline studies needed before the long-term project is implemented. It is felt that a reintroduction of seabeach amaranth at Assateague would go far to answer critical questions set out in the Recovery Plan.

Greenhouse propagation, redistribution by seed sowing, germination parameters and seed viability studies are all important in filling information gaps and perhaps would be accomplished with a Maryland reintroduction project.

More study is needed before the overall impacts of bypassing projects are known on amaranth. The potential benefits and negative effects should be determined. The experimental research on the importance of seed banking and effects on germination of seeds buried in underwater substrates should be done. The severity of the effect depends on understanding more about the seed banking of this species.

Management strategies need to be studied for protecting and enhancing seabeach amaranth habitats so that other rare early successional beach plant species can benefit. Parameters need that can be measured on Assateague Island are, amount of suitable habitat available and effects of OSV use, to help understand the quality differences in the habitats on the northern and southern ends before reintroduction can take place.

### **5.3 Actions to avoid or minimize adverse impacts to seabeach amaranth**

If seabeach amaranth populations were present at Assateague, it is recommended that two main actions be implemented to minimize adverse impacts to seabeach amaranth and its habitat. These are, 1) monitor vegetation succession and overwash frequency (or other disturbance such as storms or sand deposition) in order to assess available habitat changes with regard to seabeach amaranth. Since vegetation succession temporarily eliminates the suitability of habitat for seabeach amaranth, annual overwash or something mimicking a natural disturbance may be required to keep habitat open. Although there is no guarantee of a particular overwash frequency with the long-term project, the volumes and placement locations of sediment may need to be adjusted; and

2) not making management assumption that reintroducing seabeach amaranth to piping plover areas protects both species from impacts of off-road vehicles, potential breach closures and other disturbances. If a piping plover protection area has all the proper conditions for seabeach amaranth (not too vulnerable to high tides, not too vegetated) then encompassing the two species together is reasonable. Plover nesting areas do not always have habitat qualities that favor seabeach amaranth, and although the differences may be too subtle to "engineer" for, the success of both species depends on understanding they will not predictably occur together inside a pre-determined protective area.

While it is true that some of the largest seabeach amaranth populations are associated with nesting sites of the piping plover and least tern (USFWS 1986b). In many places, while seabeach amaranth plants are found within symbolic fencing erected around piping plover nesting concentrations (in New York and North Carolina) there are some important distinctions to be made between the two species. While there is some overlap in habitat types, piping plovers can nest in a more broad range of habitats compared to seabeach amaranth.

Piping plovers are known to tolerate a certain amount of overwash, higher elevations, increased vegetation cover, and horse grazing compared to seabeach amaranth. From a management standpoint, when considering reintroduction sites for seabeach amaranth, it would be best to select areas along the edges where piping plovers are nesting because protection is already afforded with the symbolic fencing and presence of monitors. If plants show up in a given year outside the symbolic fencing, it could be extended to include the plants with some allowance for buffer.

Over-sand vehicle traffic is present during the nesting/growing season on the southern end and fencing can be used to route traffic away from amaranth plants. Although symbolic fencing will presumably keep off-road vehicles outside of seabeach amaranth areas, it will not keep feral horses from grazing on plants. Also, reintroduction sites selected on the basis of locations of nesting plovers does not make it certain that piping plovers will return to nest in the same areas the following year.

#### **5.4 Summary of potential impacts**

Because of the dynamics and unpredictability of storms, the potential project impacts are very difficult to assess on barrier beach landscapes. There are both positive and negative impacts that a project of this type might have on seabeach amaranth.

##### **Direct impacts**

The long-term sand management project would potentially not effect seabeach amaranth since it is not at the site. If seabeach amaranth were found, no direct impacts are expected from the long-term project because the dredged material will be placed in the surf zone, and for the most part, outside the growing season.

##### **Indirect impacts**

If a high elevation is a result of the long-term project and a period of relative stability (i.e. no storms) coincided, this would likely expand succession of perennial plants. The increase of long-lived woody plant species create a stronger defense from storm damage. Shrub thickets on the Virginia barrier islands have expanded in interior portions in last 50 years (Yound *et al.* 1995) and only the most severe storms will affect the thickets, being found to be well adapted to survive most storms, once established. Shrub thickets are perhaps less protected at the northern end of Assateague Island, and the large expanse seen in the 1910 historic photograph (Figure 7.2) had been reduced in subsequent storms.

If increased wind sand deposition occurs as an effect of the long-term project, American beach grass can expand, as it requires burial for maximum growth (Barbour *et al.* 1985). The expansion of American beach grass can reduce open habitats for seabeach amaranth.

If sites along the southern end are chosen for seabeach amaranth reintroduction, the OSV zone use could impact its success or maintain the open habitat. Off-season OSV zone traffic has

been known to disturb the establishment of perennials at Cape Hatteras, North Carolina. Off road vehicle use during the growing season can be very detrimental causing mortality from one truck pass. Pedestrian traffic generally has little effect on seabeach amaranth, mostly because areas are avoided by beach user preference (USFWS 1996b). Piping plover symbolic fencing can discourage foot traffic as well.

## 5.5 Summary of cumulative impacts

The same regional and coastal uses that affect piping plovers (Section 4.5) combined with current ongoing projects may result in cumulative impacts to seabeach amaranth.

After several years of the long-term project in effect, it is likely that all habitat types will still be represented on Assateague Island as were historically. The effects of the short-term combined with the long-term project are unknown. As sand becomes redistributed along the island, portions of the island become elevated and potentially more vegetated, indirect effects are likely to occur. The increase of sand during the long-term project could reduce the amount of overwash to maintain seabeach amaranth habitat on the northern end. The projects occurring together may reduce the amount of area to reintroduce seabeach amaranth by eliminating some potential low, overwash corridors. The long-term component (in conjunction with the short term restoration project) may potentially promote growth of windblown dunes, possibly decreasing cross-island overwash and increasing the rate of vegetation encroachment on the north end of ASIS. Plant communities may succeed into more stable associations and more stands of herbaceous and shrub communities dominating stabilized sand. If overwash diminishes, American beach grass and other perennials can likely quickly spread. This would likely eliminate seabeach amaranth because it can be readily out competed. The cumulative effects could also include burying a potential seed bank.

Management by ASIS, including allowing the degradation of the southern end dunes and backtrail road will likely accommodate seabeach amaranth populations.

## 6.0 OTHER SPECIES OF CONCERN

Barrier beach habitats used by piping plovers are dynamic, storm-maintained ecosystems. The 1991/92 storms strongly overwashed northern Assateague Island removing much of the herbaceous and shrub vegetation. Piping plovers have responded favorably with numbers of breeding pairs reaching record highs. Early successional habitats on Assateague Island have also recently favored other ground nesting birds, including least terns (*Sterna antillarum*), common terns (*Sterna hirundo*), black skimmers (*Rynchos niger*), and American oystercatchers (*Haematopus palliatus*).

It is not expected that the long-term project will have detrimental effects on these other species. Protection measures proposed to minimize adverse affects to piping plovers would also encompass protection needs for other ground nesting species. Elevating portions of the island to natural conditions may provide more secure sites for these species whose nests are vulnerable to flooding. Although, common terns and black skimmers generally prefer more vegetative cover than piping plovers, nests of least terns and American oystercatchers are typically found in more open, large, unvegetated beach habitats.

Populations of the state endangered white tiger beetle (*Cicindela dorsalis media*) are scattered along the shoreline of Assateague Island just above the high water mark where they select mates, lay eggs, and forage for food. During a 1996 survey, white tiger beetle populations were found only along the northernmost 5 km of the island. Due to the lack of information concerning locations of tiger beetle populations, it is unknown whether sediment placement from the bypassing would impact this species (B. Knisely Pers. Comm. 1997).

State listed plant species that have been recently re-discovered (1997) on the northern end of Assateague Island that share the same general habitats as seabeach amaranth are seaside knotweed (*Polygonum glaucum*) and seabeach purslane (*Sesuvium maritimum*). Hill (1983) found seaside knotweed on the southern end but Lea (1997) found a large population on the northern end. The concerns with these early successional species are the same outlined for seabeach amaranth.

The long-term sand management project may adversely affect Skimmer Island by bypassing sand around the inlet. This accreting island supports large rookeries of colonial nesting waterbirds, including state endangered royal terns. Dredging sand from the inlet shoals may reduce the amount of sand accretion at Skimmer Island resulting in a decline in suitable habitat for large amounts of nesting birds. However, an island creation project has been proposed to partially mitigate for habitat losses to Skimmer Island. This area, called Dog Island Shoals, is located north of Skimmer Island, and was selected as a preferred site for habitat island creation for nesting waterbirds. The Maryland Department of Natural Resources should be consulted concerning potential impacts to state listed species. Observations of federally-listed roseate terns (*Sterna dougallii*), bald eagles (*Haliaeetus leucocephalus*), and peregrine falcons (*Falco peregrinus*) have recently been observed along northern Assateague Island, but adverse impacts from the proposed project are highly unlikely.

## 7.0 MONITORING AND MITIGATION

The Monitoring and Action Plan drafted for the short-term restoration project (USACE 1997a) is not assumed to be in effect for the long-term sand management project. The monitoring plan for the short-term project is slated as five years post project implementation, and is to document changes in the key physical and biological resources of northern Assateague Island in order to evaluate the project's overall performance in meeting objectives. Depending on the evaluation of project results, the monitoring review group may decide to shorten or extend the monitoring period.

Implementation of the long-term project is planned to immediately follow the restoration effort. Although some favorable effects are expected from the long-term project, potential cumulative effects from both projects should be carefully evaluated.

Project effectiveness of the long-term project may be difficult to assess due to the potential for cumulative impacts from the more controversial short-term project. A similar monitoring approach, but much more limited in scope, may be appropriate for the initial few years of the long-term project to evaluate both project success and potential effects on piping plovers.

A monitoring program could involve measuring different physical and biological variables within the project area. Physical measurements including shoreline position, beach profile and hydrologic surveys, aerial photography, measures of water and sediment. Biological parameters include changes in vegetation in relationship to plover distribution and plover productivity. In this way, it could be determined if areas affected by the bypassing develop physical characteristics substantially different than areas unaffected by the project.

Efforts by NPS staff are already underway to measure many of these physical conditions by different means, including beach profiles, shoreline changes, and vegetation studies. By monitoring these physical parameters, key factors related to piping plovers, such as overwash frequencies, invertebrate abundance and availability, and vegetative cover could be compared to portions outside of the project area to aid in determining if conditions are similar or if they fall within the range that may have occurred historically. However, due to the limited available information, we don't fully understand the historic range of variability to be able to fully determine what is expected on Assateague Island.

Depending on the evaluation of monitoring results, one mitigation approach that has been suggested is to adjust sediment volumes and placement. However, this option should be approached cautiously because a modification of volumes and/or placement may result in undesirable effects the following year depending on storm activity and behavior.

Some of the highest elevations along northern Assateague are due to artificial placement of dredged material. These mounds and artificial dunes, although very limited relative to the northern end as a whole, continue to support woody vegetation despite several storm events

over the last decade. To restore the island to its natural condition by way of the long-term project, modifications of these artificial features would be appropriate so that natural processes drive the shaping of the landscape.

Populations of piping plovers should continue to be monitored on Assateague Island. The long-term project may likely result in a range of benefits for plovers, including reverting inundated areas to potential nesting habitats. Data regarding distribution of nests and broods, productivity, and habitat use during nesting and foraging should continue to be collected. As piping plovers continue to use the southern portion, it is important to determine habitat use of adults and chicks (including foraging) and reproductive success.

## **8.0 SUMMARY OF 1998 STORM IMPACTS ON ASSATEAGUE ISLAND, MARYLAND**

During the period between 27 January and 9 February, 1998, two major consecutive storm events occurred along the mid-Atlantic coast, resulting in extremely atypical long duration of high water levels. Constant high onshore winds followed by a third small weather system exacerbated effects of the overall storm activity. These characteristics make these storms unique with respect to historic storms. Storm severity approached that of the 1962 "Ash Wednesday" storm, which at that time resulted in a breach on Assateague Island.

The recent 1998 storms had devastating effects on the already degraded northern Assateague Island. The continued overwash and severe erosion due to the long duration of high water levels may have caused more damage to the island than any other storm over the past 30 years (Neilson 1998, unpub. report).

Although much of the northern end suffered significant erosion and lowering of elevation, two areas that represent the lowest points along the shore appear to have been more affected. A 1.6 km (one mile) area extending between 6.0 - 7.5 km (3.8 - 4.8 miles) south of the inlet, and a low channelized area that extends to approximately 5.1 km (3.2 miles) south of the inlet. At the writing of this report, sand layers have been eroded and the peat layer is currently exposed in certain areas. Future storms may result in more permanent flows even under normal tide conditions, resulting in potential inlets or breaches. It is believed that the effects of overwash will gradually erode the peat layer exposing the underlying sand and is expected to create a condition much more susceptible to breach formation. A photograph of a portion of an affected area on the northern end of the island reveals a loss of sand layers and exposure of ancient tree stumps and peat (Figure 12).

The amount of sparsely vegetated foredune and interior habitats increased as a result of the storm effects. It is unknown how results of the storm will effect the design of the short-term and long-term projects.

Figure 12: Effects of February 1998 storm at 7.5 km marker; view towards north.



National Park Service Photo, 1998.

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## 10.0 ANNEX

### Historic Photographs of Assateague Island

In a ca. 1930 family photo taken of the H.W. Taylor cabins at 'North Beach' (Annex 1.1). Low dunes with American beachgrass (*Ammophila breviligulata*), tufts of three-square (*Scirpus pungens*), and a patch of shrubs, plants typical of the sparse vegetation of a low dune beach habitat, are seen in front of the cabins. Cabins can act as sand and seed traps which accounts for the presence of plants along the outside walls of the cabin in this and other photos studied.

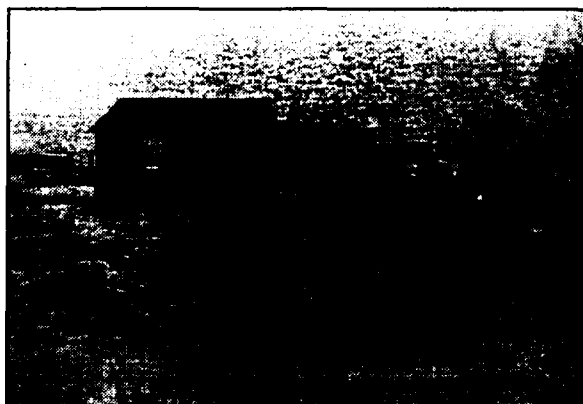
A ca. 1918 photograph of the bayside of northern Assateague shows gunning lodges (like houseboats) docked on shore. Typical tidal wetland vegetation is evident in the photo. Assateague was primarily used for grazing animals and sport hunting during this period of history and this photo is typical of the hunting and surf fishing photos located historic documents searches.

An image of Ocean City aerial photo (ca. 1925) shows the open beach condition north of Ocean City before the opening of the inlet (Annex 1.2).

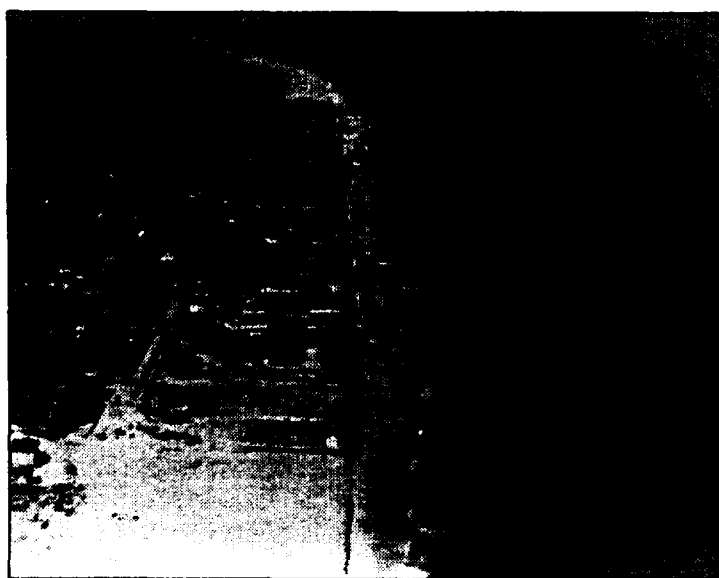
After a storm created an inlet and washover area in 1967, beach stabilization responses included erecting snowfence. An aerial photo shows the inlet closure process (Annex 2).

A map re-drawn from an 1800's map illustrates the general shape of Assateague Island at that time. Note the position of Sinepuxent Inlet as an open navigational channel (Annex 3).

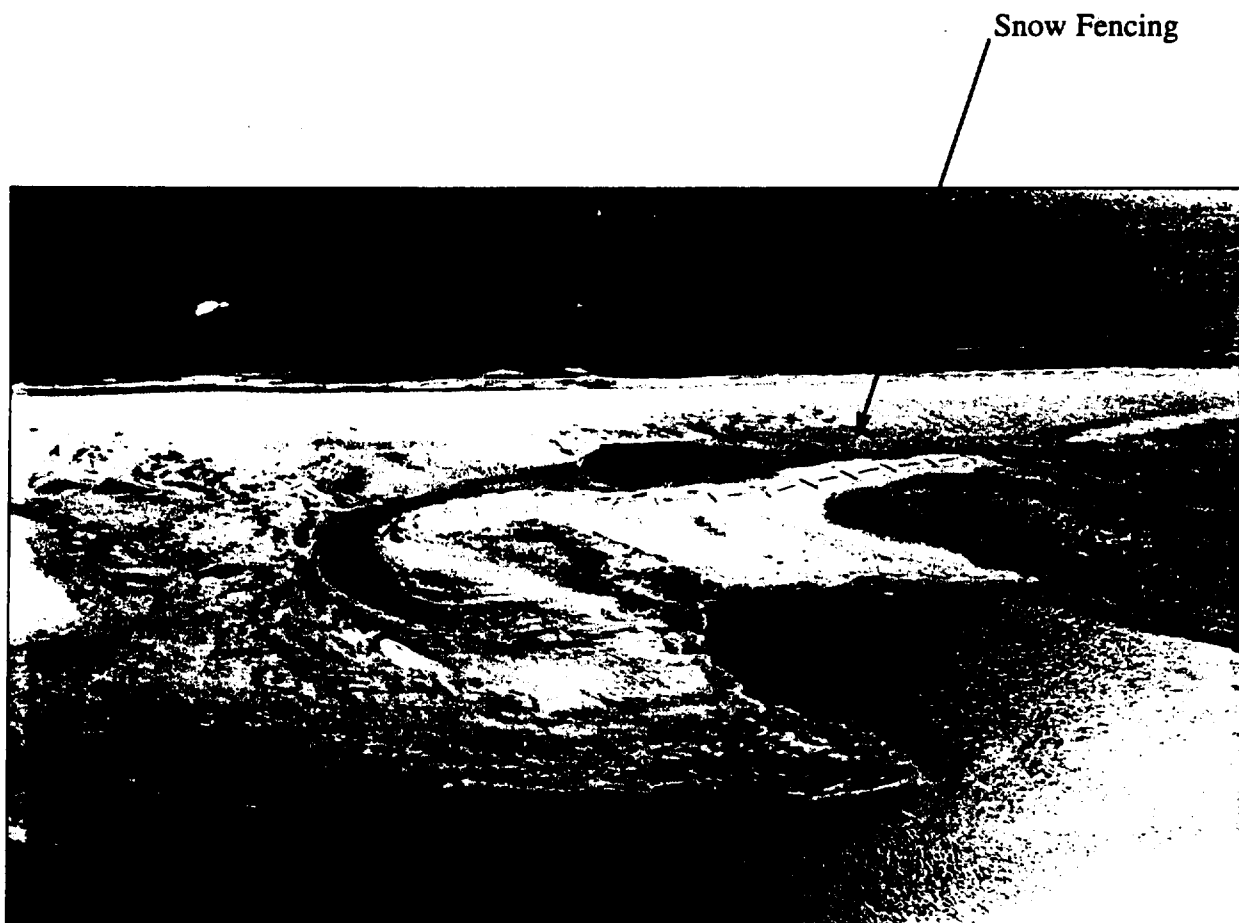
Annex 1.1: *ca.* 1930 "North Beach" cabins operated by H.W. Taylor. From photo collection at Assateague Island National Seashore.



Annex 1.2: *ca.* 1925 Ocean City, view to the North.



Annex 2: *ca.* 1967 Northern Assateague Island National Seashore inlet filling after 1967 storm.



**Annex 3: ca. 1800 Map of Worcester County, Maryland showing Sinepuxent Inlet**

