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Geomorphic Interpretation of Vegetation on Fisherman Island, Virginia

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GEOMORPHIC INTERPRETATION OF VEGETATION
ON FISHERMAN ISLAND, VIRGINIA

A Thesis

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The Faculty of the School of Marine Science

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In Partial Fulfillment

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Master of ~~Science~~ ARTS

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by

Mark E. Boulé

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APPROVAL SHEET

This thesis is submitted in partial fulfillment of
the requirements for the degree of

Master of Arts in Marine Science

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Approved, June 1976

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A

DEDICATION

TO

Lee Silver, who showed me it could be done,
and John Zeigler, who showed me where.

If you believe this, perhaps you are not right, but at least you are not a fool.

- Clavigero

I do not greatly care whether I have been right or wrong at any point, but I care a good deal about knowing which of the two I have been.

- Samuel Butler

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A thanks to all the friends and fellow students who aided this work, I know they'll miss the island almost as much as I will.

Finally, a special thanks to Kay Stubblefield and Chris Plummer. Their excellent illustrations and typing turned my garbled manuscript into what you see here.

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ABSTRACT

Fisherman Island, at the southern tip of the Delmarva Peninsula, has shown almost continuous accretion since its first subaerial expression early in the Nineteenth century. This growth is accurately recorded in a series of maps, charts and aerial photographs, the earliest of which is dated 1852.

The accretion has occurred primarily as multi-directional spit growth, with subsequent marsh growth in the protected areas to the lee of the spits. The expansion of the islands has resulted in the creation of both physiographically similar areas of different ages, and physiographically different areas of the same age.

The composition of the plant communities which occupy these different areas is a product of: 1) the initial environmental conditions, or primary sere, 2) subsequent physiographic changes, both locally and distant, (e.g. formation of new ridges to the seaward, marsh encroachment) and 3) the time since initial colonization, during which plant succession has taken place. The result of these factors is a mosaic of plant communities.

A map of the plant communities was made. The spatial distributions and relationships of the plant communities were compared to the historic maps and photographs. This provided information as to the age and location of various physiographic changes, and subsequent plant communities on the island.

These comparisons resulted in the determination of the age of various plant communities. These determinations, combined with field observations, led to the formulation of a probable sequence of succession. This succession results from geomorphic alteration of the habitat (e.g. accretion) as well as biochemical alteration.

The dune swale environment is generally characterized by a shallow water table and low wind exposure. *Myrica* spp. usually invades this community preferentially. This is a major step in the seral succession which leads ultimately to maritime forest. The early stages of this succession, which proceed to a *Prunus-Sassafrass* woodland, have been described and approximate rates of succession have been determined.

These ideas can be an aid to the geologist in determining the recent geomorphic history of a coastal environment. Using these concepts as guidelines it is possible to: 1) distinguish minor topographic variations in the marsh zone, which can lead to delineation and identification of relict geomorphic features, 2) determine approximate relative ages of ridges and dunes, aiding in the delineation and identification of structural features associated with them, and 3) predict changes in vegetation, and thus environment and habitat. Thus, these plant communities can be an aid in deciphering the geomorphology of sometimes complex and often altered coastal areas.

GEOMORPHIC INTERPRETATION OF VEGETATION
ON FISHERMAN ISLAND, VIRGINIA

INTRODUCTION

Studies of the geomorphology of the dynamic barrier beach environment of the Atlantic coast are often hindered by the difficulty in distinguishing landforms. Unlike studies of most inland areas, there may be little or nof differentiation of substrate to aid the investigator, little distinct topographic relief, and a constant alteration of physiognomy as a result of the action of wind and waves.

My objective in this study was to determine whether vegetative communities could be used as keys to the geomorphology of a highly dynamic coastal island. If so, then the technique should be applicable to other coastal areas as an aid to determining their recent geomorphic history.

Fisherman Island, in the mouth of the Chesapeake Bay (Fig. 1), was chosen as the location for this study because of its highly dynamic and well documented history. The island has an area of about 500 ha. (2 sq. mi.) and is located 2 km. south of Cape Charles at the southern tip of the Delmarva Peninsula.

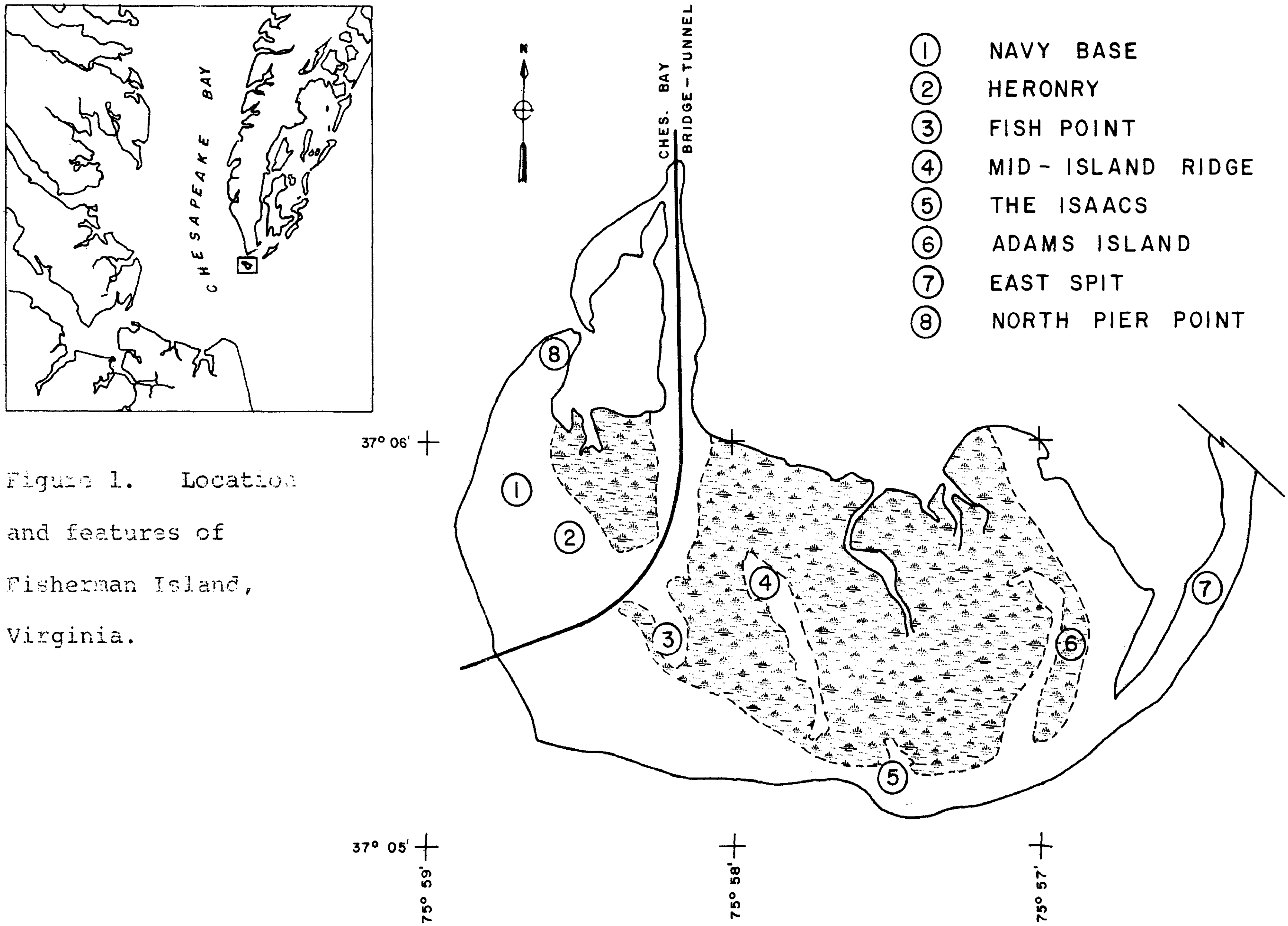

Figure 1. Location and features of Fisherman Island, Virginia.

The island's geomorphic history is reflected in both accretional structures such as spits, ridges, bars and marshes; and erosional effects such as blowouts, overwashes and structural unconformities. This history has been well documented in a series of hydrographic and topographic surveys of the island made approximately every 20 years from 1852 to the present. In addition to the US Coast and Geodetic Survey (USCGS,now National Ocean Survey) charts, there has been considerable aerial photographic coverage since 1938 done by USCGS, US Department of Agriculture, National Aeronautics and Space Administration (NASA) and the Virginia Department of Highways.

Because of the abundance of detailed and accurate mapping of the island, recent vegetative configurations, as shown in the enclosed vegetation map, could be compared to features of the past. The detailed vegetation map upon which these comparisons were based was prepared using a classification and description of plant communities modified from previous work, and a list of vascular plants collected on the island (see appendix).

METHODOLOGY

Maps and charts

A base map was constructed by enlarging an approximately 1:20,000 scale NASA color infra-red (IR) photograph to a scale of 1:10,000. Maps presented in the History of Island Development were traced at a scale of 1:20,000 from stable base copies of original Coast and Geodetic Survey topographic and hydrographic charts. Maps made from photos were either traced or enlarged to a common scale. Tables 1 and 2 are a list of maps photographs used in this study.

Photointerpretation

The usefulness of plant communities as indicators to environmental or geomorphic conditions is limited if restricted to "in the field" identification and interpretation. Fortunately, with the advent of remote sensing techniques this is not the case.

Color infra-red photography has been used by many researchers as a means of identifying and delineating plant communities (see for example Shahrokhi, 1974). In addition attempts have been made at creating classification keys to aid in plant community identification (e.g. Williamson, 1974, 1975).

TABLE 1

Maps of Fisherman Island

Date	Title	Cartographer	ID#	Scale
1770	A New and Accurate Map of Virginia	John Henry	-	-
1780	A chart of the coast of New York, New Jersey, Pennsylvania, Maryland, Virginia, North Carolina, etc. (from _The Atlantic Neptune_)	Josiah Frederick W. Des Barres		
1781	A plan of the entrance of Chesapeake Bay with James and York Rivers	Anonymous		1"=4 mi.
1799	A new chart of America (from _The Marine Atlas_)	W. Heather		
1815	Chesapeake Bay, Virginia Between the Capes and Shoals	Major Kearney		1"=2000 yds.
1852	The hydrography in the vicinity of Cape Charles	Lt. J.J. Almy	H-345	1:20,000
1852	Smith's Island, Cape Charles and Vicinity	G.D. Wise	T-509	1:20,000
1869	Hydrography of Magothy Bay, Virginia	W.W. Harding	H-1013	1:20,000
1888	Cape Charles and vicinity, Virginia	M.L. Wood	T-1203	1:10,000

TABLE 1 (cont.)

Date	Title	Cartographer	ID#	Scale
1905	Chesapeake Bay, Eastern Shore, Cape Charles and vicinity, Virginia	E. B. Latham	T-2675	1:20,000
1906	Chesapeake Bay, Fisherman Island, Virginia	J. B. Miller	T-2757	1:6000
1910-1911	Fisherman's Island to Ship Shoal Island	S. Forney	T-3191	1:20,000
1911	Ship Shoal, Smith Island and Fisherman's Island	S. Forney	H-3295	1:20,000
1942	Cape Charles, Va. 7.5 min. Quadrangle	U.S. Army	T-8183	1:20,000
1955	Cape Charles, 7.5 min. Quadrangle	U.S.G.S.		1:24,000
1968	Fisherman's Island 7.5 min. Quadrangle	U.S.G.S.		1:24,000

TABLE 2

Aerial Photographs of Fisherman Island

Date	Type	Agency	ID#	Scale
1938	Black & White	USDA	ANP22-18,19	1:19,000
1949	Photographs (B&W)	USGS	ANP 2E-42 ANP 3E-15	1:20,000
1955	Photograph (B&W)	C&GS	55 W 4321	1:20,000
1959	Photograph (B&W)	USAF	AF 59-35 1936	~ 1:50,000
1962	Photograph (B&W)	C&GS	6253251	1:20,000
1967	Photograph (B&W)	C&GS	GS-SWBK-1 1-211	1:20,000
1971	Photograph (color 1R)	NASA	Frame 1800401 Roll 187	~1:35,000
1974	Photograph (color 1R)	NASA	6-4-74 2443	~1:20,000
1974	Photograph (color)	NASA	Frame W3160102 Roll 272	~1:20,000

Using color IR imagery, marsh, dune and thicket communities can be easily delineated. With a little practice the various marsh communities can be distinguished. Dune communities are more difficult to distinguish, but it is possible to obtain an idea of relative cover for the various dune areas, since areas of low cover have a high albedo and thus appear white in the photographs.

Flora

A complete list of all the plants collected on the island is appended. Type specimens are on file in the Herbarium of the Wetlands Section at the Virginia Institute of Marine Science. For identification, "Guide to the Vascular Flora of the Carolinas" (Radford, Ahles, and Bell, 1964) and "The new Britton and Brown Illustrated Flora of Northeastern United States and adjacent Canada" (Gleason, 1952) were used. In addition,"Manual of the Grasses of the United States" (Hitchcock, 1971) was used for the Gramineae (grasses).

HISTORY OF ISLAND DEVELOPMENT

Holocene History

The Chesapeake Bay has been described as the drowned valley of the Susquehanna River (Shephard, 1973). Harrison (1965) was able to show through the use of test borings taken for the Chesapeake Bay Bridge Tunnel, that the thalweg of the "Pleistocene Susquehanna" probably ran directly below the present location of Fisherman Island (during the Wisconsin Glaciation). In order for his data to agree with that of Hack (1957), which located the channel thalweg at -60m MLW at Annapolis, Md., it was necessary to propose a crustal uplift of approximately 52m over the last 18,000 years in the vicinity of Fisherman Island. In addition, Harrison's data show a maximum of approximately 50m of sediment deposited over the channel thalweg at Fisherman Island.

These sediments have been extensively studied by Meisburger (1972). From numerous cores in the Chesapeake Bay mouth he was able to determine that the "Cape Charles Terrace", a broad terrace at about -9m MLW extending up to 9.5 km west, south and east of Cape Charles, was surfaced almost entirely with a fine gray sand (which he named Unit A) overlaying a variety of Holocene and Pre-Holocene sediments. For numerous reasons he suggests that this unit had a seaward, rather than bayward origin and probably could not have been deposited prior to 6000 years BP (Meisburger, pers. comm.).

Extending 4 Km south of Cape Charles lies the "Fisherman Island Terrace", whose outer edge is -3.7 to -5.5m (-12 to -18 ft.) MLW. Rosen (1976) has found similar terraces at this depth throughout the bay. He has suggested that these represent the shoreline at approximately 3000 years BP, the time of a slowdown in sea level rise as presented by numerous authors (Redfield, 1967; Newman and Munsart, 1968: Kraft, 1971).

To the west of Cape Charles however, the edge of these terraces is only .65 Km. from the shore, while the Fisherman Island Terrace extends 4 Km to the south. This may suggest a different origin for the Fisherman Island Terrace. The volume of this terrace above -11m MLW is approximately 1.9 X 10^8 m^3. If this feature was formed over the last 3000 years it would have grown approximately 0.6 X 10^5 m^3/yr. This is slightly less than the calculated growth rate of Fisherman Island from 1850 to 1955, which will be discussed shortly.

Thus, during the relatively constant rate of sea level rise from 6000 to 3000 years BP sediment of a seaward origin was deposited through much of the bay mouth region, creating a relatively flat terrace. With the slowdown of sea level rise, sediment deposition would tend to be confined to a smaller area close into shore, ie. the shallow Fisherman Island Terrace.

In discussing the probable effect of sea level changes in the vicinity of Fisherman Island, a note should be made of Harrison's (1965) sea level curve. He proposed a still stand of sea level up to 2.4m above the present MLW between 1500 and 200 years BP. Since sea level curves for the present (Holdahl and Morrison, 1974) show a rise in sea level for at least the past 50 years, Harrison's curve requires a sea level fall to below its present height in the recent past and subsequent rise to present rates and levels. While this is probably not an impossible situation, it does require some significant perturbation of the sea level rise-crustal movement systems. Clearly, if sea level had fallen much below the present level then a large portion of the Fisherman Island Terrace would have been exposed subaerially as an island, or possibly as an extension of Cape Charles.

Of interest to this discussion are some calculated rates of sediment deposition and discharge:

1) Volumetric growth of Fisherman Island above -3.7m MLW, 1852-1955 (This study) $1.8 \times 10^5 m^3/yr$

2) Calculated growth of Fisherman Island from -11m MLW to present surface during the last 3000 years (This study) — $0.6 \times 10^5 m^3/yr$

3) Volumetric growth of Unit A over Cape Charles Terrace over 3000 years (Meisburger, 1972) — $4.6 \times 10^5 m/yr$

4) Calculated sediment within the littoral drift system at Wachapreague Inlet (Byrne, 1974) — 5×10^5 m/yr

Such rates may vary with time, but the similarity of sediments and deposition rates suggests that the Delmarva littoral system inferred by Meisburger (1972) as a possible source for Bay Mouth sediments is, and has been the source for the sands which make up Fisherman Island.

Recent History

It is rather difficult to ascertain the earliest history of Fisherman Island or the time when it first appeared permanently as an island, due to the inaccuracies and lack of details in the old maps. These uncertainties are probably the result of a number of factors, perhaps the most important of which was the fact that the major navigation routes entered the bay in the southern portion of the mouth, avoiding the northern shoal areas. Therefore, inaccuracies in this area would not be a major concern of the cartographer. However, for the purpose of this study the available maps are being accepted as they are unless they are in major disagreement with other, more acceptable evidence.

Of all the maps on file at William and Mary's Swem Library and the National Archives in Washington, D.C. only three made prior to 1800 show any subaerially exposed area near the present location of the island. These include a map of Virginia by John Henry dated 1770, and a map dated 1781 which was presented to King George detailing the Battle of Yorktown. The Atlantic Neptune of Des Barres (1780) and the Marine Atlas of W. Heather (1799), both of which are collections of navigation charts, show only shoals in the area. Apparently Fisherman Island did not exist permanently prior to the early 19th century, although it may well have been exposed as a series of ephemeral shoals which would appear, be destroyed and reappear.

A possible mechanism to trigger permanent subaerial exposure and begin the dramatic growth of Fisherman Island has been suggested. In his court deposition of 1912, John Wise relates that Fisherman Island was known locally as Linen Bar and that "some of the old folks claimed that it took its name from the fact that it formed around the wreck of a vessel which went ashore there early in the nineteenth century, laden with a cargo of linen..."[1] In the same case, a deposition by E. W. Nottingham notes that the William

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1 U.S. vs. Skidmore, 1912. U.S. Circuit Court, Virginia Eastern District

Knight Shoals (later known as The Isaacs (See Fig. 1)) "formed around an old wreck, said to be that of the schooner William Knight."

The earliest mention of the island is an 1815 chart of the southern Chesapeake Bay by a Major Kearney, which shows two islands just south of Cape Charles identified as Bird Islands (Fig. 2). A map of Virginia by James Madison completed in 1807 and revised in 1818 identifies the area as Isaacs Shoals. The 8th edition of the American Coast Pilot (Blunt, 1815) makes no mention of Fisherman Island, and does not show it on a chart of the lower bay. In the 10th edition of the same book (Blunt, 1821) the island is shown, but neither labeled nor mentioned. It seems reasonable to assume that the Island finally became permanently exposed around 1815.

The first accurate chart of Fisherman Island(or Linen Shoals)and the Isaacs (or William Knight Shoals) was made by the Coast Survey in 1852 (See Fig. 3). At that time the island was owned by Henry Wise, governor of Virginia, and two others. In 1869 the Coast Survey completed another chart of the area, as shown in Figure 4. From this it is apparent that Fisherman Island had undergone very little subaerial change since the first survey, but the Isaacs appear to have moved

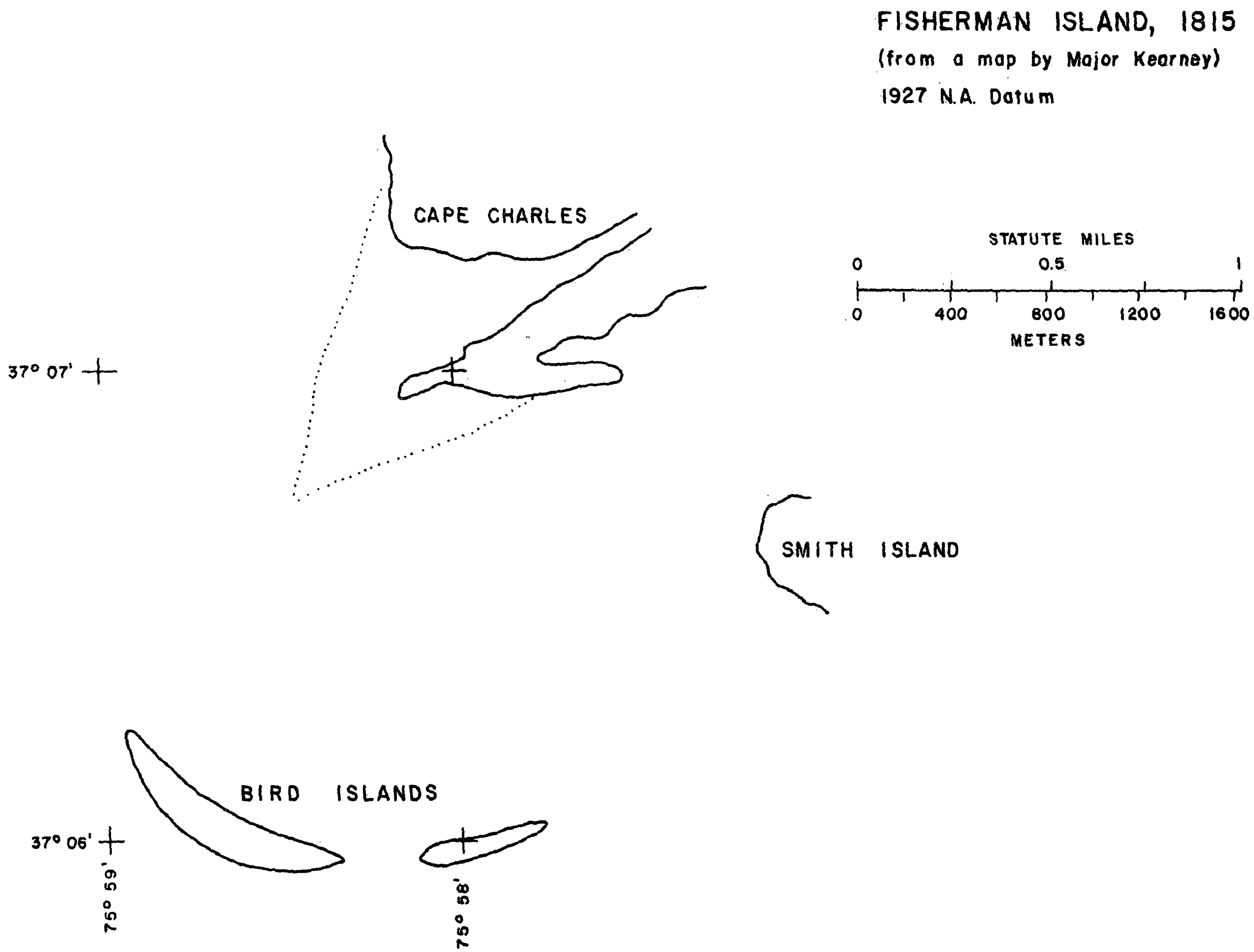

Figure 2. Fisherman Island, Virginia, 1815

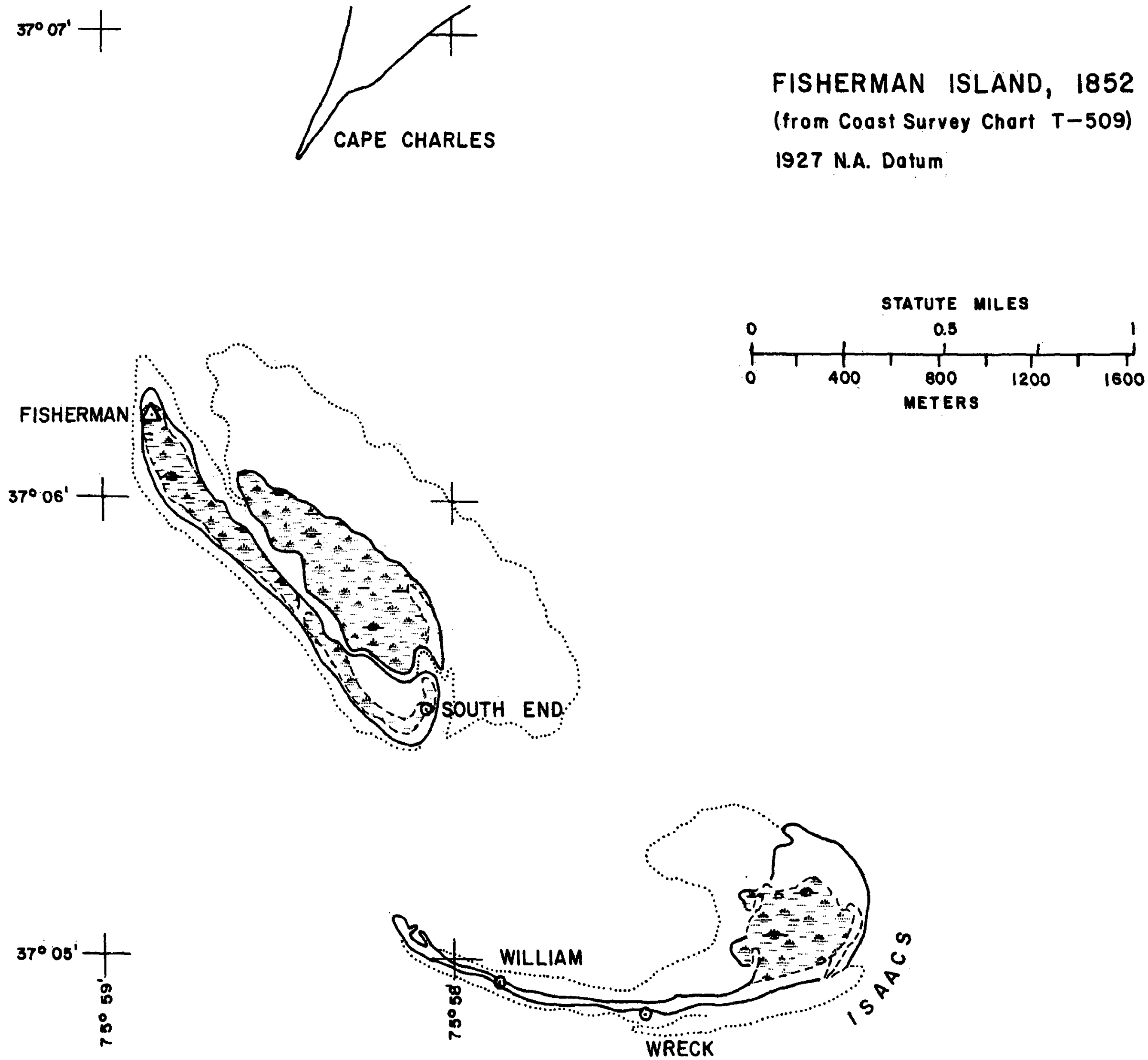

Figure 3. Fisherman Island, Virginia 1852

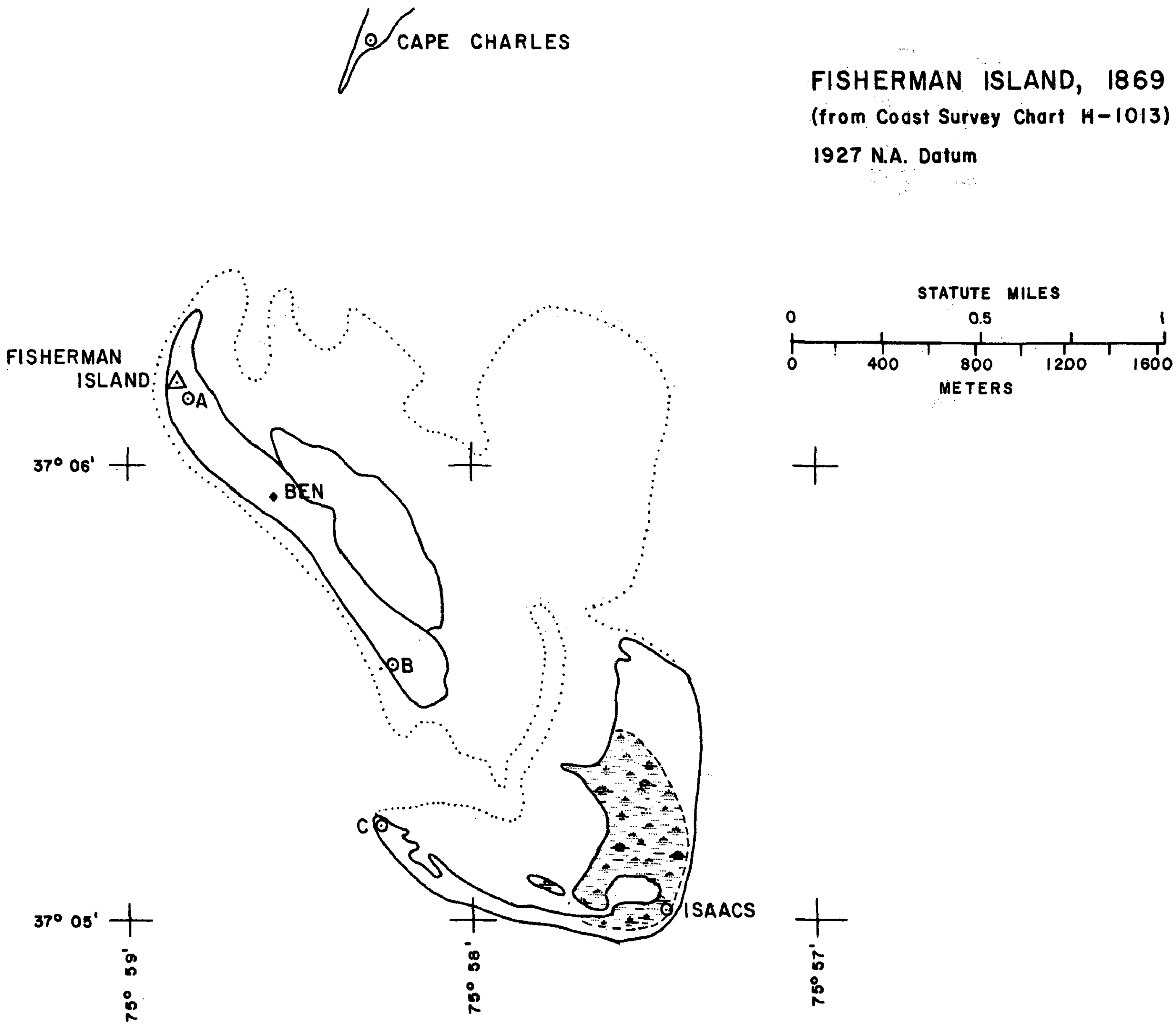

Figure 4. Fisherman Island, Virginia, 1869

considerably both to the north and west.

John Wise, son of Henry Wise, relates the effects of a major storm in 1877. He states that the island was enlarged to the east by the addition of the offshore bar which I have designated 'mid-Island ridge' (See Fig. 1). Another effect of that storm, according to Wise, was overwash on the Isaacs, separating the east-west trending spit from the north-south trending body of that island. He adds that some people felt the western spit portion of the Isaacs was a new island after that storm and called it Bird Island.

In 1888 the Coast and Geodetic Survey completed another map of the area. This is shown in Figure 5. It can be seen from this chart that a significant area of marshland had built up behind Mid-Island ridge and to the north of Fisherman Island. In addition, a sizable spit appears to have grown to the southeast from the southwest shore of the main island. As will be shown later, the lagoon behind this spit is still in existence, although it has undergone considerable alteration since its formation.

In 1883 the Marine Hospital Service began leasing the island for use as a quarantine station. Fisherman Island was permanently conveyed to the federal government in 1891 after condemnation proceedings. Soon after,

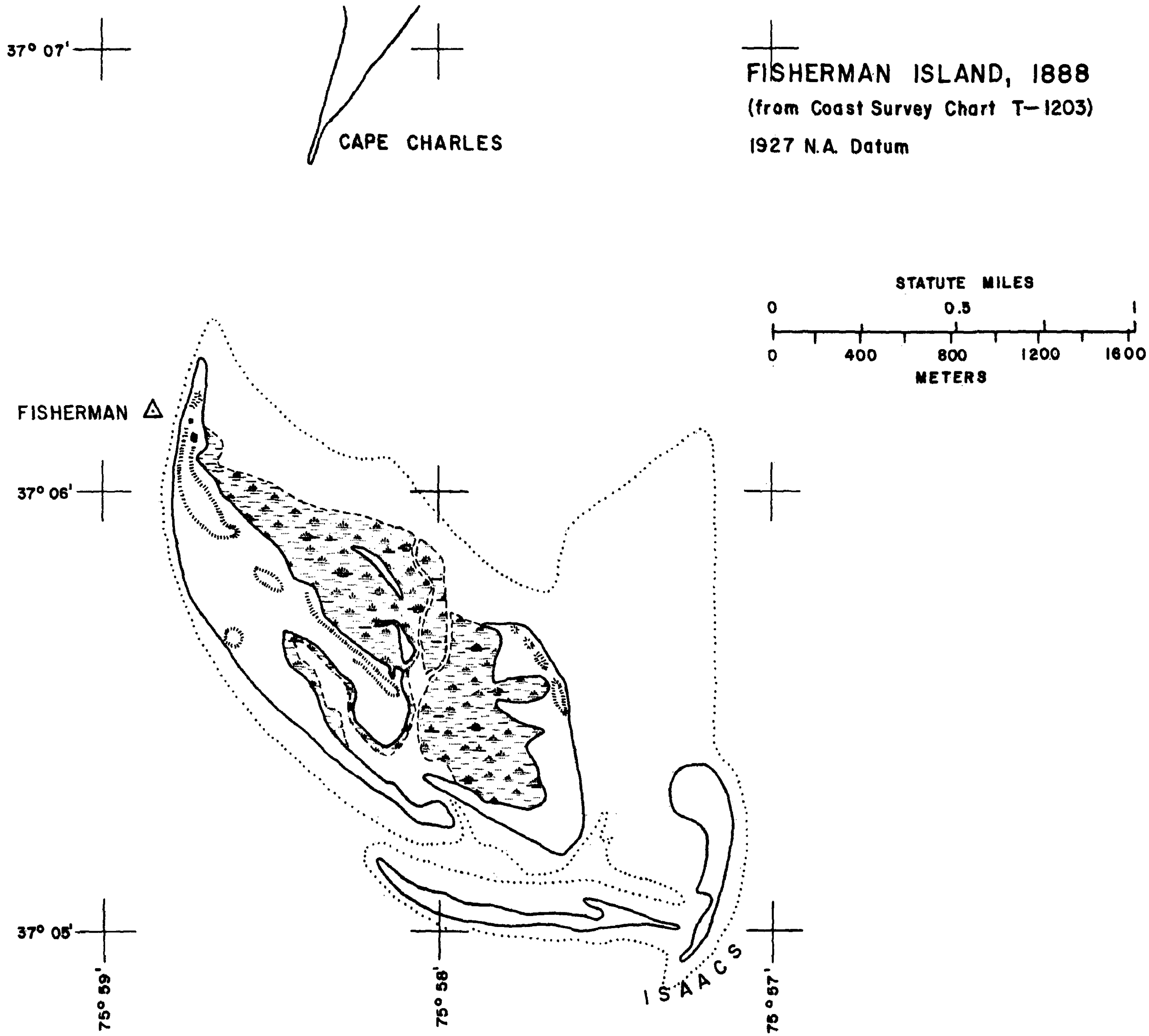

Figure 5. Fisherman Island, Virginia, 1888

work was begun on the hospital and other buildings in the complex. These buildings are shown on the charts of 1905 and 1906 (See Fig. 6). I have been unable to find any remnants of these buildings. This is probably because subsequent military installations on the island were built in the same location.

A survey was made in 1906 to determine the exact limits of the federal government's jurisdiction on the island. These boundaries, due to the constant changes in the island's configuration were often disputed by local fishermen, who were interested in gathering clams and crabs in the shallows around the island. The reports of John Wise quoted in this section are taken from a court deposition he made relating to one of these disputes.

This survey shows a westward movement of the mid-Island ridge and consolidation of the ridge with Fisherman Island proper through continued marsh growth. The Isaacs also appears to have moved westward. Coincidentally, the west end of the Isaacs seems to have separated from the east end and become joined to the south shore of Fisherman Island.

A 1914 survey by the Northampton County surveyor located a 30 acre sand bar east of the location of the Isaacs, and identified it as Adams Island. The location of this bar is plotted on the 1910 Coast Survey Chart (See Fig. 7).

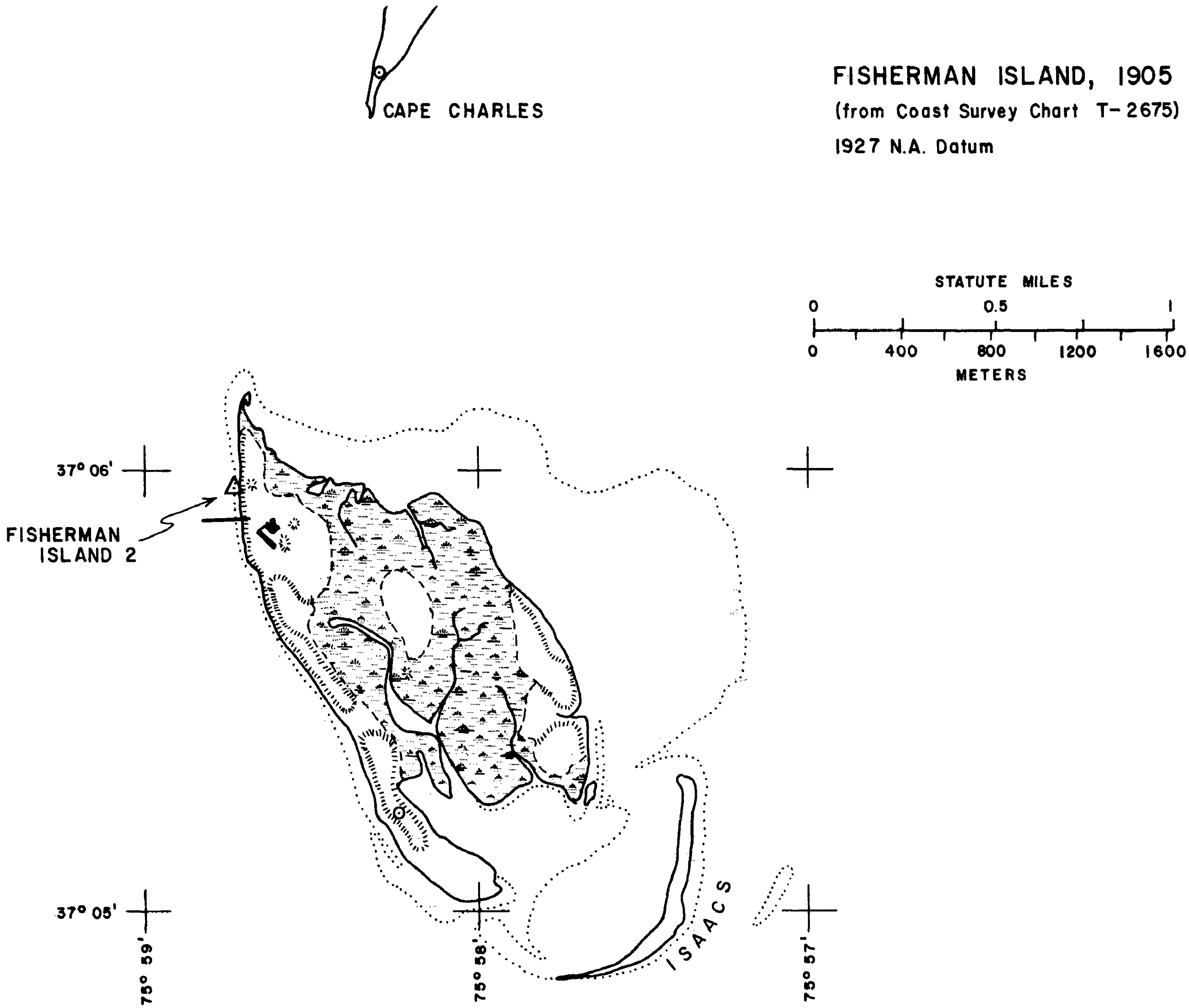

Figure 6. Fisherman Island, Virginia 1905

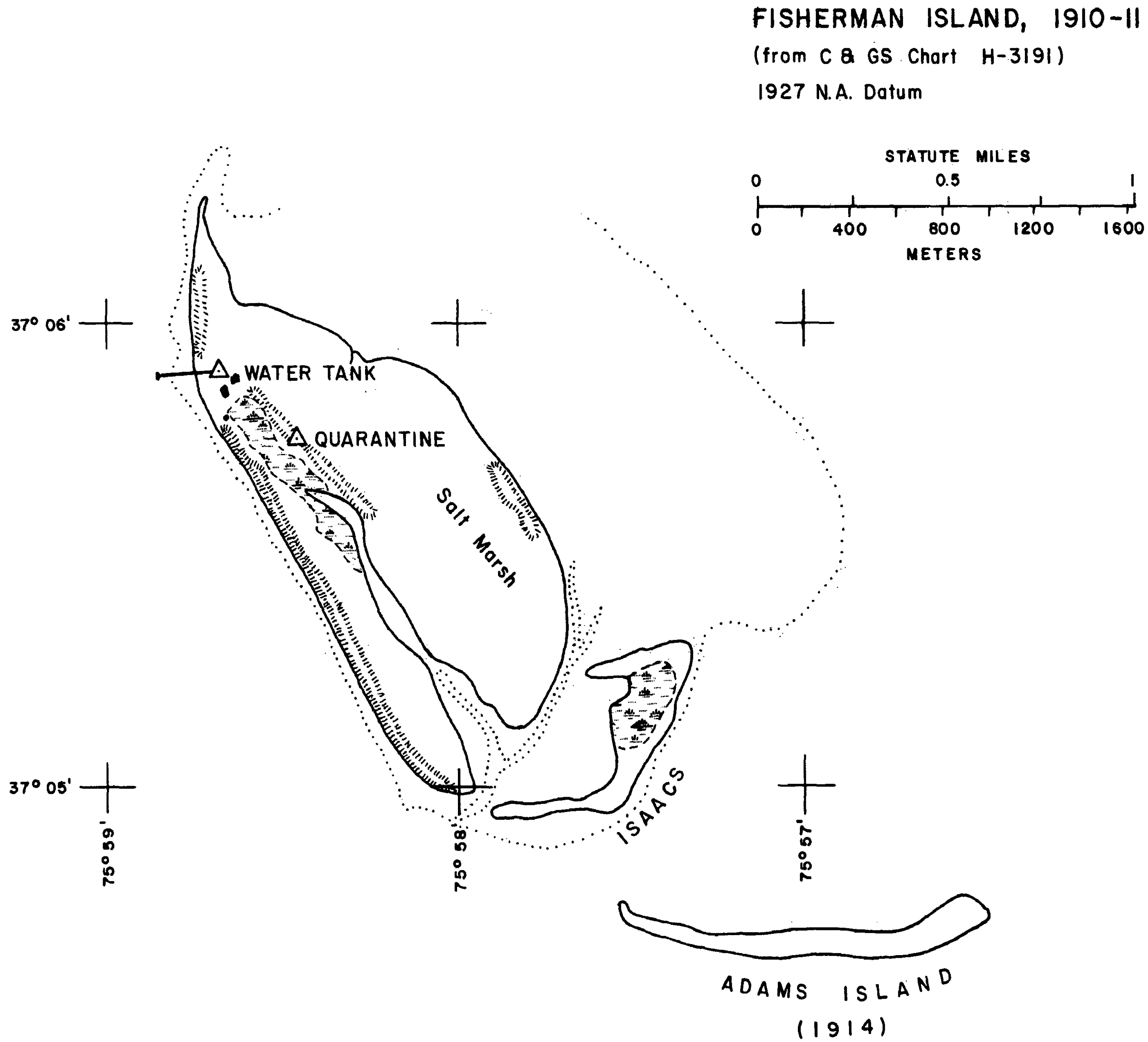

Figure 7. Fisherman Island, Virginia, 19190, with the 1914 location of Adams Island

In 1918 the island was transferred to the Dept. of Defense as a coastal artillery station. It appears that all construction and activities were confined almost entirely to the area west of the present location of the highway. This base was maintained until the early 1930's. In 1931 the Army recommended it be abandoned, and in 1934 the Secretary of War, George H. Dern, authorized the transfer of the island to the Dept. of Agriculture for use as a game preserve, as recommended by the National Audubon Society. Apparently the transfer was slow to materialize, for in 1937, the Dept. of Agriculture was notified of the necessity to maintain the island for military purposes. In 1938 the transfer was officially refused and the island recommissioned as a Coast Artillery base.

Figure 8 is constructed from a photograph taken for the U.S. Department of Agriculture in 1938. It shows an island (or sand bar) with some marsh along the west side, east of the Isaacs, but north of the 1914 location of Adams Island. In addition, the Isaacs appears to have become divided and moved westward, the northern section maintaining its integrity as an island, and the southern section joining the southeastern tip of Fisherman Island.

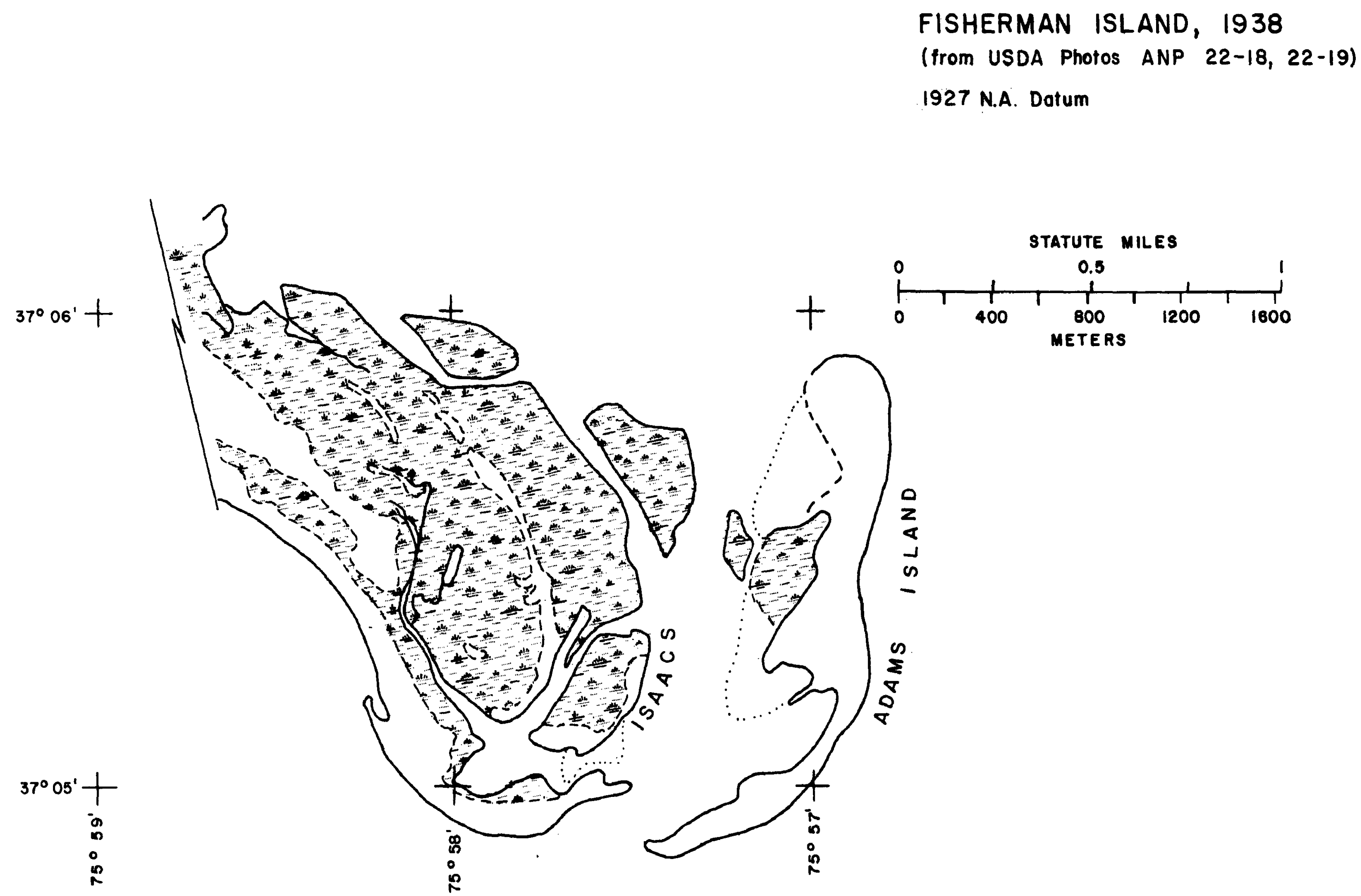

Figure 8. Fisherman Island, Virginia 1938

The C&GS has records of the establishment of a bench mark on Adams Island in 1929.[2] Later recovery notes state that the station could not be found in 1934 and was probably lost in the storm of August 1933, when the entire island was awash.

The 1942 edition of the USGS Cape Charles togographic quadrangle (See Fig. 9) shows little variation of topography relative to 1938. The southern spit of Adams Island had moved northward somewhat, and the southeasterly trending spit of Fisherman Island had developed a distinct recurve at the distal end.

By 1949, (See Fig. 10) considerable change had taken place in the island configuration. The southeast trending spit had been eroded back about 600 m, and during the same period the remaining beach along the southwest shore had noticeably widened. Also the south shores of the three islands had all but joined, forming an almost continuous shoreline separated only by inlets draining the marshes between the islands. Fisherman Island had become one. During the same period a new spit had formed to the northeast from the south shore of Adams Island, protecting the 1942 shoreline from exposure to the open ocean. This probably aided the growth of marsh west of Adams.

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2. C&GS Benchmark Recovery Notes (Adams, Northampton Co., Va., J.S. 1929)

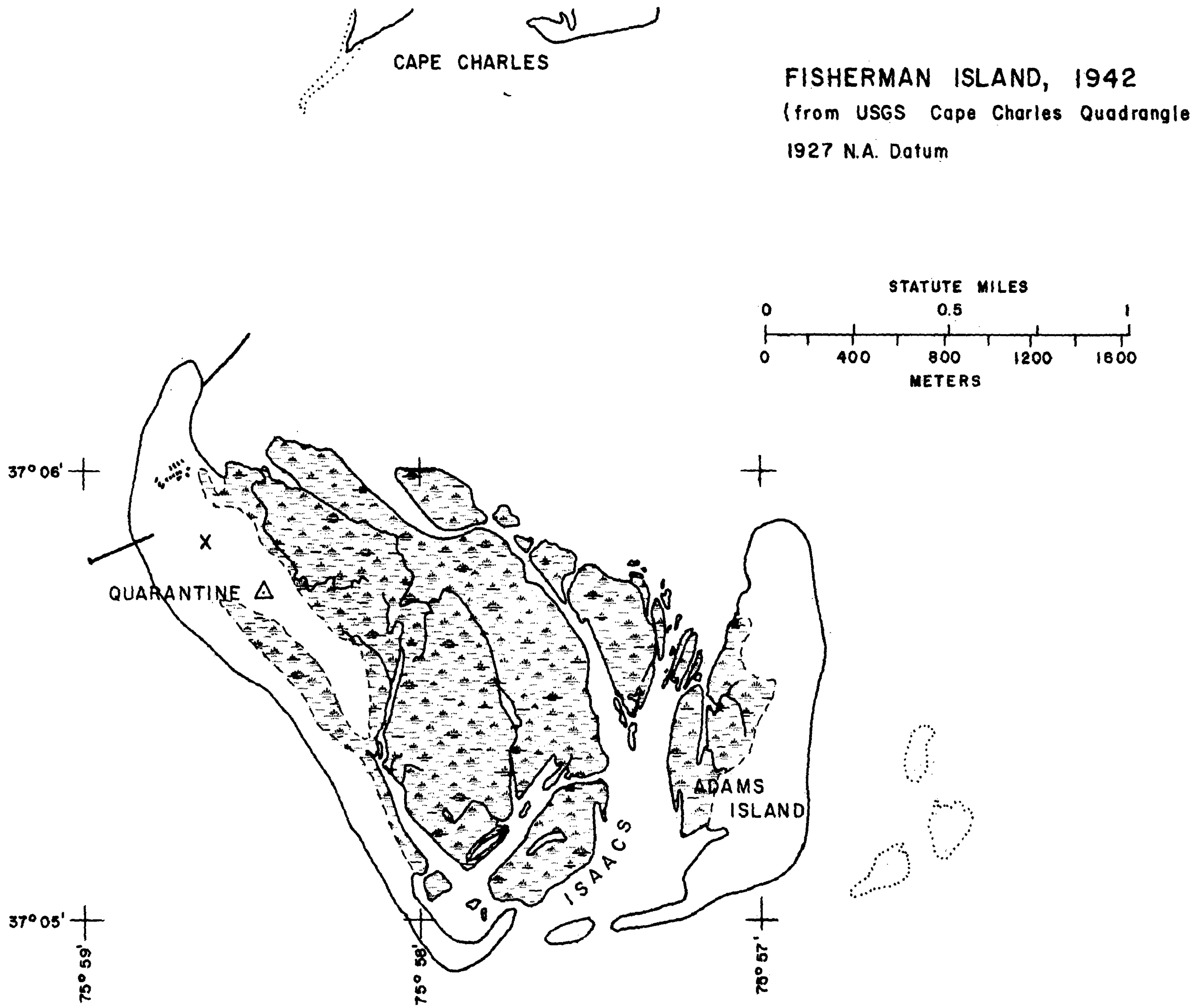


Figure 9. Fisherman Island, Virginia, 1942

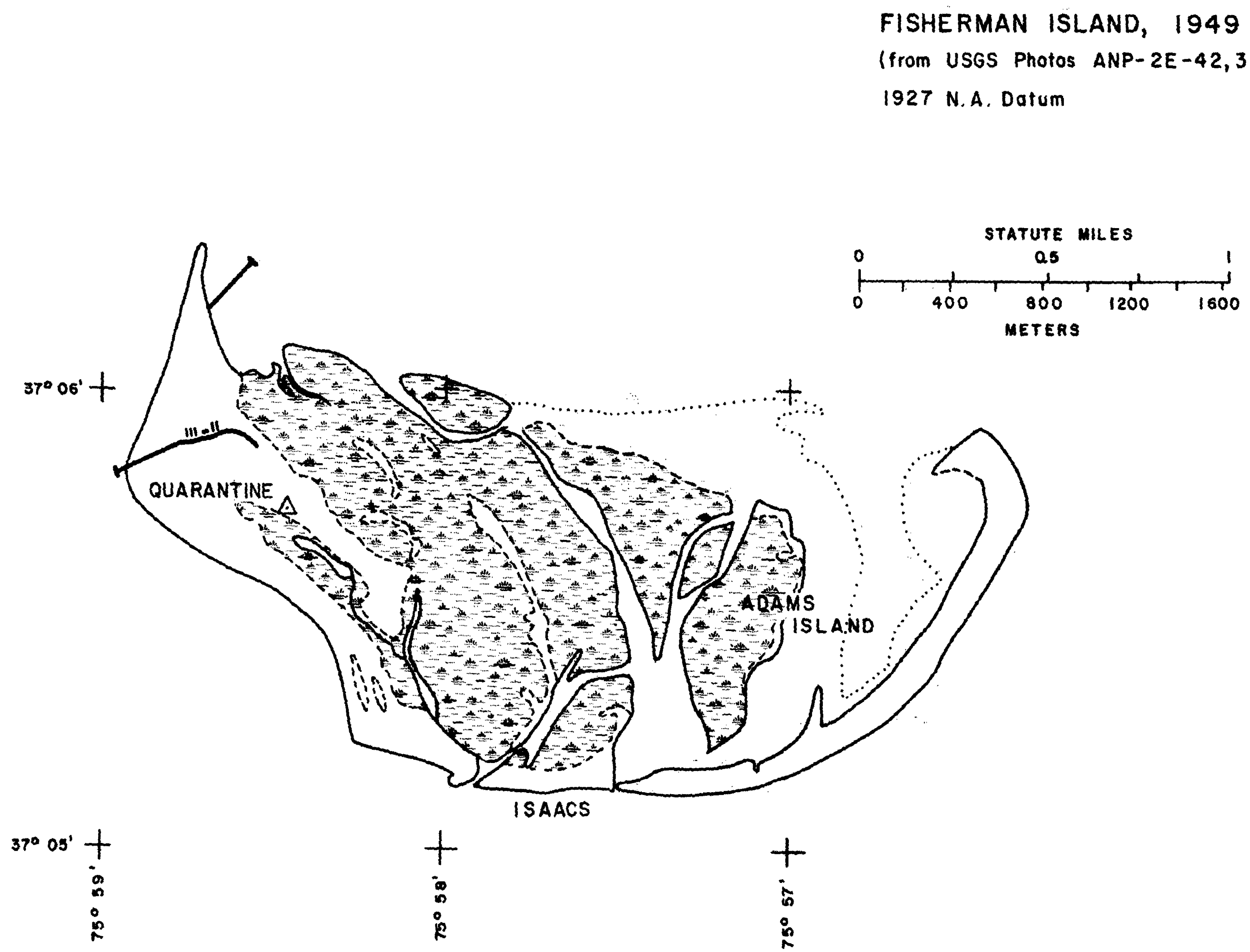


Figure 10. Fisherman Island, Virginia, 1949

A 1955 C&GS photo shows little of major change during the six years since 1949. (See Fig. 11). The south shore beach appears somewhat stabilized with a new line of dunes and a large lagoon just south of the 1949 shoreline. Also the eastern spit appears to have migrated westward and to have been breached.

By 1959 the breach in the east spit had been healed, and a new spit had formed to the east of it (See Fig. 12). This photo also shows the first effects of dredge spoil removed from the intercoastal waterway between Fisherman Inlet and Magothy Bay to the north. A small crescent shaped shoal is located about halfway between the island and Cape Charles, near the eastern terminus of the approved spoil disposal area (USA C of E, Unpub.). This same locale has been used for spoil disposal on 9 different occassions from 1959 to 1972.

The effects of the Ash Wednesday Storm (March 5-8 1962) are apparent in a photo taken on 24 March 1962 (See Fig. 13). The most obvious effects are considerable erosion and overwash along the south shore beaches, eliminating the lagoon and ridge system. In addition, the eastern spit which had appeared in 1959 was completely eroded away, leaving a low remnant of the 1954 spit to protect the ridge of 1942 and intervening lagoon from the open ocean.

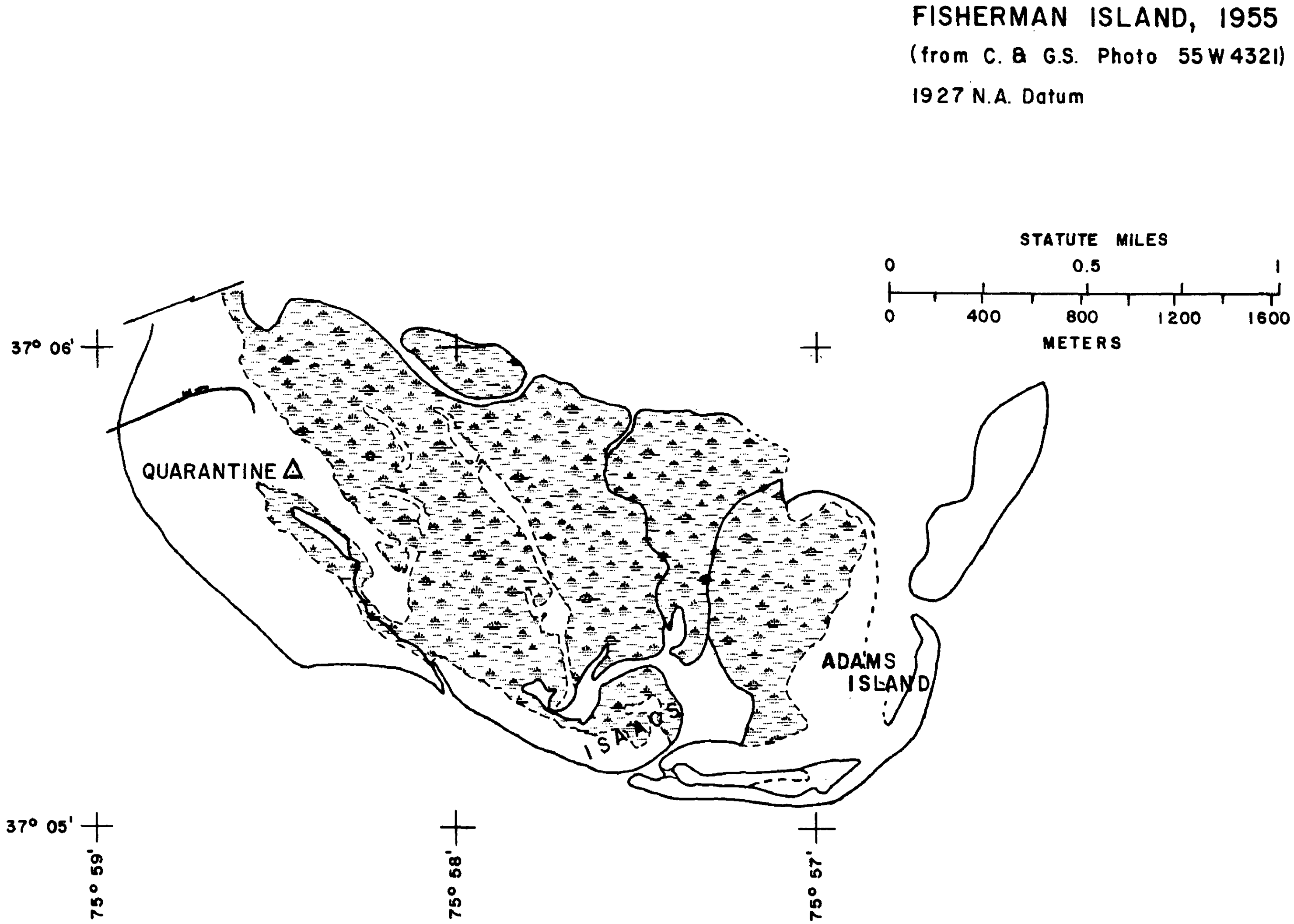


Figure 11. Fisherman Island, Virginia, 1955

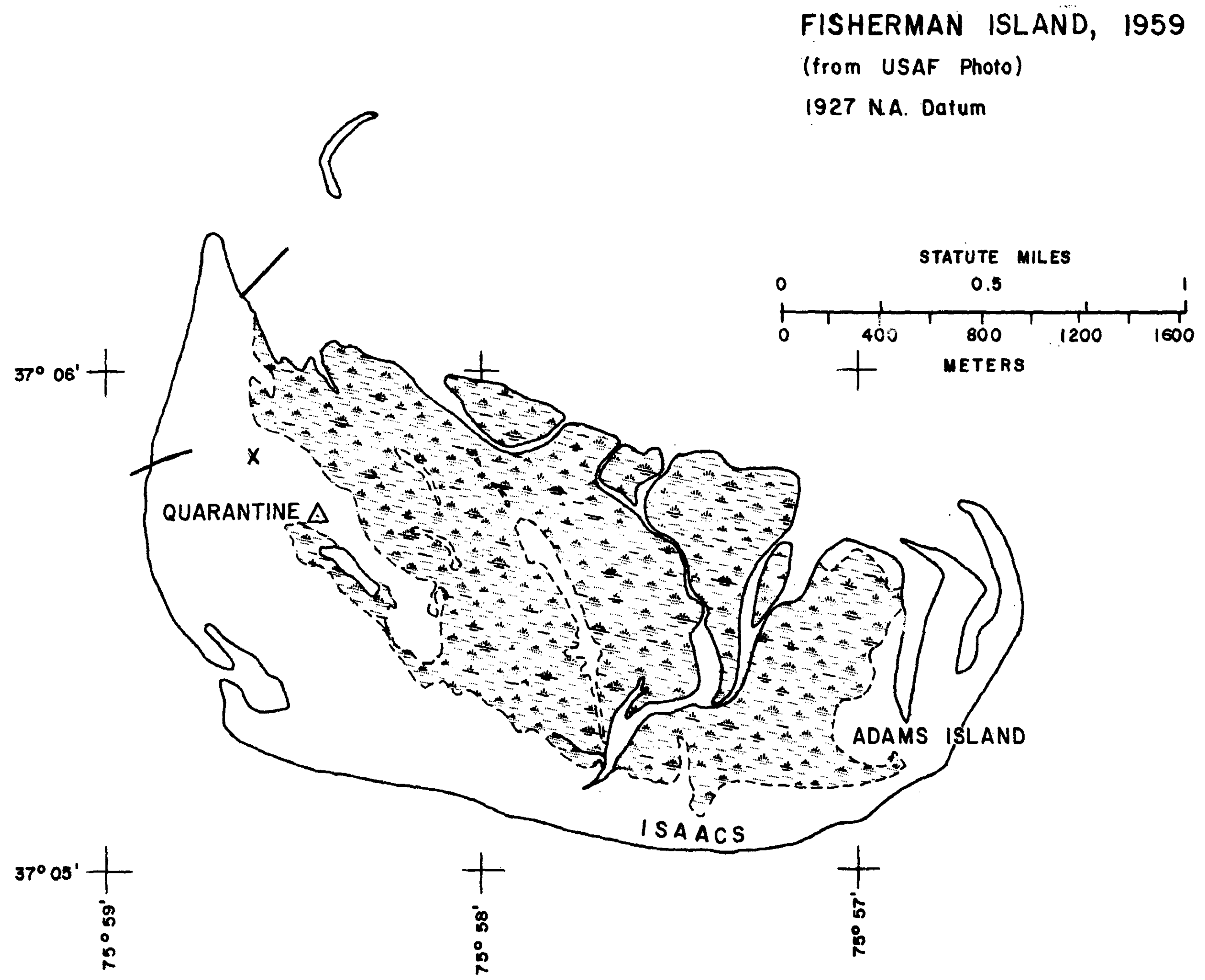


Figure 12. Fisherman Island, Virginia, 1959

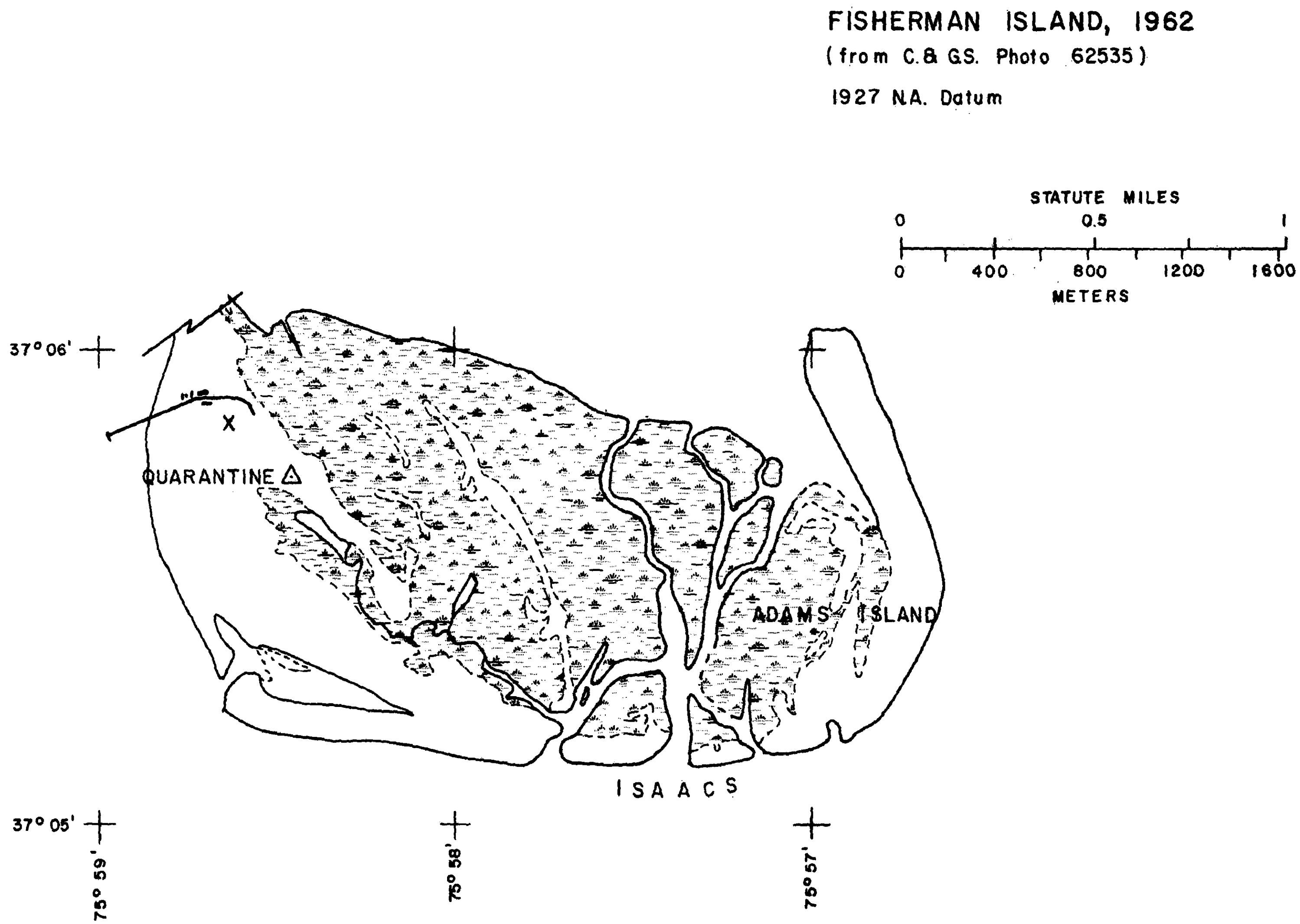


Figure 13. Fisherman Island, Virginia 1962

In April of 1962 construction was begun on the Fisherman Island Causeway portion of the Chesapeake Bay Bridge Tunnel. This construction was completed in August 1963 and consisted of a 1.5 mile causeway across the island. Construction included removal of unwanted material, which was dumped as spoil near the sides of the road, and implacement of riprap and a roadway 15 ft. above MLW. (J.P. Bailey, Chesapeake Bay Bridge Tunnel Authority, Personal communication) In addition, the Corps of Engineers deposited soil from nearby maintenance dredging at the north and southwest ends of the causeway. (J. Westcott, U.S.A. Corps of Engineers, Norfolk, Personal communication)

A 1967 C&GS photo, from which the 1968 topographic quadrangle was produced, shows the reorientation of that spoil as a spit joined to the north end of the causeway and enclosing a small tidal lagoon. (Fig. 14). Also apparent in this photo is the growth of a new spit along the eastern shore of the island. Unlike previous spits in this vicinity it is joined to the island at the extreme eastern shore, and not from the southeast corner.

A large scale (1:35,000) NASA photo taken in 1971 shows noticeable consolidation of the spoil

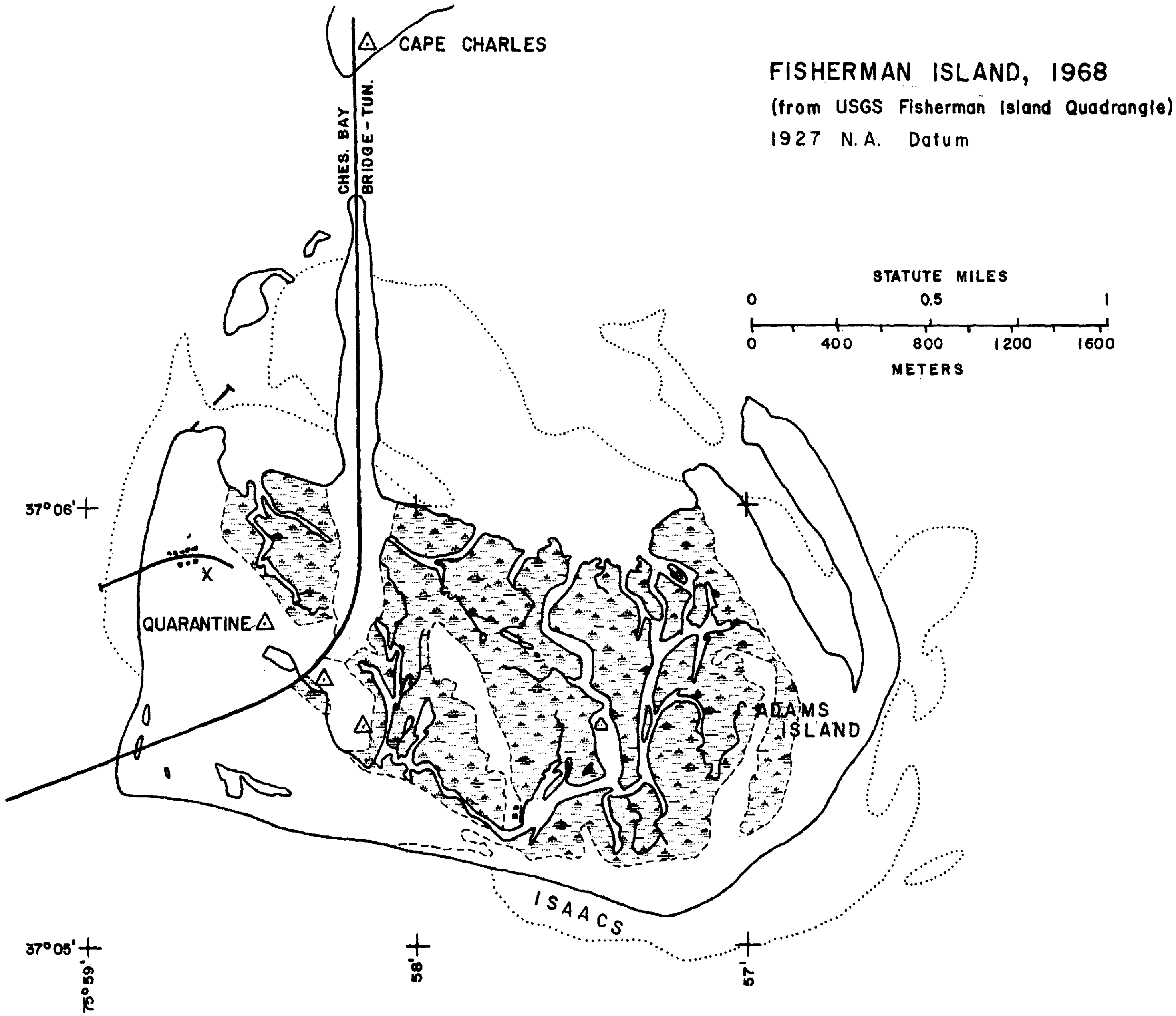


Figure 14. Fisherman Island, Virginia, 1968

island west of the causeway. In addition, North Pier Point had grown northward, leaving only a small portion of the pier in the water. Also, considerable erosion had taken place at the southwest end of the island, eliminating much of the beach apparent there in 1967. At the same time, accretion along the south shore had enclosed a number of small lagoons, resulting in a smooth, curving shoreline along the south and west shores. Along the east shore of the island another spit had formed, joining the island at the southeast shore as all but the 1967 spit had done. From this photo it is apparent also that the spit formed in 1967 had not yet become noticeably vegetated.

The final map in this series was made from a photograph taken by NASA in 1974. (Fig. 15). By this time, the spoil island to the northwest had joined the causeway and North Pier Point had grown so far north that the pier was totally exposed at low tide. Continued accretion along the south shore widened that beach seaward of the lagoons. On the east side of the island the 1971 spit had extended some 300 m.

Since 1974 few changes have taken place. The southern beach has widened and narrowed with periods of calm and storm, but remains about the same. The big

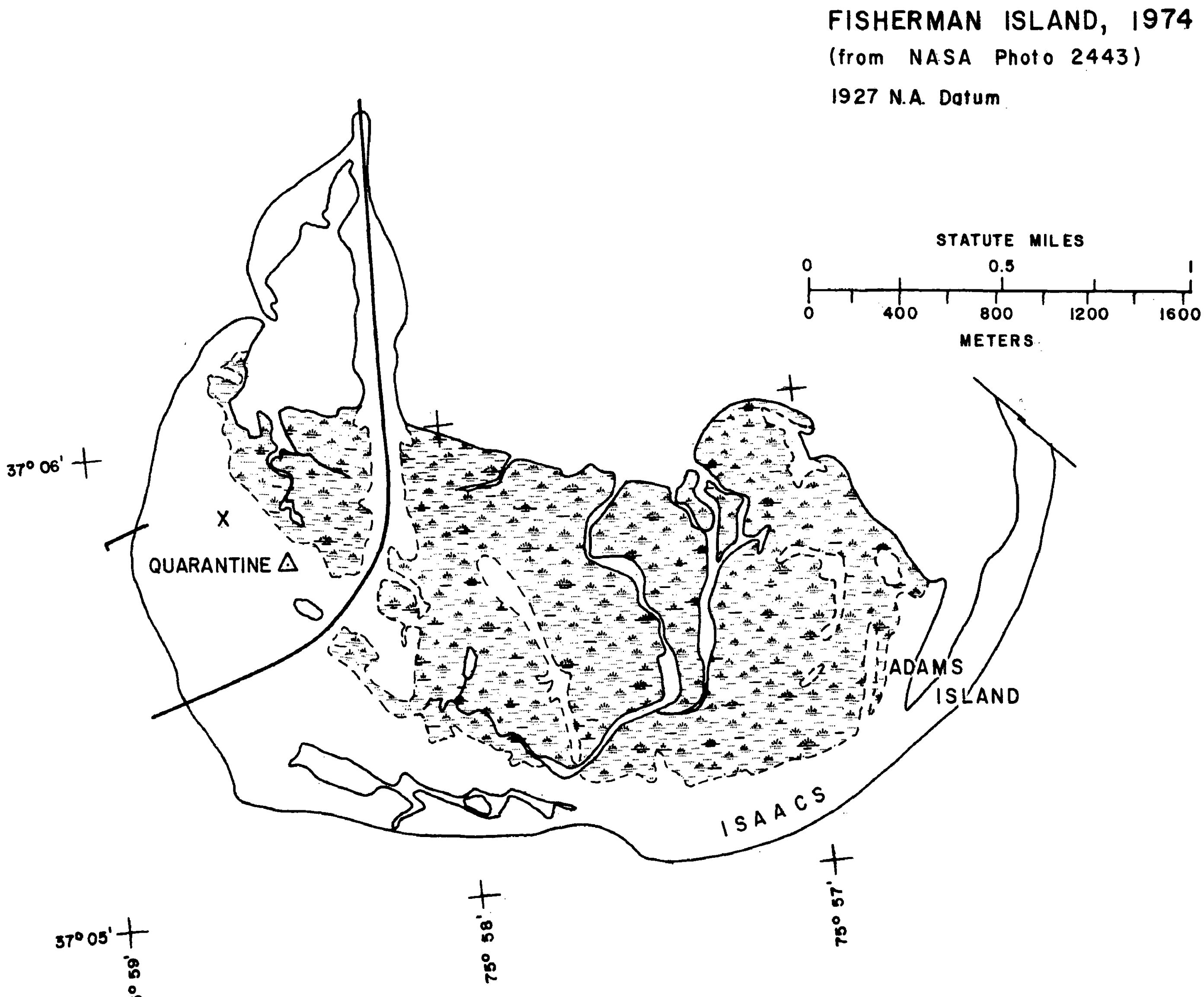


Figure 15. Fisherman Island, Virginia 1974

spit to the east was breached in November 1974 and quickly healed. No other significant changes have been observed.

Summary of Island Development

According to the account of John Wise, shipwrecks and storms probably have been significant factors in the growth of the island. With the aid of US Coast and Geodetic Survey charts and more recent aerial photographs it can be shown that much of the growth of the island has been through spit and bar formation, with subsequent growth of marsh in the protected areas behind these features.

Figure 16 is a graphic summary of the volumetric growth of Fisherman Island above -3.7 m(-12 ft) MLW as determined through planimetric analysis of available hydrographic and topographic surveys. The data from the hydrographic charts and topographic quadrangle are probably more accurate than that from the navigation charts because they are at smaller scale, and also because they result from an actual survey from that year, rather than a cursury update, as in the case of the navigation charts. Error bars are based on the history of error criteria as related by Sallenger, et al (1975). Since the error factor (5%) is much

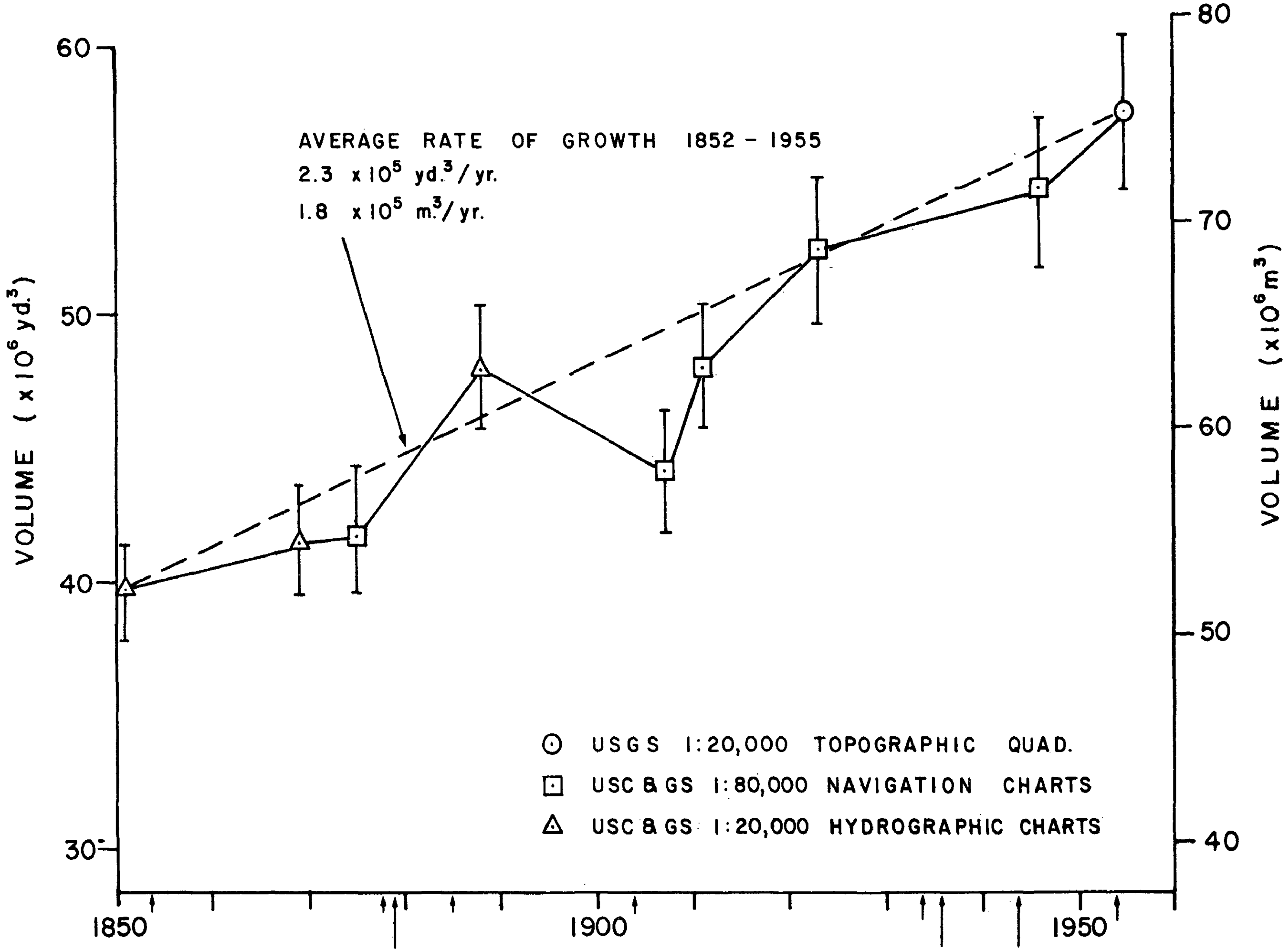


Figure 16. A volumetric history of Fisherman Island, Virginia, 1852-1955. (Arrows indicate dates of significant hurricanes on the Virginia coast. Intensity is indicated by arrow length)

greater than the apparent annual growth rate (0.3-0.5%/year) only long term trends can be inferred from this data.

CLASSIFICATION OF PLANT COMMUNITIES

Numerous authors have proposed classification schemes for vegetation on barrier islands and coastal environments along the Atlantic Coast of the U.S. The similarity of environments implies that these are also pertinent to Fisherman Island. Au(1970) presents a comprehensive discussion of these classifications as applied to the area of the Outer Banks of North Carolina. Egler (1942) presented a classification system as a result of his work at Cape Henry, Virginia. To the north, Higgens et al (1971) described a classification scheme for Assateague Island. She also reviewed the classification schemes proposed by Oosting (1954), Egler (1942) and Martin (1959).

Martin's (1959) classification was based entirely on the structure or life form of the vegetation he was studying. Thus the dune grass and salt marsh communities fall in the same broad category of herbaceous communities, despite the drastic variations in habitat and geologic history these communities represent. Higgins et al (1971),Au (1970) and Egler (1942) use a life form classification similar to Martin's (1959), but they also separate the marsh communities from those in the dunes. These life form classifications are then subdivided on the basis of topographic (hills and swales), environmental (xeric and mesic), or floristic (Pine and Pine-deciduous) criteria. The other classifications mentioned are based on a simple habitat division (sand strand and marsh) with subdivisions on the basis of structural (treeless or trees and shrubs) or topographic (beach and dune) criterions.

The goal of this study has been to create a method of vegetation analysis which can be of use to the geologist as well as the botanist studying the coastal environment. Thus the processes and rates of succession are of primary importance, and must be reflected in any classification scheme. In addition, to be of use to the geologist, who is often untrained in botany, the communities must be readily identifiable. This requires describing communities on the basis of a few easily recognizable and prevalent (i.e. dominant) species.

My system of community classification is based on Clements (1928) concept of the development of a formation or climax community. This concept describes the development as a cause and effect interaction of habitat, life-forms and species. In essence, the creation (or geological development) of a primary sere (i.e. a new and unvegetated area) provides a habitat for pioneer plant species to invade. These species in turn alter the habitat (through nutrient enrichment and sediment accumulation, for example) so that other species are capable of outcompeting the original pioneer species, due to the less extreme conditions of the habitat. This process of habitat improvement and consequent alteration of plant communities (which leads to continued habitat improvement) progresses until a stable condition is attained. This stable condition is represented by the climax community, which is capable of reproducing and maintaining itself, preventing any possible invaders from overcoming it.

There has been considerable debate about the validity of the monotypic climax concept as advocated by Clements (1928). It is generally agreed however, that the maritime forest community (a Pine-Oak association) is climax for the mid-Atlantic coastal area. For this study, salt spray climax communities of grasses or shrubs, as described by Wells (1942) have been considered to represent a disclimax situation, subject to change with subsequent shoreline change.

Probably the most common method of describing plant communities is on the basis of dominant species. In the case of multilayered communities, restricting the description of the community to the dominants of the overstory might be a weakness if the classification system were applied to areas beyond the mid-Atlantic coastal region. However, the ideas and concepts presented here should be useful over most of the Atlantic coast, although the community composition will not always be the same.

DESCRIPTION OF VEGETATION

A short description of the plant communities distinguished in this study will now be given. The primary title for each community refers to its physiographic location, or, where appropriate, its structural form. The subtitle, in parentheses, gives its dominant composition. The lettered abbreviation is the symbol for the community on the vegetation map. In this discussion both scientific and common names (where applicable) will be given. In the following sections only common names will be used, as an aid to the non-botanist.

Pioneer Beach Community (*Cakile*, *Xanthium*), BP - On the back beach and below the foredune (if one exists) is found a sparse community which is subject to infrequent inundation but frequent and intense salt spray and wind-blown sand. *Cakile edentula* (Sea Rocket) and *Xanthium strumarium* (Cocklebur) are the most common occupants of this area. Others include *Salsola kali* (Russian Thistle or Tumbleweed) and *Atriplex arenaria* (Beach Orach). On protected beaches, such as on the lee side of spits,or overwash channels, Sueda linearis, Euphorbia polygonifolia (Seaside Spurge) and Portulaca oleracea (Purselane) can be found. These are often rooted in sand covered debris (usually the Spartina rafts so common in the coastal area). Through the growing season wind-blown sand is trapped around these pioneer plants and low irregular hummocks are formed. With the added elevation or a widened beach, Panicum amarum (Running Panic Grass), Spartina patens (Salt Meadow Hay), Cenchrus tribuloides (Sandbur) and even an occasional specimen of Solidago sempervirens (Seaside Goldenrod) will become established.

Foredune Community (Ammophila, Spartina), DF - Usually the most prominent feature on the beach is the foredune. It is densely covered with Ammophila breviligulata (American Beach Grass) and occasionally Spartina patens (Salt Meadow Hay), with rare or locally abundant specimens of Cenchrus tribuloides (Sandspur), Xanthium strumarium (Cocklebur), Panicum amarum (Running Panic Grass), Panicum amarulum (Bunch Panic Grass), and Solidago sempervirens. Ammophilia tolerates, and may actually be dependent on the accumulation of sand about its base (Ranwell, 1972). For this and other reasons it is the dominant species of the active foredune.

Low dune (Spartina patens, Solidago, Eupatorium), LD - When the foredune is isolated from its sediment supply by the formation of another dune seaward of it, its vegetation cover undergoes changes. Conditions are no longer optimum for Ammophila and it begins to thin out. Cover is only locally greater than 50%, and usually less. Eupatorium hyssopifolium (Thoroughwort), E. capillifolium (dog fennel), Solidago sempervirens (seaside goldenrod), Oenothera humifusa (evening primrose), Atriplex patula (orach), Cynodon dactylon (bermuda grass), Eragrostis spectabilis (purple love grass) and Panicum amarulum (bunch panic grass). Less frequently Hordeum pusillum (little barley) and Cyperus retrorsus are found.

In areas where a continuous disturbance has existed, it appears a state of "disclimax" (Odum, 1959) is reached. The disturbance may be wind induced, or the result of man's influence, as in areas around the navy base. These communities appear to maintain this state of disclimax until the cause of the disturbance is arrested. The next two communities reflect these conditions.

Ridge Crest (Solidago, Monarda, Cenchrus), RC - This community is found along ridges or the crests of ridges which are isolated from wind-blown sediment but sufficiently higher than the foredune to receive most of the full force of the onshore winds, often causing blowouts. Such erosion undercuts (Ammophila breviligulata (American beach grass), Spartina patens (salt meadow hay) or other grasses with horizontally spreading rhizomes. As a result, the common members of this community are Solidago sempervirens (seaside goldenrod), Monarda punctata (horsemint), both vertically rooting perennials; and Cenchrus tribuloides (sandspur), a grass whose seeds are generally too heavy to be windblown. Often the tufts of dead A. breviligulata will attest to the unsuitability of this habitat for that species.

Old dune (Panicum, Cenchrus, Spartina patens) DO- In large areas, substrate disturbance will result in constantly changing patterns of erosion and deposition. The result is a medium to sparse cover of representatives from various dune communities which are locally dominant. Here Panicum amarulum (bunch panic grass), and Cenchrus tribuloides (sandspur) are easily recognizable. Spartina patens (salt meadow hay) and Ammophila breviligulata (American beach grass) can be found, indicating local aeolian deposition. Oenothera humifusa, Solidago sempervirens (seaside goldenrod), Opuntia sp. (prickly pear), and Diodia teres (buttonweed) can also be found, often widely scattered. On the lee side of some dunes dense concentrations of Heterotheca nervose (grass leaf aster) and Gnapalium obtusifolium (sweet everlasting) can be found. Cover may vary locally from 0 in the base of blowouts to almost 100% in areas where sand accretion is conducive to the growth of Ammophila breviligulata.

Low marsh (Spartina alterniflora), SA - This is the lowest portion of the marsh, characterized by daily and extended tidal inundation. S. alterniflora (salt marsh cordgrass) is the only phanerogam which can survive here, and here it flourishes. It may vary from low vigor plants of only 25 cm. which rarely bloom and provide as little as 30% cover, in the upper portion of the marsh, to high vigor plants of over 100 cm. with prolific flowering and near 100% cover in the lower portions of the marsh. This high vigor form has also been noted on creek levees in some localities.

High marsh (Salicornia, Spartina), MH - Almost everywhere along the upper limits of the low marsh a usually narrow zone dominated by Salicornia or saltwort, usually S. virginica, but also S. biglovii is found. Spartina patens (salt meadow hay) and S. alterniflora (salt marsh cordgrass) are also present, but do not dominate. *Distichlis spicata* (salt grass) can also be found here, as can *Limonium nashii* (sea lavender) with its distinct panicle.

Upper marsh (*Spartina*, *Distichlis*, *Borrichia*), MU - Moving up the marsh, the next readily visible floristic change is a zone characterized by *Borrichia frutescens* (sea oxeye), *Spartina patens* (salt meadow hay) and *Distichlis spicata* (salt grass). Discrete patches of *Juncus roemerianus* (Black tipped needlerush) rarely more than 7-7 m in diameter are also found in this zone, but not usually in abundance. Individual specimens of *S. alterniflora* and *Salicornia* spp. are sometimes found here also.

Panne (*Distichlis*, *Sueda*, *Salicornia*)P - These areas of sparse vegetation have often been described and explained (Chapman, 1974; Redfield, 1972) as locales of highly saline sediment due to inadequate drainage. Usually located in upper or high marsh zones, they are often covered by a mat of blue-green algae. *Distichlis spicata* (salt grass) *Suaeda linearis* (sea blight) and *Salicornia virginica* (saltwort) are the most common invaders of this algal mat area. *Salicornia europea* and *Agalinis maritima* (Geradia) are also found here in lesser numbers.

Marsh transition (*Iva*, *Baccharis*)MT - This zone is generally considered the upper limit of the marsh (Marcellus, 1972; NOAA, 1975). *Iva frutescens* (marsh elder) and *Baccharis halimifolia* (groundsel tree) are the dominant shrubs of the community. These are known collectively as the salt bushes. The understory is primarily *Spartina patens* (salt meadow hay) and *Distichlis spicata* (salt grass). *Teucrium canadense* (American germander), *Borrichia frutescens* (sea-oxeye), and *Setaria geniculata* (foxtail) can also be found here, though not usually in significant numbers.

Dune-marsh boundary (*Spartina*, *Setaria*, *Festuca*) DM - This community almost always separates any marsh community from any dune community. The ubiquitous *Spartina patens* (salt meadow hay) is usually a major component of the community. However, the easily recognized flowering heads of *Festuca octoflora* (six-weeks fescue) *Setaria geniculata* (foxtail)and sometimes *Andropogon scoparius* (little blue stem) distinguish it from both dune and marsh communities. In addition the lack of *Ammophila* also aids in distinguishing it from dune communities.

The community can also be found in dune swales where the elevation is at or near the water table. These swales may hold several centimeters of standing water after a heavy rain. Under these conditions other elements of this community may include *Sabatia stellaris* (sea pink), *Strophostyles umbellata* (marsh bean), *Scirpus americanus* (common threesquare), *Juncus gerardi* (black grass), *Cyperus filicinis*, *Fimbristylis spadicea* and *Andropogon elliotii* (Broom sedge).

Where the community borders a permanent water body which may grow temporarily after a rain, *Hibiscus moschutos* (marsh mallow)and *Kosteletzkya virginica* (seashore mallow) are found.

Thicket (*Myrica*, *Prunus*, *Rhus*), T - In many locales this community is made up of *Myrica cerifera* (wax myrtle) and *M*. *pennsylvanica* (Bayberry). (These near-identical shrubs will be referred to collectively as bayberry.) Generally this monogeneric situation appears to be indicative of a relatively young thicket. Older thickets often contain *Baccharis halimifolia* (groundsel tree), *Rhus coppalina* and *Prunus serotina*. In some locales individuals or clumps of *Zanthoxylum clava-herculis* (Hercule's club) can be found. The very dense canopy of this thicket precludes almost any understory. Around the edges *Lonicera japonica* (Japanese honeysuckle) is a principle invader. Other lianas may include *Mikania scandens* (climbing hempweed), *Rhus radicans* (poison ivy), *Parthenocissus quinquefolia* (virginia creeper) and Campsis radicans (trumpet vine).

Woodland (Sassafrass, Prunus, Ilex) W - In the winter when the understory has died back this community has the appearance of a low open woodland. The bottom of the canopy is 3-5 m. above the ground, and the top may be 10-15 m. Sassafrass albidum is the dominant species, accounting for as much as 60-70 % of the canopy. Prunus serotina (black cherry) is the other major part of the overstory. In addition, scattered specimens of Juniperous virginiana (red cedar) can be found. Two specimens of Pinus taeda (loblolly pine) have been noted also, and may represent the beginnings of an influx. Below the canopy can be found Ilex opaca (holly), Myrica cerifera and M. pennsylvanica, although many of the Myrica appear to be old and dying.

As can be seen on the vegetation map there is only one example of this community on the island. Since it is used as a nesting area by hundreds of egrets and herons, Fish and Wildlife personnel requested that work be limited there until after the nesting season. Therefore I cannot be sure of adquate sampling within this area. The understory is very sparse and made up primarily of Lonicera japonica, Parthenocissus quinquefolia, Rhus radicans, Smilax spp. (green brier) and other lianas.

Annuals found here include Phytolacca americana (poke) and Bidens bipinnata (spanish needles).

Fresh marsh (Spartina patens, Scirpus, Andropogon) FM - This small community is not a fresh marsh as normally defined since there is no regular inundation. However, the preponderance of species common to the upper regions of fresh-water marsh led to this designation. Spartina patens (salt meadow hay) and Scirpus americanus (threesquare) are the predominant species in this area. Andropogon virginicus (beardgrass) and A. elliottii (Elliott beardgrass) are common, as are Woodwardia virginica (Virginia chain fern), Osmunda regalis (royal fern) and Apocynum cannabinum (Indian hemp). Polygonum punctatum (water smartweed) and P. pensylvanicum are also found here, but not in great numbers. At present the surrounding thicket is slowly encroaching on this community.

Ruderal (Melilotus, Ambrosia, Spartina patens) R - This community borders the highway along most of its route across the island. A roadside waste area, it contains many species common to such areas. Melilotus alba (sweet clover), Ambrosia artemsiifolia (ragweed), Spartina patens (salt meadow hay) and Heterotheca *subaxillaris* (camphorweed) are the dominant species here. *Eupatorium capillifolium* (dog fennel), *Oenothera laciniata* (seaside evening primrose) and *Plantago virginica* (plantain) are also common.

It should be noted that these community descriptions are the result of subjective judgements and based on both visual estimations and considerable laboratory identifications. In general the communities are well defined and easily recognized, both in the infra-red aerial photography and in the field. However, this is a dynamic system, so changes are constantly taking place. Geomorphic changes can result in the alteration of exposure to the wind and its associated sand and salt. Seral changes are also taking place, as will be described in the succession section.

In the transition from foredune to low dune or ridge crest communities, which results from geomorphic changes, American beach grass does not die out immediately, but rather loses vigor and fecundity. As bayberry invades the dune-marsh community, a seral change, foxtail, salt meadow hay and other species tend to thin out, probably as a result of competition for light. Ultimately the investigator must decide how far along these changes must progress before the community is considered altered. Such problems must be considered, but the result should not seriously affect the conclusions.

Floristic notes

Approximately 140 species, representing 46 families have been collected and identified from Fisherman Island. These are listed in the appendix. Among these are 8 species not previously reported from Northampton County, and two state records. (A. M. Harvill, Personal communication). These are all noted in the appendix.

Hibiscus syriacus and Ligustrum amurense were probably both imported during the period of human occupation of the island (1885-1959). Carex kubomungi, reported from widely scattered locales on the East Coast, is found at only one location on the island, a vigorous patch near the north end of the Bridge-Tunnel causeway.

Uniola paniculata, a common foredune colonizer of the Outer Banks of North Carolina, is scattered over much of the west side of Fisherman Island. However, it is interesting that nowhere is it found on the foredune. Instead it is found, usually locally abundant, in the low dune communities, 20 to 250 m. from the nearest active foredune.

Several areas of interest have been noted on the vegetation map by numbers. The description of the areas follows.

1) This dense community, located in two widely separate areas, is dominated by Gnaphalium obtusifolium, which accounts for perhaps 50% of the cover. Other species within the area include Eupatorium capillifolium, Spartina patens and occasionally Solidago sempervirens or low vigor Ammophila breviligulata.
2) Located at the distal end of the eastern spit which was severely washed over during the Ash Wednesday storm (5-8 March 1962) this area is characterized by Spartina patens meadow. The meadow is irregularly broken by small dunes which are sparsely vegetated with a ridge crest community. Solidago sempervirens is the dominant species. Spartina patens and Ammophila breviligulata are widely scattered within the area. Cenchrus tribuloides is apparent but infrequent.
3) Surrounding this shallow pond is a high marsh community dominated by Spartina patens and Scirpus robustus. Kosteleskya virginica, Hibiscus moscheutos and Ptilimnium capillaceum are not frequent, but this is the only location on the island where they are found.
4) This is a flat area on Mid-island ridge, apparently in the mouth of an old overwash. The vegetation here is characterized by clumps of Andropogon with rare specimens of Fimbristylis spadicea and Spartina patens.

The clumps are up to 0.5 m in diameter and appear slightly raised (2-5 cm.) above the surface of the surrounding unvegetated substrate. There is about 0.5-2 m of space between the edges of these clumps.

5) Both areas covered by this community are relict spits which are bordered by marsh on three sides. Vegetatively they are characterized by a moderate to dense stand of Ammophila breviligulata which appears robust, but shows a low fecundity. Spartina patens, Festuca octoflora and Setaria geniculata are also common here. The community appears to be making a slow transition from foredune to dunemarsh, probably as a result of both isolation and marsh encroachment.

6) This area, located in the center of a large Myrica thicket, is dominated by a stand of recently killed Myrica spp. It is discussed extensively in the Transect Study section.

7) This is an almost pure Distichlis spicata meadow surrounded by Iva frutescens and Baccharis halimifolia. Sparse Fimbristylis spadicea is also found here.

As a result of a very dry winter and spring in 1976, the pond and impoundments along the southern shore of the island have all but dried up. This will undoubtedly lead to significant changes in the communities of these regions. It is hoped that study in these regions will be continued in order to document the floristic changes this drought will bring about.

Summary of community classification

Table 3 is a summary of the plant communities and their physiographic locations as just described. The various communities reflect variations in environmental conditions which result from variations in physiography. These physiographic variations in turn are a result of the geomorphic processes which created them.

Thus, only in some cases can individual geomorphic features be defined strictly on the basis of the vegetation which covers them. The most obvious example of this is the marsh. Here certain halophytic species, such as salt marsh cordgrass and saltwort are positive indicators of the feature. Some of these species (e.g. saltworts) are obligative halophytes, requiring saline habitats for survival. Others such as salt marsh cordgrass are only facultative halophytes, tolerating frequent saline inundation and depending on it to eliminate competitive species (Chapman, 1972).

In addition to identifying the marsh as a geomorphic feature, the various marsh communities can also be an aid in delineating subtle changes in topography. Chapman (1974) and others have noted that the frequency of tidal inundation is a principle factor in determining the distribution of salt marsh vegetation. In the upper portions of the marsh where the slopes are often low, TABLE # 3

Plant Communities and Their Physiographic Relationships

Community	Symbol	Species Composition (common name)	Physiographic Feature	Indicates
low marsh	SA	*S. alterniflora* (cordgrass)	marsh	frequency of tidal inundation and thus, elevation
high marsh	MH	*Salicornia* spp. (saltwort) *S. alterniflora* (cordgrass)	marsh	frequency of tidal inundation and thus, elevation
upper marsh	MU	*S. patens* (saltmeadow hay) *Distichlis spicata* (salt grass) *Borrichia frutescens* (sea oxeye)	marsh	frequency of tidal inundation and thus, elevation
transition zone	MT	*Iva frutescens* *Baccharis halimifolia* (salt bushes	marsh	frequency of tidal inundation and thus, elevation
pioneer beach	BP	*Cakile edentula* (sea rocket) *Xanthium strumarium* (cocklebur) *Cenchrus tribuloides* (sandspur)	back beach above high water line	accreting beach and new foredune forming

TABLE # 3 (cont.)

Community	Symbol	Species Composition (common name)	Physiographic Feature	Indicates
foredune	DF	*Ammophila breviligulata* (American beach grass) *S. patens* (salt meadow hay)	active foredune	vertical accretion; high exposure to wind, sand and salt
low dune	DL	*S. patens* (saltmeadow hay) *Solidago* (goldenrod) *Eupatorium capillifolium* (dog fennel) *Oenothera laciniata* (evening primrose)	inactive, protected dune or ridge	low exposure to wind, little accretion or erosion
ridge crest	RC	*Solidago sempervirens* (goldenrod) *Cenchrus tribuloides* (sandpur) *Monarda punctata* (horsemint)	exposed ridge or dune crest, blowouts	high exposure to wind, but no windborne sand,
dune marsh	DM	*S. patens* (saltmeadow hay) *Setaria geniculata* (foxtail) *Festuca octoflora* (six-weeks fescue)	dune swale	very low exposure, proximity to water table.

even a change in elevation of only 3 cm (0.1 ft) can lead to significant changes in the frequency of tidal inundation (Boon and Boule, in prep.). These variations in frequency of inundation can lead to significant changes in the vegetational distribution. Thus gross changes in plant communities in the marsh can delineate minor elevation changes. Therefore, plant communities can be used to identify topographic changes and consequently aid in identifying relict features, such as deltas, channels and bars which have been "drowned" by encroaching marsh.

An excellent example of this can be seen at the north end of mid-island ridge where a number of features can be delineated by changes in vegetation (See Fig. 17). A line of hummocks covered with Transition vegetation rise only inches above the surrounding upper marsh, but probably indicate a low spit-like elongation from the northern end of the old ridge. Likewise the narrow band of high marsh surrounded by upper marsh in this same area probably indicates the site of an old overwash which separated the previously mentioned hummocks from the main body of the ridge.

In the dune area, the foredune community of American beach grass is indicative of an active building foredune.

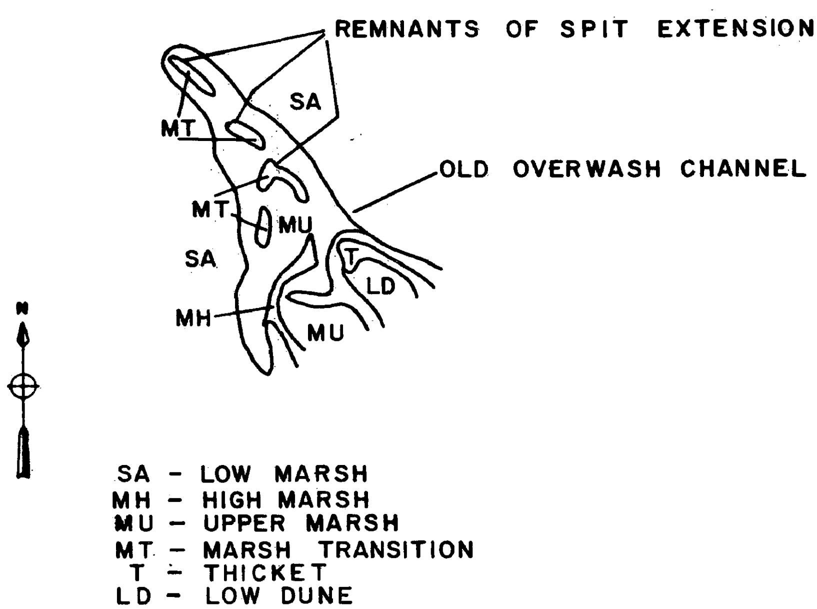


Figure 17. Vegetation at the north end of Mid-Island Ridge, Fisherman Island, Va.

Behind this, in the back dunes, the low dune ridge crest and dune marsh communities are indicative of relative topography and the degree of exposure. The swales are almost always occupied by the dune marsh community or its seral successors, the ridges by the low dune or ridge crest communities.

The ridge crest and low dune communities can be used to define the elevations of these backdunes of older ridges relative to the present foredune elevation. As mentioned before this seems to be primarily a result of the degree of exposure of these backdune areas to the erosive effects of the wind. (The effects of wind-borne salt probably figure into this also. However, the evidence suggests its effect drops off precipitously behind the foredune (Oosting, 1954; Martin 1959).) This relative elevation may also be an aid in determining the period of time a given ridge existed as a foredune, if the rate of vertical accretion can be considered relatively constant.

Thicket and woodland communities are not indicators of particular features, but rather of a process of environmental development or seral succession as will be described in the next section. Bayberry is an early invader into dune-marsh communities, often beginning this invasion within 10 years after the dune-marsh community is established. Once this invasion begins, the bayberry thicket will enlarge until it dominates the habitat and begins to expand into neighboring habitats.

Once the thicket has become established Sassafrass and black cherry will soon move into the area, beginning the formation of a woodland community. This influx of hardwoods may begin as soon as 10 years after the initiation of a thicket, but usually appears 20-30 years later.

SUCCESSION

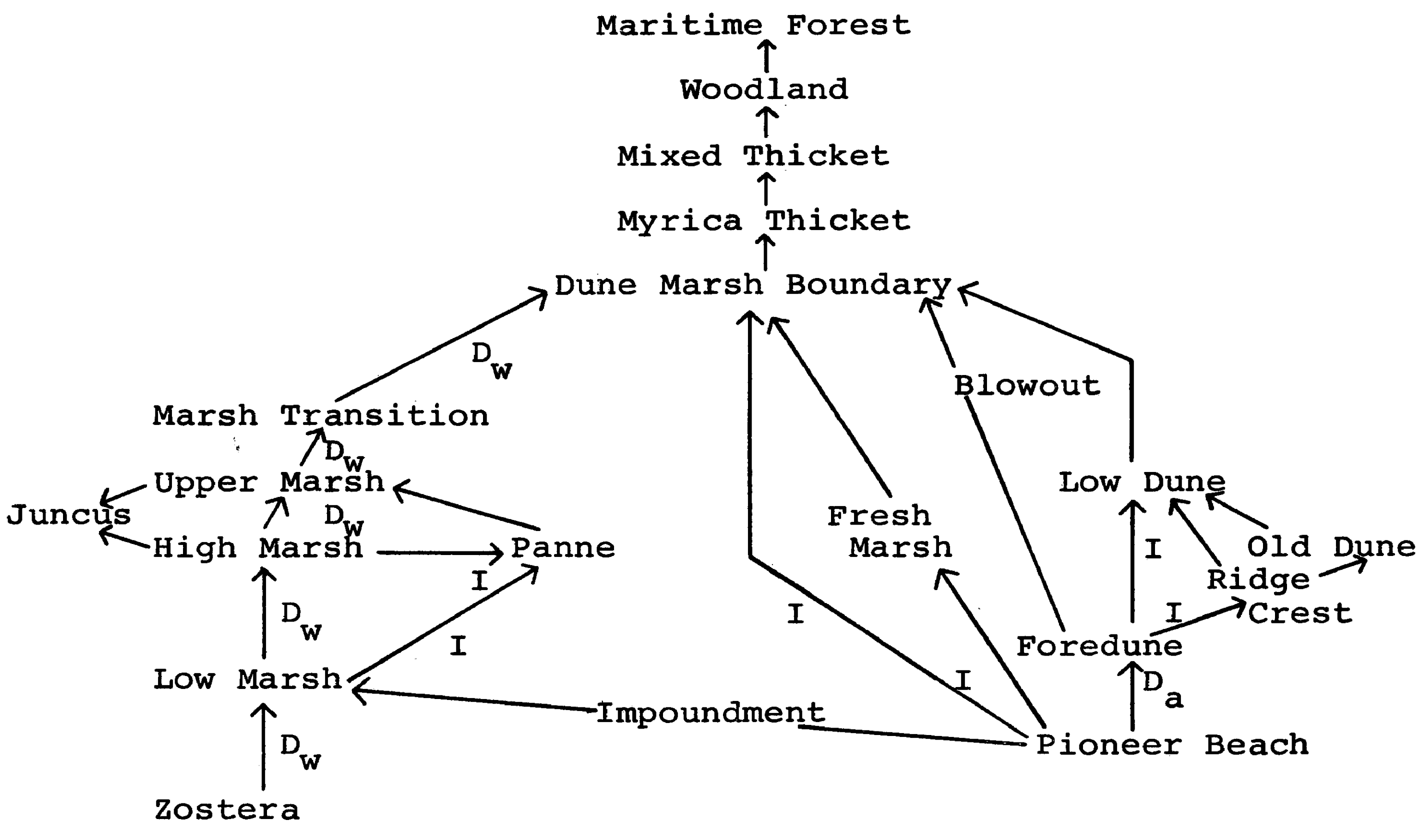
Development

Clements (1928) has defined succession as "the universal process of formation development", where the formation is a distinct vegetative unit which develops from a prisere or primary stage to a climax. The process of this development from pioneer to climax was outlined in the previous section. He further states that within a given climax physiography may produce a number of developmental areas, and by implication, developmental pathways (i.e. the stages of biotic succession). These pathways are exhibited in the zonation of vegetation on coastal islands.

Wells (1928) has outlined a simplified version of two developmental pathways. Au (1970) has expanded on this and described a three path successional relationship for Shackleford Bank. Fig. 18 presents the recognizable seral pathways as they have been noted on Fisherman Island. Where physiographic changes are an important part of the seral process they have been noted.

PATHS OF SUCCESSION AS OBSERVED ON FISHERMAN ISLAND

(With additions from Wells, 1929; Au, 1970; and others)



Legend

D_a - Subaerial Deposition

D_w - Subaqueous Deposition

I - Isolation

Fig. 18

It should be noted that Oosting(1954), Martin (1959) and Higgins (1971) have questioned whether the structural zonation in these areas represents seral stages in biotic succession. Each speaks of the stability of "successional relationships between vegetative zones if there is no physiographic change " (Higgins, 1971 p42). Yet each recognizes the lack of physiographic stability in this environment. This implies that local physiographic changes affect the successional relationships.

Description of the process

Generally there are only two types of primary bare areas on coastal islands. The xerosere is a very dry area, such as the pioneer beach environment. The hydrosere in contrast is a wet, intertidal area and characterizes the primary marsh habitat.

The xerosere is initiated with the subaerial deposition of sand beyond the reach of destructive high tides. This deposition may take place at the terminal end of a spit, as an offshore bar or seaward of the foredune. Invasion by pioneer beach species such as sea rocket, cocklebur or russian thistle is the first stage of the dune sequence. If these pioneers survive subsequent destructive storms they begin collecting wind-blown sand about themselves (Chapman, 1964). Sand is also deposited about any debris which collects on the back beach.

Eventually deposition around beach pioneers species forms incipient dunes sufficiently elevated above tidal influence to allow establishment of American beach grass (and often salt meadow hay). These rhizoidal grasses not only act to stabilize the dunes, but also trap sand, building the dune. Continued deposition can also lead to connection of the dunes into a linear beach ridge.

The formation of a beach ridge brings about a variety of physiographic and environmental, and thus floristic changes. The previous foredune is now cut off from the beach. This diminishes not only its available windblown sand, but also the wind-borne salt spray. Without regular sand deposition to inhibit invaders and encourage its growth American beach grass soon thins. This, combined with the decrease in salt spray, enables other species to become established and soon a low dune community develops.

Occasionally one of the back dunes is higher than the foredune. Such a back dune may be far enough back to be protected from wind borne salt and sand, but sufficiently elevated to receive the full force of the onshore winds. The erosive effects of these winds create a habitat unfavorable to grasses which spread by horizontal rhizomes or wind carried seeds. Perennials and grasses with vertical rooting and/or heavy seeds seem to do best here. This state of disclimax will be maintained as a ridge crest community as long as wind induced erosion prevails.

Where the ridge crest community is large enough an unusual situation develops. Erosion in one portion of a dune field leads to deposition elsewhere. Thus the old dune community is characterized by barren blowouts, sparsely vegetated areas and dense stands of American beach grass where local deposition is taking place. In addition, most influences of man in the area will probably tend to increase erosion also. Like the ridge crest this community will be maintained as a disclimax until the erosional influences are minimized and stabilized vegetation can become dominant.

The formation of a new foredune also leads to the creation of a swale between it and the previous foredune. Numerous authors have discussed the differences in environment between ridge and swale (Au, 1970; Oosting and Billings, 1942; Chapman, 1964; Martin, 1959) and some of the vegetation of the swale (Au, 1970; Martin, 1959). The protection from both wind blown sand and salt; and the proximity to the water table combine to form a habitat much different than that of the nearby dunes. This is the dune marsh boundary community.

When an offshore bar or a spit is formed there lies behind it a zone protected from the open ocean. Where this zone is shallow enough salt marsh vegetation will become established. The vertical distribution of most salt marsh phanerogams seems related primarily to frequency of inundation and salinity, but temperature, soil types and other factors undoubtably affect the distribution also (Chapman, 1974).

These marsh plants act to slow water motion even more than the original barrier, allowing more sediment to drop out. In addition, onshore winds bring sand into the marsh area (so occasionally does overwash).

As the area behind the barrier becomes shallower the marsh spreads, expanding to fill the available protected area. Chapman (1964) has said that in an area of subsiding coastline, such as the Chesapeake Bay (see Holdahl and Morrison, 1974), marsh can only from where deposition is greater than subsidence.

Chapman (1964) described eel grass as the pioneer vegetation of the marsh zone. Such a community has not been found on Fisherman Island. The low marsh, a pure stand of salt marsh cordgrass, occupies the lowest elevation of the marsh. As the marsh is slowly filled by wind and waterborne sediment species less tolerant of inundation are able to invade and outcompete the cordgrass. This is exemplified by the high marsh, which is dominated by saltworts. Above this is the upper marsh, salt meadow hay - salt grass meadow zone which often contains significant amounts of sea oxeye.

While this is the mechanism for zonation within most of the marsh, there appears to be an exception along the windward side of relict spits or islands isolated within the marsh. At the time of their formation these structures had a relatively steep exposed shore to the seaward and a low-gradient, protected shore on the other side, behind which marsh was able to form as previously described. Later a new spit or island formed seaward of the first and the process of marsh formation was repeated. As marsh grows up onto the previously exposed shore, the steeper slope leads to narrower bands of high marsh, upper marsh and transition zone. In addition storm rafted debris tends to be deposited by high tides along these previously windward shores. This debris tends to be highly destructive of shrubby species such as saltwort, sea oxeye and marsh elder. It also creates a mat which is more easily penetrated by grasses such as salt meadow hay and salt grass. Thus along relict exposed shores, marsh vegetation zones tend to be narrowed and dominated by grasses. Soil characteristics, such as nutrient availability and interstitial salinity probably have some affect on this zonation also, but no data on these parameters were available in this study.

Above the marsh transition zone is generally found a community which has previously been described from dune swales. This dune marsh boundary community is made up of a variety of grasses and sedges which are rarely found anywhere else (with the exception of salt meadow hay). This is the community which is most often being invaded by bayberry.

Early invasion of the dune marsh boundary can be seen as a sparse scattering of young bayberry specimens. Where the dune marsh boundary borders a bayberry thicket the frequency of young bayberry increases with proximity to the thicket. Once the thicket has been well established in a dune swale it seems to expand upslope, as well as along the swale's length.

Soon after bayberry begins to invade the dune marsh community, groundsel tree and dwarf sumac begin to appear also. Hardwoods, such as sassafrass and black cherry may also appear, particularly along the protected leeside of the thicket. These are usually scattered specimens and do not dominate the thicket. Soon bayberry begins to die back, perhaps as a result of overcrowding. With this some annuals and lianas can become established.

In time the lee side of the thicket becomes dominated by the hardwoods and holly moves into the understory. The bayberry continues to thin out, probably as a result of the decrease in available light, as the woodland expands. This woodland area has a very open understory except around the edges where bayberry finds adequate conditions to remain well established. Lianas, particularly Japanese honeysuckle and greenbriar are commonly intertwined among the trees, and annuals such as Spanish needle and dogfennel become locally frequent. At this time an occasional loblolly pine can be found also.

This is as far as succession has advanced on Fisherman Island. The next stage according to other authors, would be an increase in pine, and introduction of other trees, such as red bay (Persea), persimmon (Diospyros) and oak (Quercus). Such a community would ultimately develop into the climax maritime forest so frequently described.

Figure 19 summarizes this successional sequence. A new beach ridge isolates older ridges from the beach. The foredune community on the older ridges evolves into either a low dune or ridge crest community depending on the elevation of the old ridge relative to the new. Between the ridges a dune marsh community becomes established in the swales. Invasion of the dune marsh community by bayberry leads to formation of a thicket community. This community spreads along the swales and also up the ridge. The thicket also provides adequate protection from exposure for sassafras and black cherry to become established. These will eventually dominate, forming a woodland. The woodland in turn is a precursor to the maritime forest climax community of the coastal environment.

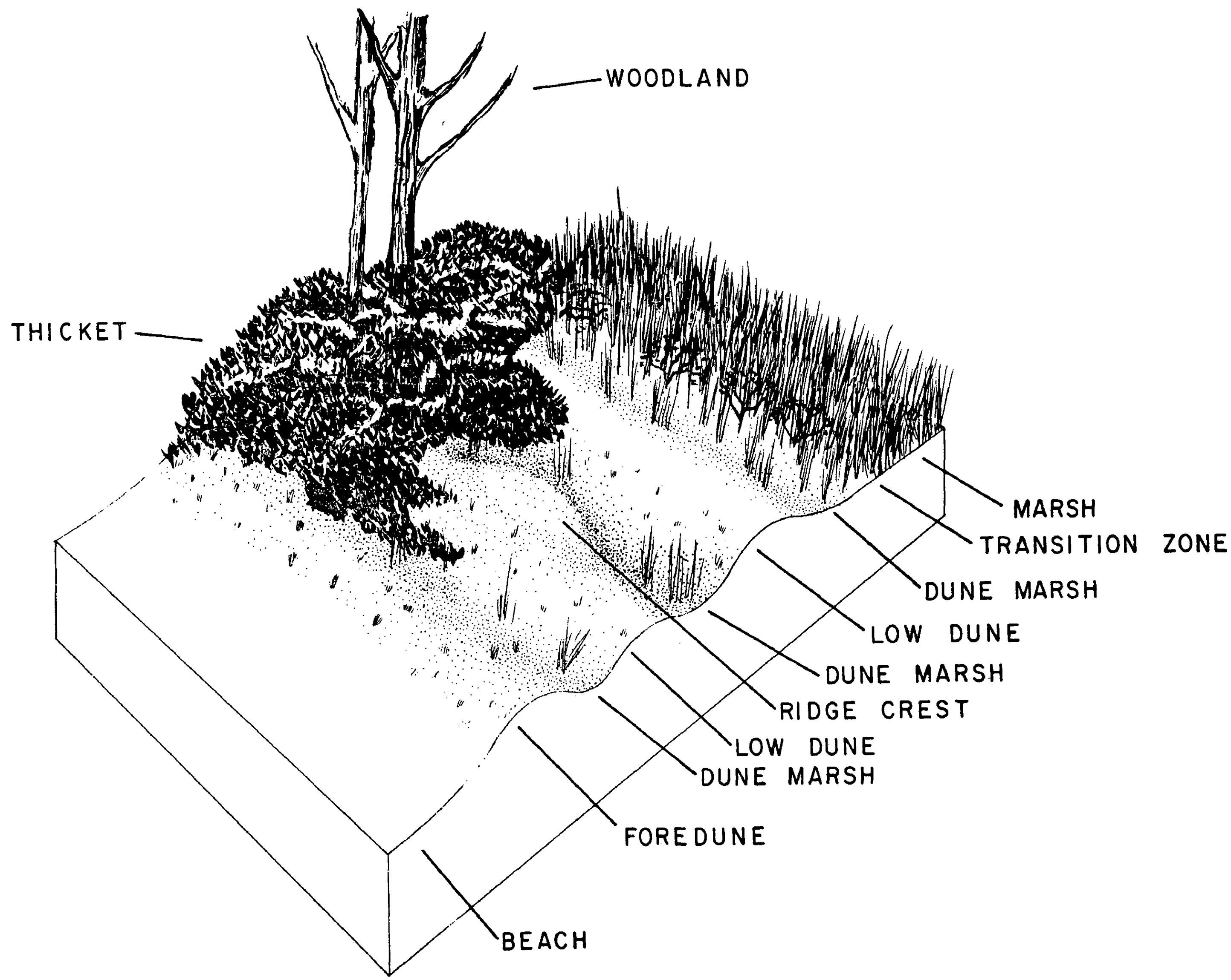


Figure 19. Graphic summary of succession as observed on Fisherman Island

TRANSECT STUDY

A series of transects were run across the island from the beach to the marsh in locations shown on Fig. 20. Community composition and boundaries were noted in an effort to determine any relationships between vegetation and physiography. The results of these transects are shown in Fig. 21-22. All transects were run in an approximately northeast-southwest direction, in order to cross as many major structural features as possible. Numbers in parenthesis, which indicate locations, refer to distance from the transect beginning, in meters.

<u>Transect A</u>

Transect A begins at approximately MHW on the bay side of the island and runs to the lagoon on the other side. It crosses perpendicular to the beach orientation and then turns at the crest of the foredune in order to pass perpendicular to a series of ridges to the east. These ridges, are the remnants of the recurved and hooked distal ends of the spit that makes up N. Pier Point.

The beach at the beginning of the transect appears to be undergoing a slow but continuous erosion. This

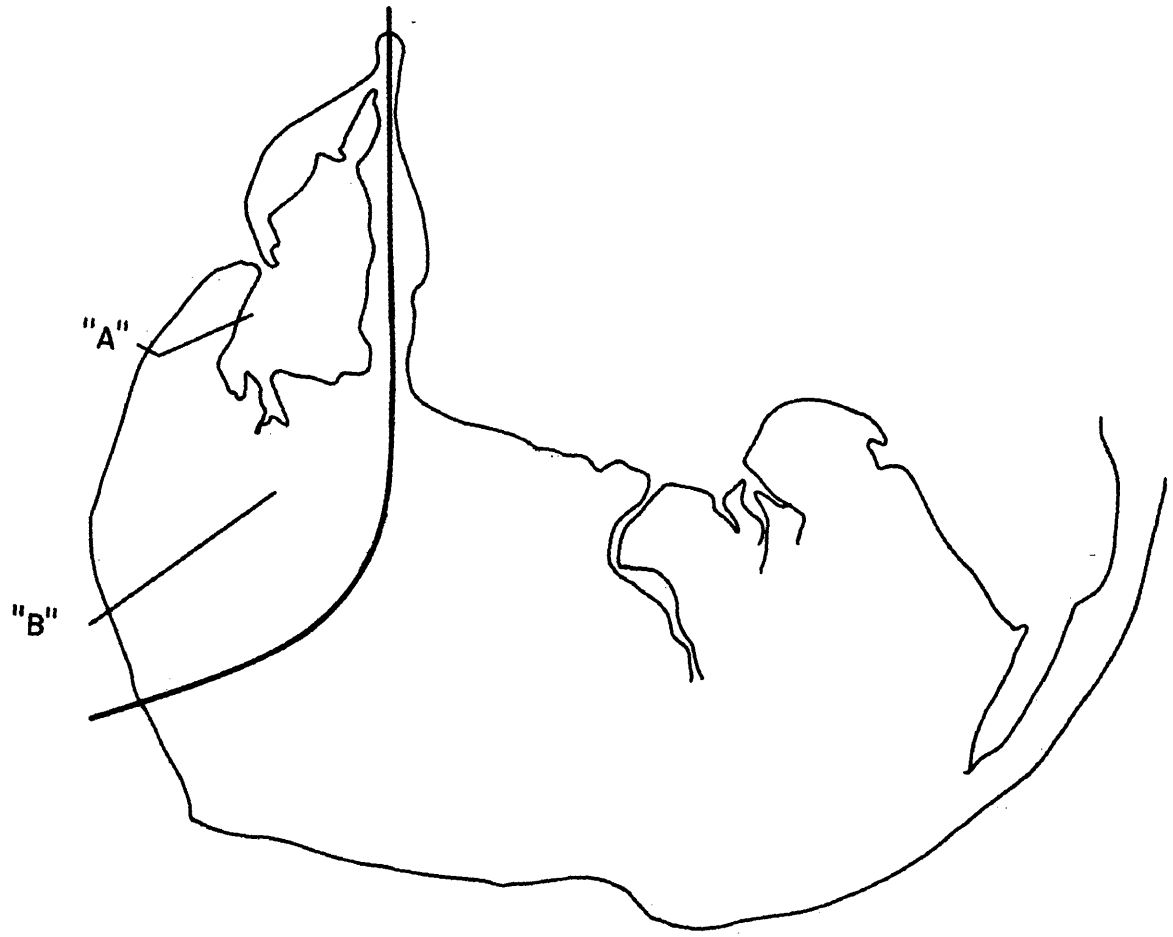


Figure 20. Location of transects on Fisherman Island.

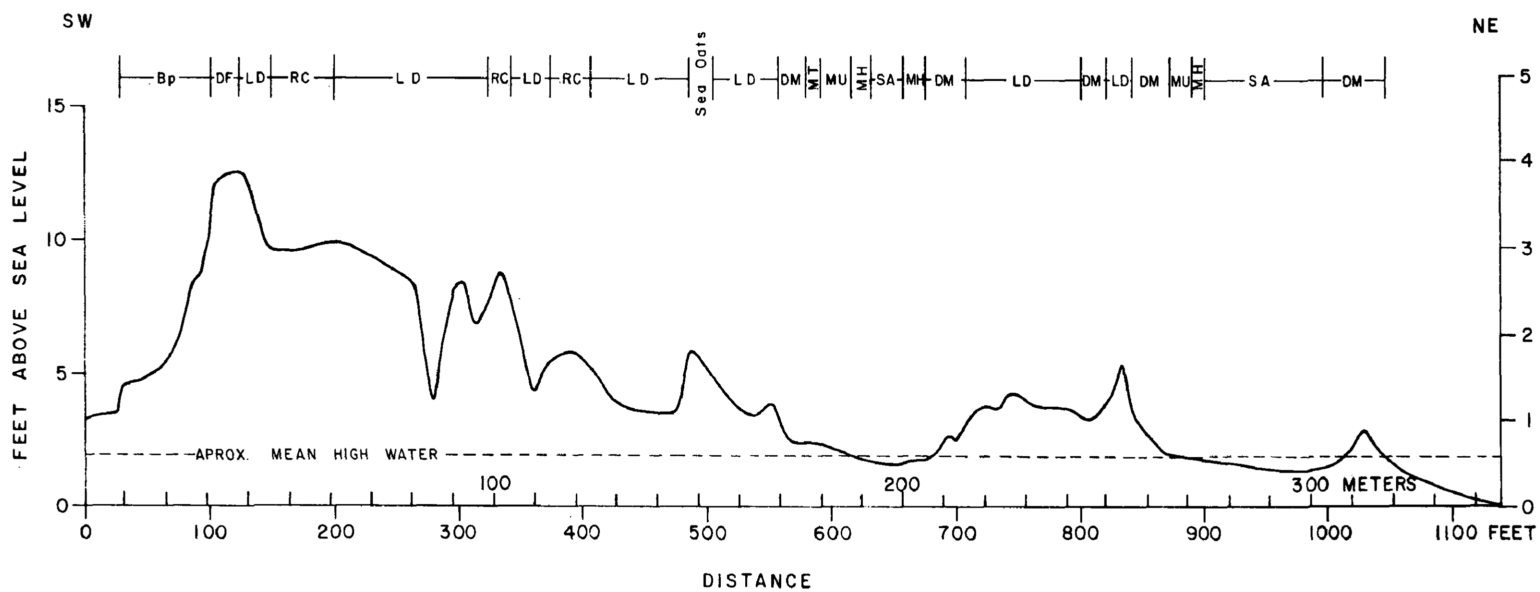


Figure 21. Transect A

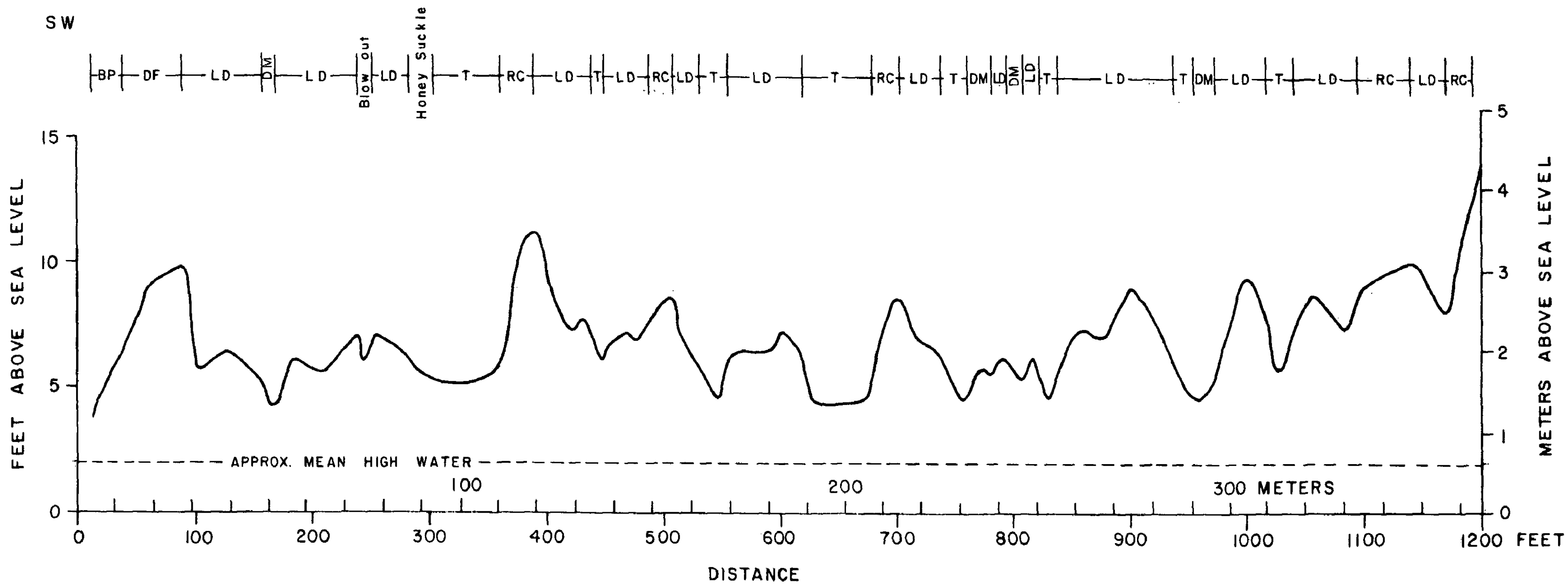


Figure 22a. Transect B

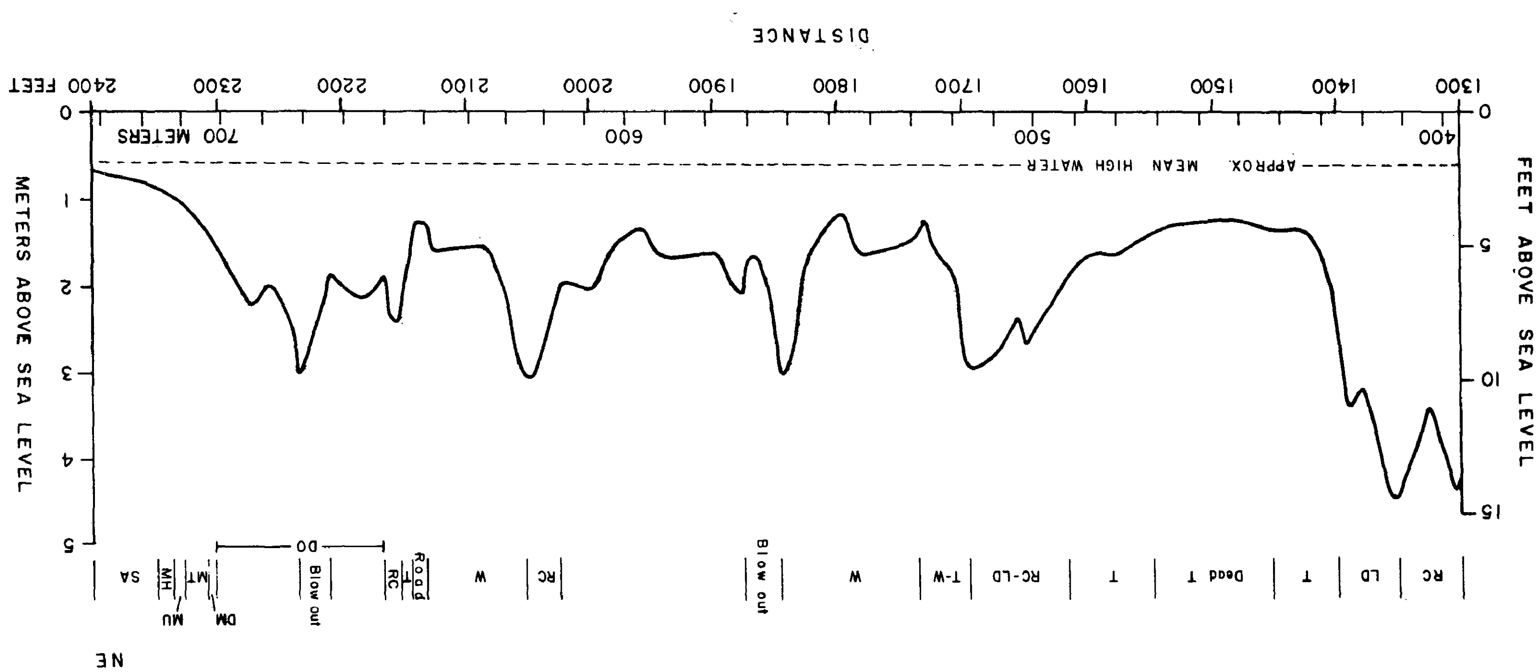


Figure 22b. Transect B (continued)

is exhibited by both the scarped foredune and the beach pioneer vegetation dominating the face of the dune almost to the crest. In addition, the dune crest, while predominantly American beach grass, shows only moderate (20-40%) cover. This is a rather low cover for a foredune community and may be another indicator that erosion is taking place.

Although the ridges behind the foredune are much lower than the foredune and thus well protected from the west, they are highly exposed to winds from the northeast. This probably accounts for the ridge crest communities often found on these ridges. It is interesting to note that the lower ridges (at 150, 230 and 256 m) have dense populations of American beach grass (and in one case, sea oats) suggesting that these areas receive at least some wind blown sand, possibly from the sandy lagoon at low tide.

Another interesting point is the lack of dune-marsh communities in many of the swales (85, 98, 110 and 137 m). This community does appear however, just above the marsh areas (174, 214, 260 and 314 m) as an almost pure salt meadow hay association. This lack of dune-marsh community in some areas may be due to the depth of the water table.

Transect B

Transect B runs from the beach to the marsh on the west side of the island. It is nearly parallel to and approximately 1000 m. south of transect A. The first 400 m of this transect passes through beach and backdune areas. Behind this is a zone approximately 230 m in width of thicket and woodland. Next there is a zone of old dunes about 50 m in width, and then the marsh.

Unlike transect A most of the swales along this transect are occupied by a dune-marsh community, or the subsequent thicket or woodland communities. The establishment of dune-marsh communities along transect B may be the result of closer proximity to the water table or greater protection from exposure than in the swales along transect A.

Another interesting situation along this transect is a grove of dead bayberry at about 425 m. In addition to the dead bayberry, knotweed (*Polygonum* spp.), dock (possibly *Rumex verticillatus*) and other apparently hydrophilic species are found here. These are not usually found in the understory of bayberry thickets. This area is a closed basin at the headwaters of the lagoon formed behind the 1888 spit (See Fig. 5). This basin is isolated from the relict lagoon by a low sill (about 0.25 m above the basin bottom). Analysis of recent color infra-red photographs of this area show decreased chlorophyll concentrations in 1975 (indicating dead or dying shrubbery) but not in 1971. This suggests that the death of these plants was the result of some event between 1971 and 1975. One possible explanation is a supra-high tide which over topped the sill at the mouth of this basin and flooded the area.

Analysis of the tide records from Kiptopeke ferry pier and comparison of that data to the transect, shows that between 1971 and 1973 there were probably about 15 tides which exceeded the elevation of the bottom of this basin. Of these, two probably exceeded the highest elevation presently occupied by dead bayberry. If one or more of these tides overtopped the sill and the water then drained slowly from the basin through percolation, this might account for the killing of the bayberry. The lack of accurate tidal data for Fisherman Island, and the lack of information on the tolerance of bayberry to saline inundation makes further analysis of this question impossible.

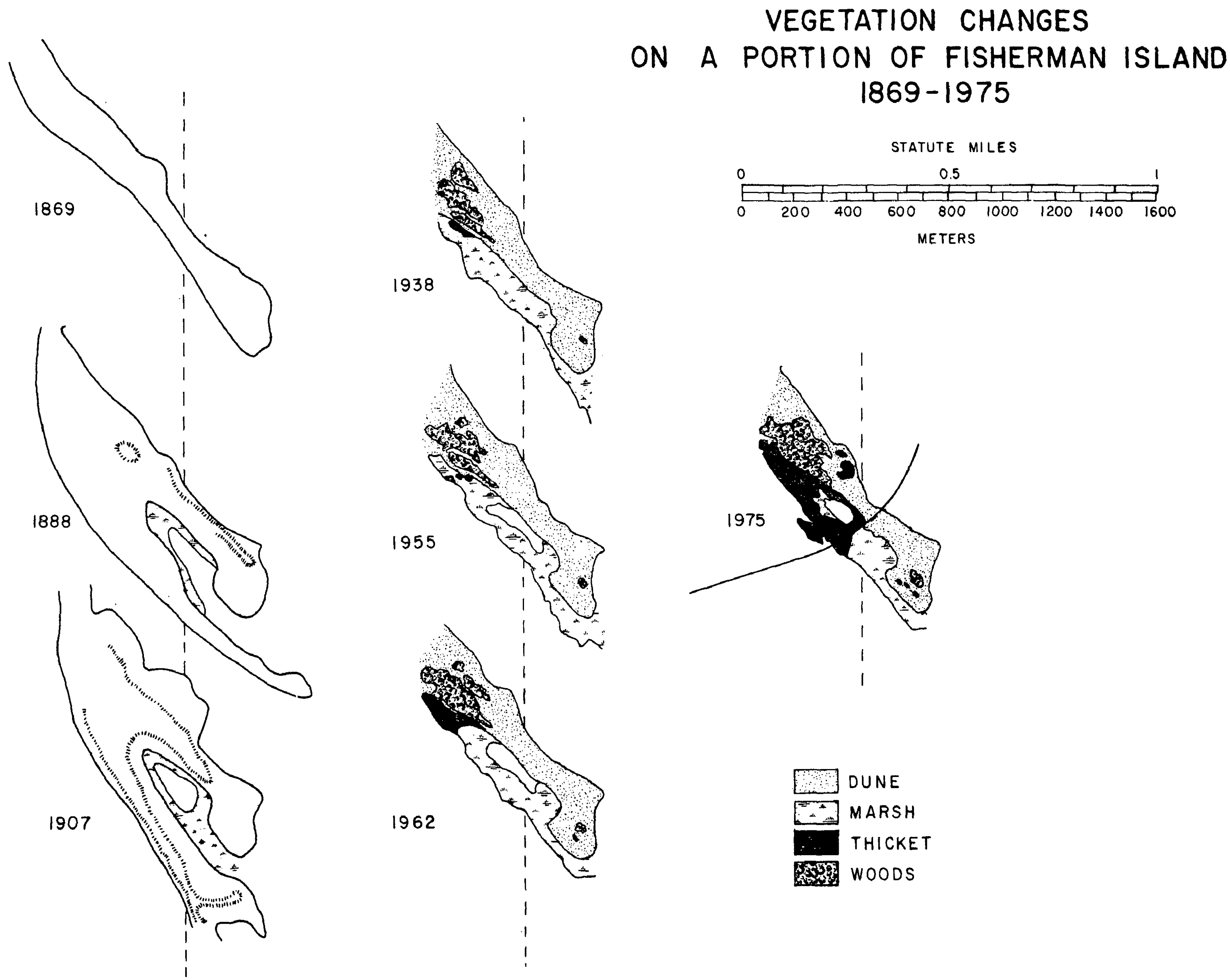
One final note of interest is the presence of blow-outs and ridge-crest communities within the woodland area where they are literally surrounded by high trees. The persistance of these communities under these conditions and their consistant northwest-southeast orientation probably attests to the effectiveness of winds along this axis as geomorphic agents.

INTERPRETATION OF VEGETATION

The oldest portion of the island is a narrow series of ridges which extend from Fish Point northwest through the heronry and beyond into the navy base. Fig. 23 shows changes in this area from 1852 to the present. This area was first accurately mapped in 1852 and showed little changes in the 1869 survey. During this period the island was probably a low sandy ridge covered with dune vegetation and protecting a small marsh on the northeast side. John Wise mentions that on his first trip to the island in 1857 it was low-lying and there were no trees (this is the observation of a 10 year-old boy and probably means there were no large bayberry either).

By 1888 the island had grown considerably. The area around Fish Point had enlarged to a bulbous shape and a spit had grown to the south west, paralleling the older shoreline. During the same period, ridges had grown sufficiently on the older portion of the island to be considered mapable by the Coast Survey. These ridges and the new spit probably offered enough protection from exposure for bayberry to begin invading the dune

Figure 23.


VEGETATION CHANGES
ON A PORTION OF FISHERMAN ISLAND
1869-1975
STATUTE MILES
0
0.5
1
0
200
400
600
800
1000
1200
1400
1600
METERS
1869
1888
1907
1938
1955
1962
1975
DUNE
MARSH
THICKET
WOODS

slacks, particularly along the northwest end.

The 1907 survey shows significant enlargement and elongation to the south of the new spit, and also, considerable detail of the older ridge system. The Coast and Geodetic Survey team which went to the island in 1914 to recover benchmarks noted that the highest dune on the island was approximately 50 m east of the benchmark "Quarantine". Another team which returned in 1934 reported a large grove of tall trees along the ridge to the north west of that benchmark[3]. These trees were not identified, but the description suggests they were not bayberry, but probably cherry or sassafrass.

A photo taken in 1938 gives the first indication of the extent of the woody vegetation around the northern portion of the old ridge. The woods are narrow and elongate, trending generally northwest to southeast, parallel to the ridge system. There is also a small woods in existence at Fish Point. Directly south of the woodland at the heronry there appears to be another patch of dark vegetation which is probably a small Myrica thicket in the low ground on the edge of the lagoon.

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3. C&GS(1914) Benchmark Recovery Notes, for Quarantine (Nh Co, Virg., 1906)

The 1955 photograph shows enlargement of both the woodland areas and the bayberry thicket. As the woodland extended southwestward the intervening areas of dune vegetation appear to have narrowed, probably due to expansion of the woods upslope as well as along the swales. Also apparent is a significant reduction in the size of the lagoon.

In the 1962 photo woodland and thicket areas both show expansion, the woodland extending to the southeast and the thicket covering much of what was previously lagoon. The last figure in the series shows the present status (as of 1975) of woodland and thicket in this area.

Thus based on the old maps and on the process of succession as previously described it seems unlikely that bayberry would have become established much,if at all before 1869. Within 65 years a grove of trees had become established in the same area, and since then has continued to expand.

While this grove became established at the north end of the 1869 ridge, and another, smaller one at the south end, none was established between them. It would seem that this central portion of the ridge, noted in 1914[4] as being the highest point on the island, and shown on the 1968 quad as being higher than the area

4 Ibid

to the northwest, has not been adequately protected to allow the establishment of a thicket community, the precursor to a woodland. Until man's activity on the island began in about 1885 a sparse ridge crest or old dune community probably existed here; and blowouts and dune movement were probably not uncommon.

With the establishment of the military a small gun emplacement was set up (Capt. R. Woods, USNAVC, personal communication) and a great deal of scrap was dumped in the area. Traffic associated with these activities undoubtedly added to the instability of the area. During the construction of the bridge tunnel it was one of the few firm areas along the route that was well protected from the ocean, accessible by road from the old pier, and not densely vegetated, making it the obvious location for parking equipment (subsequently, the only parking areas on the island was located here). Therefore, human activity over the last 40 years or more has continued to maintain this area as sparsely vegetated and unstable.

Presently, a narrow zone of bayberry occurs along the edge of the old lagoon and also in some of the lowest dune slacks. Very little of this existed before 1955, and most of it is post-highway construction. The thicket line and the restriction of traffic since the Fish and Wildlife Service began maintaining the island will undoubtedly have stabilizing effects on this area. These near barren dunes will probably begin to develop a low dune community with dune-marsh communities in the slacks. At the same time, the woods will continue to expand southeastward until they ultimately reach the highway.

The edge of this woods has migrated outward on the average approximately .3-.6 m per year since 1938. The bayberry thickets have grown at a much faster rate. At one location a bayberry thicket of over one acre in extent grew almost entirely between 1955 and 1975. Given the number of slacks in which bayberry is already established, it seems reasonable to assume that this area of approximately 8 acres will be covered almost entirely by Myrica in less than 100 years (if conditions remain constant). By the same arguments the woodland vegetation will probably extend to the highway in approximately 500 years.

Since there are no examples of true maritime forest on the island it will not be possible to determine the rate at which such climax vegetation can become established and expand.

In the southwest corner of the island just south of the area discussed above is a series of ridges which began forming between 1942 and 1949. They trend from northwest to southeast turning southerly towards their distal ends. Fig. 24 shows the changes that have taken place in this area from 1938 to the present. As usual the interpretation of vegetation could only be verified for the most recent photograph. However, certain assumptions can be made based on remote sensing techniques and the concepts of succession previously described.

Between 1910 and 1938 the shoreline in this vicinity was signficantly narrowed. This may have been long term erosion or it may have been the result of either the Aug. 1933 or Sept. 1936 hurricanes, the latter being considered the worst to have ever hit the tidewater area (Tannehill, 1945).

The 1938 shore was approximately 100 m wide in this area. Close examination of the photo reveals some dense foredune like vegetation, However, most of the area

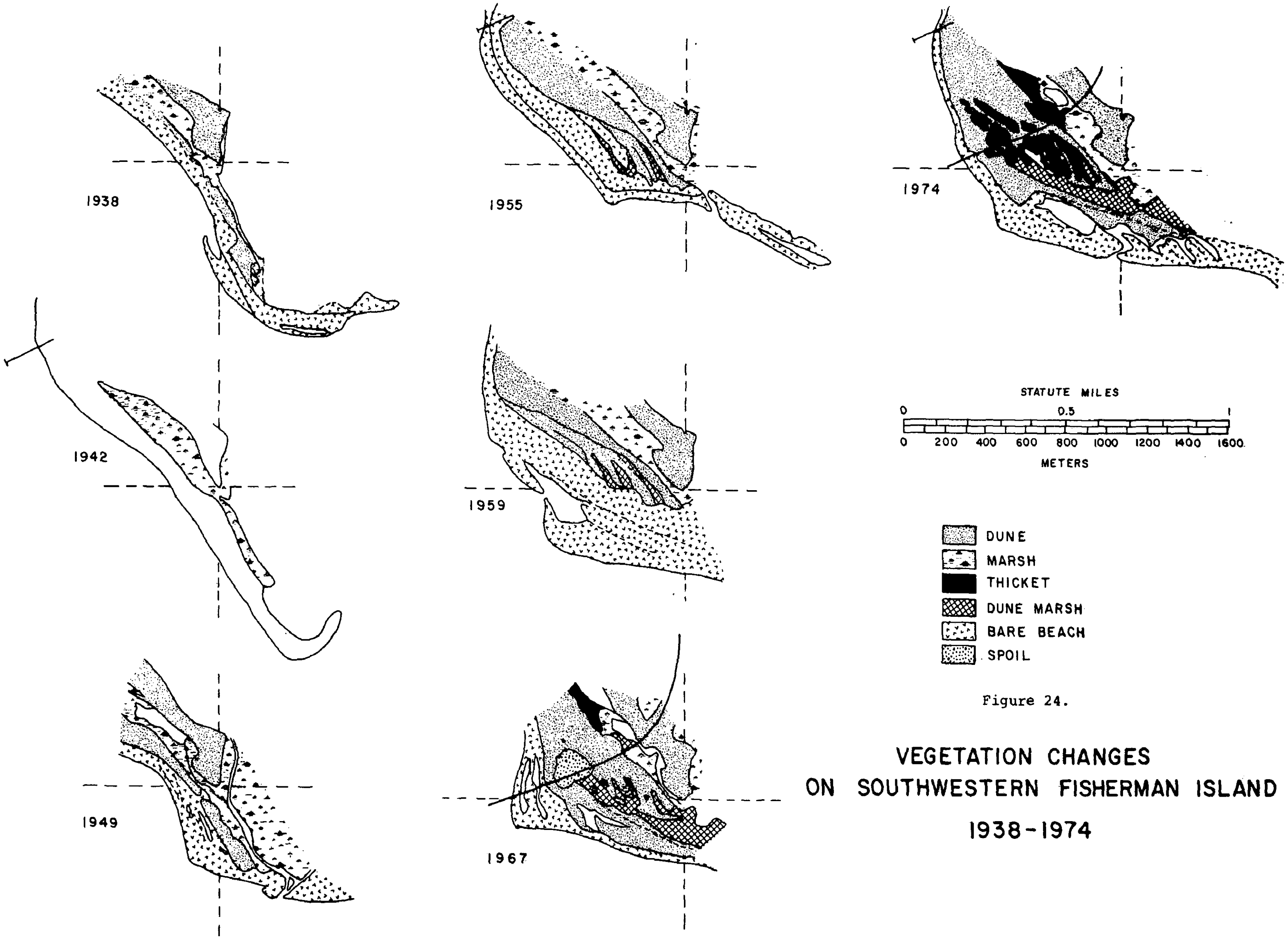


Figure 24.

VEGETATION CHANGES
ON SOUTHWESTERN FISHERMAN ISLAND
1938-1974

contains sparse and local clumps of vegetation increasing in density towards the marsh. This scattered vegetation is probably a pioneer beach community recolonizing a recently storm damaged beach. Along one stretch there is no indication of vegetation at all, and a fan shaped area of light colored material in the marsh, suggesting a possible washover.

By 1942, little change had taken place in the shoreline orientation. The beach had widened by 50-75 m and the distal end of the spit had been reoriented. Since this data is from a USGS topographic quadrangle rather than a photograph, very little information on vegetation is included.

The 1949 photograph shows numerous and significant changes. In a major shoreline reorientation approximately 500 m have been eroded away from the end of the spit, and the remaining shore had been widened by up to 200 m. Elongate impoundments suggest the formation of southerly trending ridges. The beginnings of these ridges are apparent and indicated by dashed lines. This area has now taken on the appearance of a cuspate foreland as described by Johnson (1919).

By 1955 this formation has migrated about 150 m to the northwest and several new ridges have formed, including an east-west trending one which has truncated the others. This gives the area the aspect of a migrating headland. The older ridges are moderately vegetated, with the slacks between them being darker, probably indicating either a denser vegetation or a moist substrate, or perhaps both. In contrast, the post-1949 ridges and beach are very sparsely covered, probably indicating a pioneer beach community.

The 1959 shoreline suggests that erosion of the southern ends of the ridges continued only a short distance beyond the 1955 limits. This halt in the migration of the headland may have been a result of the change in shoreline (i.e. that combination of wind, wave and tidal action responsible for the migration could only maintain it in a northwesterly direction). This migration of the headland may also have been halted by currents in the major north-south trending channel just west of the island. The apparent result of this halt in migration was a significant progradation of the beach to the south and southwest.

This shoreline reproduction was enlarged from a small scale Air Force photograph, so there is some question concerning the interpretation of features.

It appears however, that two new ridges were formed during the progradation of the beach. These new ridges appear to closely parallel the western end of the ridges formed between 1942 and 1955.

The most significant change in the island by 1967 was the construction of the Chesapeake Bay Bridge Tunnel. With this came a major progradation of the beach to the southwest. This was probably due in part to dredge spoil dumped around the bridge pilings in 1964 (C of E, unpub. data) and also to littoral sediments trapped in the vicinity. The major change in vegetation is the beginning of a bayberry invasion, primarily in the swales of the older ridge system.

The final figure in the series is simplified from the vegetation map done for this study and shows the area as of 1975. It can be seen that bayberry thickets have become a major community since 1959 when they were all but nonexistent. Also of interest is the new series of ridges and lagoonal slacks which have formed along the southern shore. These appear to be a continuation of those noted in 1959. In addition, several, low embryonic ridges have formed as branches off the main ridge, trending in a southeasterly direction.

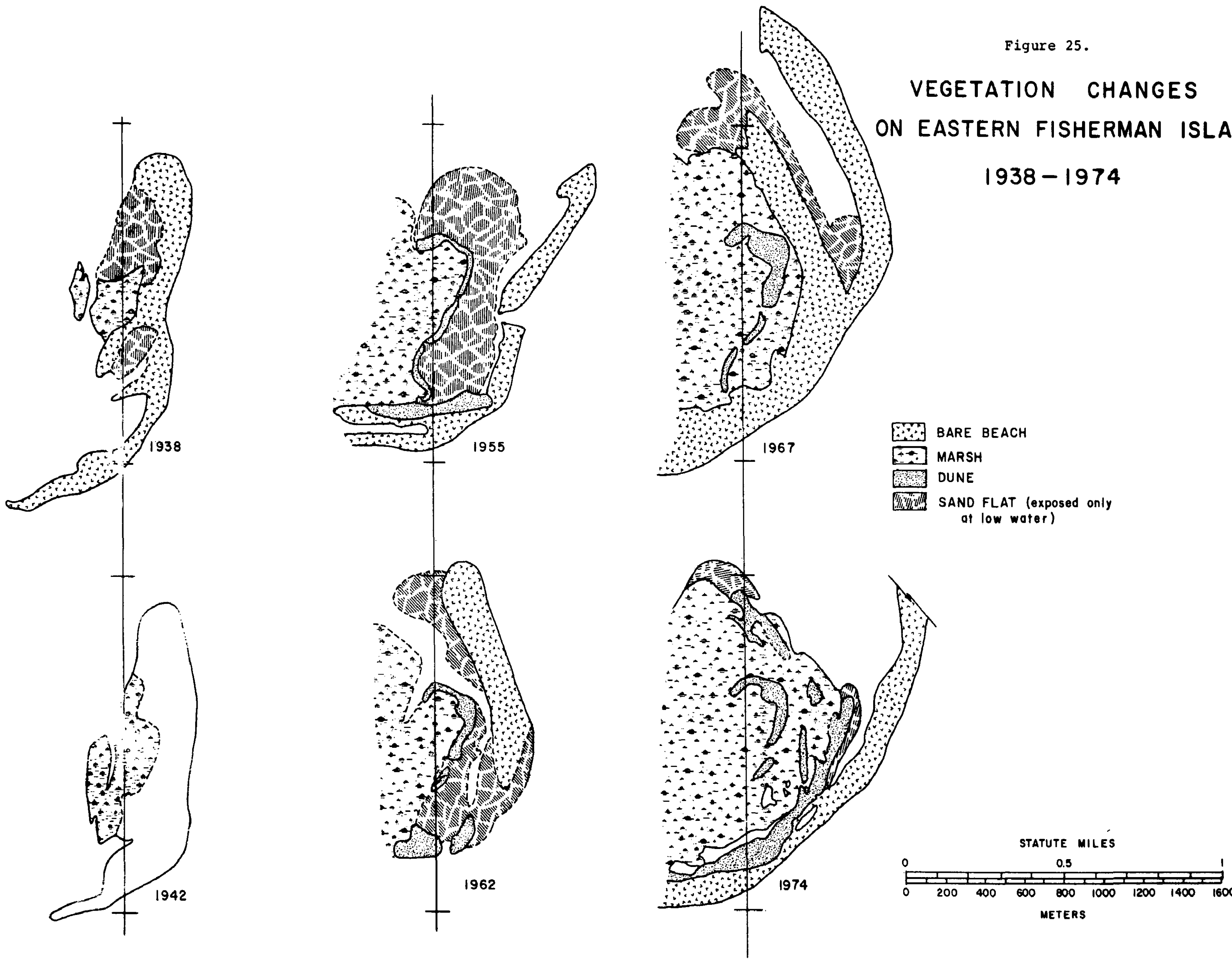
This new series of ridges suggests at least a partial repetition of the conditions under which the series of ridges was formed between 1942 and 1955. Historically in this area there has been a pattern of southeast trending spits with east or northeast trending hooks at the distal end. This new pattern may indicate a change in depositional conditions as a result of the formation of Adams Island, which undoubtedly altered the current structure of the area.

Inspection of this area shows that within 20 years after swales are established bayberry can begin to invade and that once the invasion begins the spread can be very rapid. The spread of bayberry can be such that within 10 years thickets can form which are 3 m high and impassably dense.

The eastern shore of the island is made up of a series of low north to northeast trending ridges. I don't know exactly when the oldest ridge formed, however, it is first mentioned (as Adams Island) in 1929 by a Coast and Geodetic survey field party which established a bench mark there. Fig. 25 shows the development of this area from 1938 to the present. The 1938 photo shows Adams Island as an elongate, north-south trending bar backed by a small area of marsh. The beach appears

Figure 25.

VEGETATION CHANGES ON EASTERN FISHERMAN ISLAND 1938 – 1974



to be a pair of hooked spits joined head to tail, the north one being younger and laying over the southern one.

The 1942 topographic quadrangle indicates accretion along the eastern shore and erosion of the southern spit. In addition, the marsh has grown considerably to both the north and south, extending almost 300 m in both directions over 4 years. Over the same period, east-west extension was only 50-100 m.

A photograph taken in 1949 shows Adams Island all but joined to the main body of Fisherman Island. The only evidence of the original double hooked spit formation is a one Km stretch of the west shore where they were originally joined. The remainder of the eastern shore has been graded into a long, wide beach or sand flat. Also another spit has formed northeastward as an extension of the now continuous south shore of Fisherman Island.

The 1955 photograph shows the beginnings of a salt marsh cordgrass invasion of the sand flats. In addition the eastern spit has moved westward, and been reoriented. A photograph taken in 1962 shows the results of the Ash

Wednesday storm of March 1962. The entire southern shore of Fisherman Island was cut back dramatically, and the only remaining ridge was breached at numerous points along the south shore. Also, the east spit moved to the west and was considerably eroded away.

By 1967 this last orientation of the east spit had been built up somewhat and another spit had formed to the northeast, joining the island at its easternmost point, rather than at the southern shore as had previous spits. Additionally, the sand flat area between the ridge of 1942 and that of 1962 appears to have been almost totally filled with marsh vegetation.

The last photograph in this series was taken in 1974 and shows the island essentially as it is today. A series of ridges can be seen representing the various spits which were formed and altered over the last 10 years.

Much of the history of this area can be traced through the distribution of plant communities. The older ridges are very low, often only 0.3 m above the level of the salt marsh cordgrass marsh, and dissected in numerous places. This is probably a result of the numerous extreme storms which have washed across the area.

The remnants of the 1967 ridge are the highest points in the area, being at one locale about 3 m above sea level. These high points are characterized by a ridge crest community. The lower ridges are generally covered by a community in transition from ridge crest to low dune, indicating that exposure is diminishing, probably due to the recent formation and growth of ridges to the east.

Where the ridges have been bisected the dune marsh community marks the lower spots indicating probable sites of overwash after ridge formation. In the marsh between ridges the lowest areas are covered with salt marsh cordgrass, delineating the deepest portions of the inter-ridge lagoons and the past and present drainage paths of these lagoons.

In this area, frequent overwash during storm situations has prevented the establishment of stable protective ridge formations conducive to thicket communities. In addition, much of the inter-ridge area is too low to support the dune-marsh boundary community which is usually invaded by bayberry. For these reasons, it seems that thicket communities which can become quickly established under proper conditions will be much slower to invade this area.

As a result of this analysis rates of seral change have been determined for some of the steps discussed in Fig. 18. Those seral changes which are dependent on deposition, either sub-aqueous or sub-aerial cannot be considered since rates of deposition vary greatly.

The following is a summary of the rates of change from establishment of the dune-marsh community to maturity of the woodland community. It should be noted that these rates are based on environmental conditions and may vary in other areas.

1)	Establishment of dune-marsh community	1-5 years
2)	Invasion of dune-marsh by bayberry	5-10 years
3)	Maturity of bayberry thicket	10-20 years
4)	Invasion of bayberry thicket by hardwoods	10-20 years
5)	Maturity of woodland	20-40 years

SUMMARY

Historical records show that Fisherman Island first acquired permanent subaerial exposure early in the 19th century. The interaction of wind, waves and currents (both tidal and non-tidal) in this very dynamic environment then led to the formation of numerous coastal features. Colonization of these features by vegetation aided in their stabilization. This vegetation now provides a clue to their origin and history.

The various plant communities on the island were delineated on the basis of readily discernible variations in species composition. These variations were not only easily recognized in the field, but also, most were distinguishable in color infrared aerial photography. The result was 17 communities which were described and mapped at a scale of 1:10,000.

The communities described include marsh associations, dune associations and thicket and woodland associations. The marsh communities, from low marsh to marsh transition, reflect increasing elevations in the marsh. The dune communities represent varying conditions of exposure to wind and wind-borne sand and salt (and perhaps the

depth of the water table in the case of the dune-marsh community). The thicket and woodland communities are advanced seral stages representing a relatively long term substrate stability and at least partial formation of a soil profile.

In addition, a collection of maps, aerial photographs and other historical records were available which detailed the last 120 of the island's approximately 170 years of existence. Comparisons of present vegetative configurations to the geomorphic history of the island were then made. As a result of these comparisons and field observations a succesional sequence and the approximate rates of seral change within this sequence have been proposed.

The sequence described is one in which both dune and marsh facies evolve toward a common seral stage called dune-marsh boundary community. The evolution in both cases is a result of each community's affect upon its habitat and also of local physiographic changes. The community's affect is both physical, through the accretion of wind and water borne sediments and biochemical, through nutrient enrichment of the substrate, root mats, etc.

In the marsh, accretion of both wind and water borne sediments raises the substrate surface, decreasing the frequency of tidal inundation and allowing less tolerant species to compete. Ultimately accretion raises the substrate to a point where certain mesophytic species can become established. This is the dune-marsh boundary community. The rate of transition from one marsh community to another, and ultimately to dune-marsh is primarily dependent on the rates of accretion and of sea level rise.

On the beach, accretion raises the substrate above normal tidal influence, allowing first pioneer vegetation and ultimately dune grasses to become established. More importantly however, this new foredune isolates the previous one and creates a low, well protected swale between them. In this swale a dune-marsh community also develops

This dune-marsh community is where bayberry invasion takes place, leading to formation of the thicket community. This thicket community can be established within 10 to 20 years after the swale is formed if protection from exposure is adequate. Introduction of trees such as cherry, holly and Sassafrass as dominants may follow in approximately 20 to 40 years.

A secondary result of the formation of a new foredune ridge is the isolation of the previous foredune from its source of sediment. Within 10 years this older dune will show a change in vegetation as American beach grass begins to thin and other species move into the area.

Where the older ridge is significantly higher than the younger it will continue to experience the destructive effects of the wind without the addition of much wind-borne sediment. The resulting community is sparse and dominated by annuals and perenials with downward growing root systems and heavy seeds rather than grasses with lateral rhizome growth. This ridge crest community will remain in a state of disclimax, where wind is the disturbing factor until formation of an adequate wind barrier such as a high ridge or thicket allows stabilization of the locale. Man can also be a similar disturbing factor in this situation.

A series of transects across the island provided data concerning elevational relationships of the various plant communities. The lack of a dune-marsh community in the high dune swales was noted here, suggesting the influence of the depth of the water table on the formation of this community.

The final portion of the work was the application of the floristic data, concepts of succession, and historical data to selected portions of the island. As a result a geomorphic history is proposed for these areas and correlated to the present vegetative patterns. In addition, approximate rates of seral transition for many of the proposed stages of succesion were determined.

As a result of this study, an understanding of vegetation and its successional sequences, and their dependence on geomorphic conditions can be used as an aid in interpreting geomorphic situations in dynamic coastal areas. In addition, an understanding of the topographic dependence of certain communities, particularly marsh vegetation, can be useful in deciphering recent geomorphic history.

CONCLUSIONS

In dynamic coastal areas, vegetation associations can be indicators of geomorphic features, topography and exposure. They can also be used in some cases as indicators of the approximate age of the features on which they are found. As a result, geomorphic features can be more readily delineated and aged. Once delineated these features are much easier to identify, both on the ground and from aerial photography. With the addition of age data an interpretation of geomorphic history can be made.

Table 3 summarizes the interpretive value of the various communities. Particular note should be made of the following.

1) Marsh vegetation responds primarily to the frequency of tidal inundation (other environmental parameters probably modify this response). Thus, minor elevation changes, particularly in the upper portions of the marsh, can be identified by easily recognized changes in plant communities. Minor topographic highs may be relicts of geomorphic features which have been "drowned" by encroaching marsh.

2) The zone of transition from marsh to upland is usually marked by a shrubby community of saltbushes (*Iva* and *Baccharis*).

3) Pioneer beach vegetation dominates along the back beach above the influence of tidal inundation. This zone probably receives too much salt spray for effective colonization by beach grasses.

4) A dense, and highly fecund American beach grass community (*Ammophila breviligulata*) dominates the active building foredune. This species not only tolerates, but apparently requires an environment of continuous deposition for vigorous growth. Thus, this species can be an indicator to present or past conditions of aeolian deposition.

5) Back dune communities (both low dune and ridge crest) appear to reflect the degree of exposure to wind and wind-borne sand. Thus they can be useful in determining the elevations of ridges or dunes relative to that of the protective barrier (foredune, etc.)

6) The dune marsh community is found in two different types of locations. It occupies a zone separating marsh from dune, and also most dune swales. This community

appears to be the first of a series of successional steps which leads to the formation of a maritime forest climax.

7) The observed successional sequence is: dune marsh boundary community; invasion of bayberry (Myrica spp.) and formation of a bayberry thicket; and influx of Sassafras and cherry (Prunus spp.) forming a woodland. Influx of pine and oak then leads to formation of a maritime forest. (This last step has not been observed on Fisherman Island. It is inferred from other localities, suggesting the possibility of intermediate steps.)

8) The successional sequence seems to occur at a somewhat regular rate. The rates of change for various steps in the succession are summarized at the end of the last section, thus allowing an estimate to be made of the age of various communities. These estimates can then be used to approximate the age of the features which the various communities occupy.

Although the exact composition of these communities may vary with location, the concepts should be a useful aid to interpreting the geomorphology of a coastal area. Additionally, they should be of value in predicting future changes in the vegetation of an area, thus having a use as a managerial as well as geomorphic tool.

REFERENCES

Au, S., 1970. Vegetation and Ecological Processes on Shackleford Bank, N.C. Ph.D. Dissertation, University of N.C. 170 pp

Blunt, E.M., 1815. The American Coast Pilot. N.Y. printed for E.M. Blunt, 199 pp. Printed by G. Largin, N.Y.

Byrne, R.J., J.T. DeAlteris, P.A. Bullock, 1974. Channel Stability in Tidal Inlets: A Case Study. In Proceedings of the 14th Coastal Engineering Conference, Copenhagen, 1974, Paper 92.

Chapman, V.J., 1964. Coastal Vegetation Pergamon Press, Oxford. 245 pp.

Chapman, V.J., 1974. Salt Marshes and Salt Deserts of the world, 2nd Ed. Verlag von J. Cramer, 494 pp

Clements, F.E. 1928 (1963) Plant Succession and Indicators. Haefner, N.Y. 453 pp

Daubenmire, R., 1968. Plant Communities, Harper & Row, N.Y. 299 pp

Des Barres, 1780. The Atlantic Neptune.

Egler, F.E., 1942. Check list of the ferns and flowering plants of the Seaside State Park, Cape Henry, Virginia. N.Y. State College of Syracuse 60 pp.

Gleason, H.A. 1952. The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada. N.Y. Botanical Garden.

Hack, J.T., 1957. Submerged River system of the Chesapeake Bay. Geological Society of America Bulletin. 68:817-830.

Harrison, W., Malloy, R.J., Rusnak, G.A., and Terasmae, J., 1965. Possible Late Pleistocene Uplift Chesapeake Bay Entrance. Journal of Geology. 73(2):201-229.

Heather W. 1799. The Marine Atlas.

Higgins, E.A.T., Rappleye,R.D., and Brown, R.G., 1971. The Flora and Ecology of Assateague Island. University of Maryland., Bull. A-172 70 pp.

Hitchcock, A.S. 1971. Manual of the Grasses of the United States. Dover, N.Y., 1051 pp.

Holdahl, S.R. & Morrison, N.L., 1974. Regional Investigations of Vertical Crustal Movements in the U.S., Using Precise Relevelings and Mareograph Data. Tectonophysics, 23:373-390.

Johnson, D.W., 1919. Shore Processes and Shoreline Development. Wiley, N.Y. 584 pp.

Kraft, J.C., 1971. Sedimentary Facies Patterns and Geologic History of a Holocene Marine Transgression. GSA Bull. 82:2131-58

Marcellus, K.L., 1972. Coastal Wetlands of Virginia, Interim Report No. 2., VIMS SRAMSOE 27. 27 pp.

Martin, W.E., 1959. The Vegetation of Island Beach State Park, N.J., Ecol. Mono. 29:1-46.

Meisburger, E.P., 1972. Geomorphology and Sediments of the Chesapeake Bay Entrance USA, Corps of Engineers, CERC. Tech. Memo 38, 61 pp.

Newman, W.S. & Munsart, C.A., 1968. Holocene Geology of the Wachapreague Lagoon, Eastern Shore Peninsula, Virginia. Mar. Geol. 6:21-105.

NOAA, 1975. The Relationship Between the Upper Limit of Coastal Marshes and Tidal Datums. NOAA, NOS, Rockville, Md. 110 pp.

Odum, E.P., 1959. Fundamentals of Ecology. Saunders, Phila. 546 pp.

Oosting, H.J., 1954. Ecological Processes and Vegetation of the Maritime Strand in the Southeastern United States. Bot. Rev. 20:226-262.

Oosting, H.J. & Billings, W.D., 1942. Factors Affecting Vegetational Zonation on Coastal Dunes. Ecology 23:131-142.

Radford, A.E., Ahles, M.E., & Bell, C.R., 1964. Manual of the Vascular Flora of the Carolinas. UNC, Chapel Hill. 1183 pp.

Redfield, A.C., 1965. The Ontogeny of a Salt Marsh. Sci. 147:50-55.

Redfield, A.C., 1972. Development of a New England Salt Marsh. Ecol. Mono. 42:201-237.

Rosen, P., 1976. The Morphology and Processes of the Virginia Chesapeake Bay Shoreline. W&M, Ph.D. Dissertation. 150 pp.

Sallenger, A.H., Jr., Goldsmith, V., and Sutton, C.H., 1975. Bathymetric Comparisons: A Manual of Methodology, Error Criteria and Techniques. VIMS, SRAMSOE 66. 34 pp.

Shahroki, F., Ed., 1974. Remote Sensing of Earth Resources, Vol. 3. U. Tenn. 813 pp.

Shepherd, F.P. 1973. Submarine Geology, 3rd Edition. Harper and Row, N.Y., 517 pp.

Tannehill, I.R., 1945. Hurricanes, Their Nature and History. Princeton, N.J. 275 pp.

Wells, B.W., 1928. Plant Communities of the Coastal Plain of North Carolina. Ecol. 9:230-242

Wells, B.W. 1942. Ecological Problems of the Southeastern United States Coastal Plain. Torrey Bot. Club, Bull. 66:629-634.

APPENDIX

* County Record ** State Record

Osmundaceae

Osmunda regalis var. spectabilis (Willd.) Gray. royal fern. fresh marsh. one station.

Blechnaceae

Woodwardia virginica (L.) Smith. Virginia chain fern. fresh marsh. one station.

Pinaceae

Pinus taeda L. loblolly pine. woodland. three specimens

Cupressaceae

Juniperus virginiana L. red cedar. woodland. thicket. low dune. infrequent.

Angiospermae

Poaceae[a]

Festuceae

Bromus tectorum L. downey chess. ruderal, spoil, old dune. frequent.

Distichlis spicata (L.) Green. seashore saltgrass upper marsh, marsh transition, pioneer beach, common.

Eragrostis spectabilis (Pursh) Steud. purple lovegrass. old dune. infrequent.

Festuca octoflora Walt. six weeks fescue. dune marsh common.

Festuca sciurea Nutt. spoil. locally abundant.

Phragmites austrailis (P. communis) Trim. common reedgrass. invader. locally abundant.

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a. Treatment according to Hitchcock, 1971

Triplasis purpurea (Walt.) Chapm. purple sand grass. low dune. infrequent.

Uniola paniculata L. sea oats. low dune. locally abundant.

Hordeae

Elymus virginicus L. low dune, old dune. infrequent.

Hordeum pusillum Nutt. little barley. low dune, old dune. infrequent.

Lolium perenne L. perennial ryegrass. old dune, rare.

Agrostideae

Ammophila breviligulata Fernald. American beach grass. foredune, old dune. abundant.

**Aristida tuberculosa* Nutt. old dune. locally abundant.

**Munlenbergia capillaris* (Lam.) Trin. dune-marsh. rare.

Chlorideae

Cynodon dactylon (L.) Pers. bermuda grass. old dune. infrequent.

Spartina alterniflora Loisel. smooth cordgrass. low marsh. abundant.

Spartina patens. (Ait.) Muhl. saltmeadow cordgrass. ubiquitous

Paniceae

Cenchrus tribuloides L. dune sandbur. low dune, ridgecrest, old dune. common.

Panicum amarulum Nitche. bunch panic grass. pioneer beach. infrequent.

Panicum amarum Ell. Running panic grass. pioneer beach, foredune. frequent.

Panicum scoparium Lam. road through heronry. infrequent.

Andropogoneae

Andropogon elliottii Champm. Elliott beardgrass. dune marsh. infrequent.

Andropogon scoparium Michx. little blue stem. dune marsh, fresh marsh. infrequent.

Andropogon virginicus L. broom sedge. dune marsh, fresh marsh. infrequent.

Cyperaceae

Carex alata Torrey. dune-marsh, fresh marsh. infrequent.

Carex Kobomugi Ohwi ruderal. one station

Cyperus filicinis Vahl. dune-marsh. infrequent.

Cyperus grayi Torrey. Navy base. one station.

Cyperus retrorsus var. retrorsus Chapman. low dune. infrequent.

Dichromena colorata (L.) Hitchcock. dune-marsh. one station.

Eleocharis acicularis (L.) R.& S. spike rush. pond boundary. one station.

Fimbristylis spadicea (L.) Vahl. dune-marsh. common.

Scirpus americanus Persoon. dune-marsh, fresh marsh. frequent.

Scirpus robustus Pursh. Pond boundary. One station

Juncaceae

Juncus coriaceus MacKenzie. dune-marsh. infrequent.

Juncus gerardii Loisel.[b] pond boundary. one station.

Juncus roemerianus Scheele. Upper marsh. locally abundant.

Liliaceae

Asparagus officinalis L. asparagus. low dune. rare.

Smilax spp. L. greenbriar. thicket, woodland. infrequent.

Yucca filimentosa var. filamentosa L. beargrass. low dune. infrequent.

Salicaceae

Populus deltoides Marshall. cottonwood. thicket. one specimen.

Salix nigra Marshall. black willow. thicket (within old dune), infrequent.

Myricaceae

Myrica cerifera var. cerifera L. wax myrtle. thicket. abundant

Myrica pennsylvanica Loisel. Thicket. abundant

Ulmaceae

Celtis occidentalis var. georgiana (Small) Ahles Navy base. one specimen.

Polygonaceae

**Polygonella articulata* (L.) Meissner. joint weed old dune, rare.

Polygonum pennsylvanicum L. fresh marsh, rare.

Polygonum lapathifolium L. woodland clearing. infrequent.

Polygonum punctatum Ell. fresh marsh. frequent

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b Treatment according to Gleason.

Rumex acetosella L. sheep sorrel, sour dock. Navy base, ruderal. frequent.

Rumex verticillatus L. swamp dock. dead thicket. one station.

Chenopodiaceae

Atriplex arenaria Nuttall. sea beach orach. protected pioneer beach. frequent.

Atriplex patula L. low dunes. infrequent.

Chenopodium album L. lamb's quarters, pigweed. low dune, old dune. frequent.

Chenopodium ambrosioides L. Mexican-tea. low dune. infrequent.

**Cycloma atriplicifolium (Sprengel) Coulter. winged pigweed. protected pioneer beach. one station.

Salicornia bigelovii Torrey. saltwort. high marsh. infrequent.

Salicornia europaea L. saltwort. high marsh, upper marsh. frequent.

Salicornia virginica L. saltwort. high marsh, upper marsh, panne. abundant

Salsola kali L. Russian thistle, tumbleweed. pioneer beach. common.

Suaeda linearis (Ell.) Moa. high marsh, panne. infrequent

Phytolaccaceae

Phytolacca americana L. Poke, pigeonberry. low dune. ruderal. frequent.

Aizoaceae

Sesuvium maritimum (Walter) BSP. Protected pioneer beach. infrequent.

Portulacaceae

Portulaca oleracea L. purslane. protected pioneer beach. infrequent.

Caryophyllaceae

Cerastium glomeratum Thuillier. mouse-ear chickweed old dune, low dune. infrequent.

Lauraceae

Sassafras albidum (Nuttal) Nees. sassafras. woodland. abundant

Brassicaceae

Arabidopsis thaliana (L.) Heynhold. mouse-ear cress low dune, old dune. infrequent.

Cakile edentula (Bigelow) Hooker. sea rocket. pioneer beach. abundant.

Lepidium virginicum L. poor-mans pepper. low dune, old dune. frequent.

Rosaceae

Prunus serotina var. serotina Ehrhart. black cherry. woodland. abundant.

Rubus hispidus L. dewberry. low dune. old dune, frequent.

Fabaceae

Cassia fasciculata Michaux partridge pea. old dune. ruderal. infrequent.

*_Melilotus alba_ Desr. white sweet clover. ruderal. common.

Robinia pseudo-acacia L. black locust. Navy base. one station.

Strophostyles helvola (L.)Ell. low dune. common, Strophostyles umbellata (Muhl. ex Willd.) Britton low dune, dune marsh. frequent.

Geraniaceae

Geranium carolinianum L. ruderal. frequent.

Rutaceae

Zanthoxylum clava-herculis L. Hercule's club, prickly ash. thicket. locally abundant

Euphorbiaceae

Euphorbia polygonifolia L. protected pioneer beach infrequent.

Anacardiaceae

Rhus coppalina L. dwarf or winged sumac. thicket. frequent.

Rhus radicans L. poison ivy, low dune, old dune. frequent.

Aquifoliaceae

Ilex opaca Aiton. holly. woodland. common.

Vitaceae

Parthenocissus quinquefolia (L.) Planchon. Virginia creeper. woodland, thicket. infrequent.

Malvaceae

Hibiscus moscheutos ssp. moscheutos L. rose or marsh mallow. pond boundary, one station.

Hibiscus syriacus L. althea, rose-of-sharon. Navy base. one specimen.

Kosteletskya virginica (L.) Presl. seashore mallow. pond boundary. one station.

Hypericaceae

Hypericum hypericoides (L.) Crantz. St. Andrew's cross. woodland, rare.

Cistaceae

Hudsonia tomentosa Nuttall. beach heather. old dune. one station.

Cactaceae

Opuntia compressa, (Salisbury) MacBride. prickly pear. low dune, old dune. infrequent.

Onagraceae

Oenothera laciniata var. laciniata Hill. sea beach evening primrose. low dune, old dune. ruderal; common.

Apiaceae

Daucus carota L. wild carrot, Queen Anne's lace. ruderal, frequent.

Ptilimnium capillaceum (Michaux) Raf. pond boundary one station.

Plumbaginaceae

Limonium nashii small. sea lavendar. high marsh, upper marsh. frequent.

Oleaceae

*******Ligustrum amurense* Carr. privet. Navy base, one station.

Gentianaceae

Sabatia stellaris, Pursh. dune-marsh, infrequent.

Apocynaceae

**Apocynum cannibinum* L. Indian hemp. fresh marsh, frequent.

Convolvulaceae

Calystigia sepium (L.) R. Brown. hedge bindweed. low dune, thicket. frequent.

Ipomoea purpurea (L.) common morning glory. low dune. thicket. frequent.

Lamiaceae

Monarda punctata L. horsemint. ridge crest, low dune. frequent.

Teucrium canadense L. American germander. marsh transition, infrequent.

Trichostema dichotum L. blue curls. old dune, rare.

Solanaceae

Solanum americanum Miller. nightshade. ruderal. infrequent.

Solanum carolinense L. Old dune, infrequent

*Solanum sarrachoides Sendther. ruderal. one station

Scrophulariaceae

Agalinis maritima (Raf.) Raf. Gerardia. high marsh. infrequent.

Linaria canadensis (L.) Dumont. toad-flax. low dune. old dune, ruderal. common.

Bignoniaceae

Campsis radicans (L.) Seemann. trumpet vine. thicket, Navy base. frequent.

Plantaginaceae

*Plantago aristata Michaux. Bracted plantain, ruderal. infrequent.

Plantago virginica L. hoary plantain. ruderal. Navy base. infrequent.

Plantago lanceolata L. English plantain, ruderal, infrequently.

Rubiaceae

Diodia teres Walter. Old dune, low dune. infrequent.

Galium obtusum Bigelow. bedstr aw. dune-marsh, fresh marsh. infrequent.

Caprifoliaceae

Lonicera japonica Thunberg. Japanese honeysuckle. thicket, common.

Campanulaceae

Specularia perfoliata (L.) A. DC. Venus' looking glass. Navy base, rare.

Asteraceae

Achillea millefolium L. yarrow, milfoil, ruderal common.

Ambrosia artemisiifolia L. ragweed, ruderal, common

**Anthemis arvensis* L. dog-fennel, ruderal, frequent.

Aster tenuifolius L. marsh aster, high marsh, upper marsh. infrequent.

Baccharis halimifolia L. groundsel tree, marsh transition, thicket, abundant.

Bidens bipinnata L. Spanish needles, woodland, infrequent.

Borrichia frutescens (L.) DC sea oxeye, upper marsh, abundant.

Carduus acanthoides L. plumeless thistle, low dune, old dune, infrequent.

Carduus nutans L. musk thistle, low dune, old dune. infrequent.

Erigeron canadensis L. horseweed, old dune, infrequent.

Eupatorium capillifolium (lam.) Small. dog fennel. low dune, old dune, ruderal, common.

Eupatorium hyssopifolium L. low dune, old dune, ruderal, frequent.

Gnaphalium chilense Sprengel. cudweed, low dune, frequent.

Gnaphalium obtusifolium L. everlasting, low dune, frequent.

Heterotheca graminifolia (Michaux) Shinners. old dune, locally abundant.

Heterotheca subaxillaris (Lam.) Britton & Rusby. old dune, locally abundant (also ruderal, frequent.)

Hypochoeris radicata L. cat's ear, ruderal, frequent.

Iva frutescens L. marsh elder, marsh transition, abundant.

Mikania scandens (L.) Willd. climbing hempweed, thicket, locally abundant.

Solidago sempervirens L. seaside goldenrod, low dune, foredune, old dune, common.

Xanthium strumarium L. cocklebur, pioneer beach, common.

VITA

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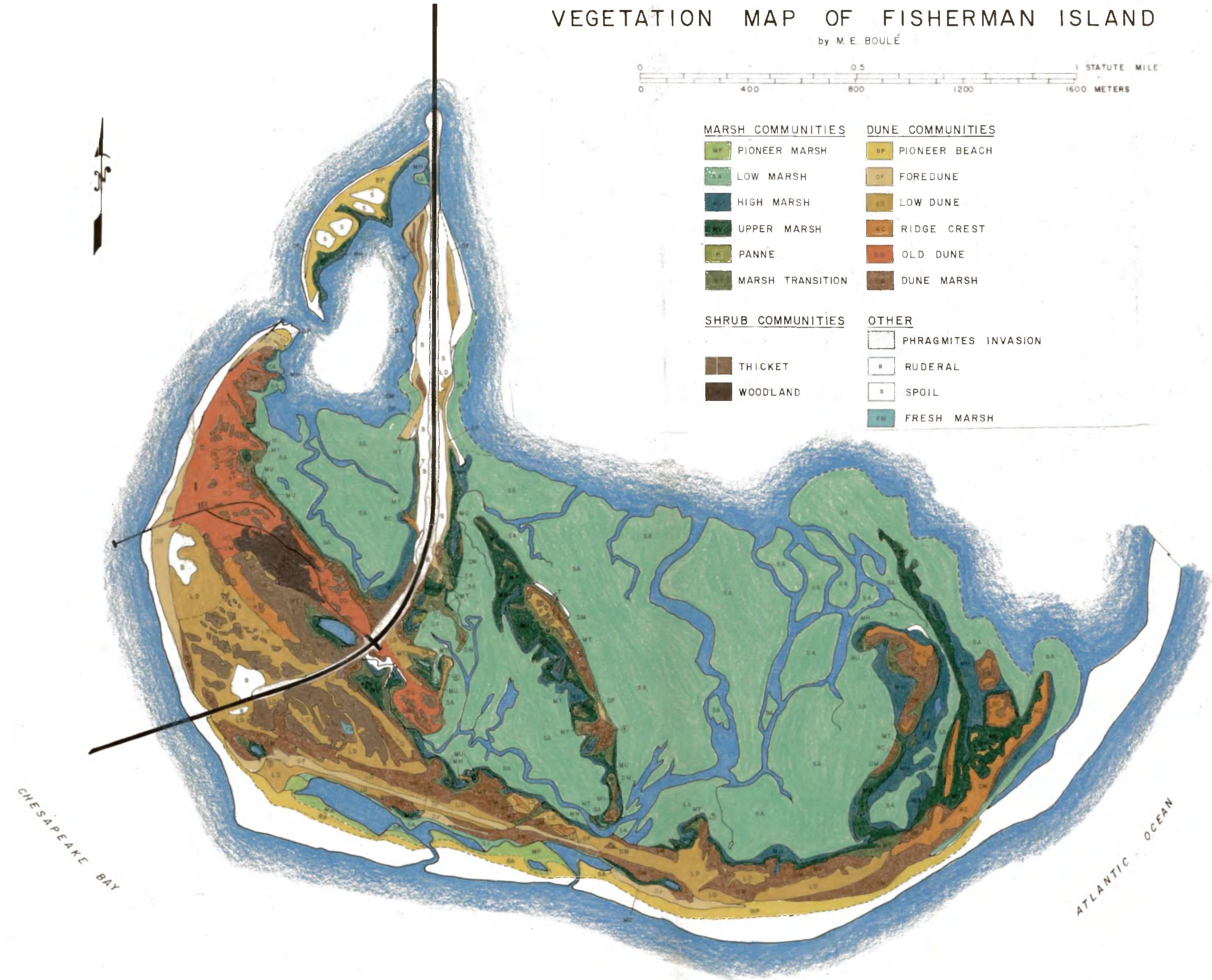
VEGETATION MAP OF FISHERMAN ISLAND
by M. E. BOULÉ
0 0.5 1 STATUTE MILE
0 400 800 1200 1600 METERS
MARSH COMMUNITIES
PIONEER MARSH
LOW MARSH
HIGH MARSH
UPPER MARSH
PANNE
MARSH TRANSITION
DUNE COMMUNITIES
PIONEER BEACH
FOREDUNE
LOW DUNE
RIDGE CREST
OLD DUNE
DUNE MARSH
SHRUB COMMUNITIES
THICKET
WOODLAND
OTHER
PHRAGMITES INVASION
RUDERAL
SPOIL
FRESH MARSH
CHESAPEAKE BAY
ATLANTIC OCEAN