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THE VIRGINIA COAST RESERVE STUDY

V. I

March 31, 1976

COASTAL ZONE
INFORMATION CENTER

Principal Researchers:

Raymond D. Dueser
Maria Ann Graham
Gerard J. Hennessey
Cheryl McCaffrey
Alan W. Niedoroda
Thomas E. Rice
Bill Williams

The Nature Conservancy
1800 N. Kent Street
Arlington, Virginia 22209

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STUDY DIRECTOR: Gerard J. Hennessey

STUDY COORDINATOR: Ray M. Culter

THE VIRGINIA COAST RESERVE ADVISORY COMMITTEE

Michael Castagna: Scientist in Charge - Virginia Institute of Marine Science Laboratory at Wachapreague, Virginia.
John Clark: Senior Associate - The Conservation Foundation.
Ray M. Culter: Director of Land Stewardship, The Nature Conservancy.
F. Victor Schmidt: Assistant to the Director, United States Fish and Wildlife Service.

THE NATURE CONSERVANCY

The Nature Conservancy is a national conservation organization, receiving its support from the public, whose objective is to preserve and protect ecologically and environmentally significant land and the diversity of life it supports.

To achieve this goal, the Conservancy purchases lands using its revolving fund which is then replenished through fund raising; accepts gifts of land, retains and provides stewardship for 60% of all projects; works with local, state and federal governments to identify and protect important natural areas and acquires and manages land in advance of government agencies' ability to do so.

Some 878,678 acres of forests, swamps, marshes, prairies, mountains, beaches, and islands in 1,516 projects throughout the United States have been saved from destruction by the Conservancy since the acquisition of its first preserve in 1954.

A member-governed non-profit organization, The Nature Conservancy was incorporated in 1951 in the District of Columbia for scientific and educational purposes.

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REPORT FORMAT

This is one of the volumes of the Virginia Coast Reserve Study, a preserve management feasibility study conducted by The Nature Conservancy. The study consists of four separate volumes. Each incorporates related disciplines. The volumes are titled and designated numerically.

Volume I, The Ecosystem Description

Volume II, Legislative Compendium, Title Search and Acquisition Priorities

Volume III, Social and Economic Analysis

Volume IV, Stewardship

These sections are explained further in the Introduction.

INTRODUCTION

The marshes and islands of the Virginia Coast Reserve are a precious resource. They are the least disturbed remnant of the thin green line of wetlands which once cloaked the Eastern Seaboard. They include beaches, maritime forests and thickets, sand dunes, grasslands, and salt marsh communities and provide a variety of habitats to adapted associations of terrestrial fauna, upland birds, waterfowl and plant species. Simultaneously they serve as a buffer separating the fragile fertile marshes and agricultural land of the Eastern Shore of Virginia from the Atlantic Ocean, support a large sector of the Shore's economy and provide an accessible aesthetic resource. Poorly planned development and wetlands alteration have accounted for the desecration of much of this resource along most of the Eastern United States' coastline. The Virginia Barrier Islands represented the last intact set of islands which faced this plight. Their relative isolation had protected them for years.

STUDY AREA DESCRIPTION

The Virginia Coast Reserve consists of approximately 33,371 acres of barrier islands and marshes owned by The Nature Conservancy on the Eastern Shore of Virginia. It contains thirteen islands (see Eastern Shore of Virginia map, page viii). The barrier islands of the reserve are Metomkin, Cedar, Parramore, Hog, Cobb, Ship Shoal, Myrtle, and Smith. The reserve's Revel and Rogue Islands are upland islands which do not front on the Atlantic Ocean. Sandy, Godwin, and Mink Islands are salt marsh components of the system. The Conservancy owns these islands with the exception of major portions of Cedar Island and small parts of Hog and Smith Islands. All of the Virginia Coast Reserve may be reached from the adjacent peninsula by boat but there are no roads connecting the islands with the mainland. This system stretches along the southern seaward edge of the Delmarva Peninsula, a coastal plain outcrop, for about fifty-one miles. The islands represent the most unaltered barrier island-lagoon complex along the east coast of North America. Latitude-longitude coordinates for the Virginia Coast Reserve are 37° 05', 37° 34'N and 75° 56', 75° 37'W.

The low lying islands' eastern border is the Atlantic Ocean. At intervals along the coast inlets connect the sea with the extensive lagoon system westward of the reserve. These lagoons typically have salinities of 25 to 34 parts per thousand. The tidal range along the ocean front of the islands normally averages 4.2 feet but may reach nine feet or more during excessive storm surges. The expansive marshes behind the barrier islands are much incised and well flushed by tidal action. Brackish and fresh water occurs in the interior of the larger islands at the head of their upland drainages or as small ponds.

Biological communities of the reserve are controlled by the islands' dynamic geology. The sandy soil of the islands is in a constant state of flux, subjected to the influences of wind, tidal currents, temporary stabilization by vegetation and high energy input along the coastal front. The system has a wide diversity of aquatic and terrestrial biota.

Human influence on the system has been persistent but for the most part, it has not altered the Reserve's integrity. The present Virginia Coast Reserve has been traditionally used for pastureland, pirateering, waterfowl and shorebird market hunting, resort development, and homesites. These human impacts have had little long term effect on the structure and function of the islands' natural systems. Their resiliency, isolation, and inaccessability protect them from most direct human influences.

The Eastern Shore of Virginia is a peninsula bordered on the east by the Atlantic Ocean and on the west by the Chesapeake Bay. It is the mainland adjacent to the Virginia Coast Reserve's islands. The landmass is divided into two counties; Northampton, the southern county, and Accomack, the northern county. The region is the southernmost extension of the Delmarva Peninsula, a physiographic unit encompassing Delaware and parts of Maryland and Virginia. The Eastern Shore is 75 miles long. It contains 70% of Virginia's total shoreline and 47% of her salt marshes.

The peninsula supports a rural population dependent primarily on agriculture and fisheries for subsistance. Land use categories of the peninsula include 29.1% agricultural land, 29% woodland, 32.2% tidal marsh, 1.5% coastal beach, and 8.2% miscellaneous. The Shore has been historically isolated. Until 1964, the peninsula was only accessible from the rest of the state by a ferry which crossed the Chesapeake Bay. U.S. Route 13 entered the region from the north through Maryland. Now, the Chesapeake Bay Bridge-Tunnel connects the southern tip of the Eastern Shore to the mainland via a 17 mile span crossing the mouth of the Chesapeake Bay. The area has traditionally been an isolated cul-de-sac. This fact, more than any other, was responsible for the maintenance of a rural life style and the preservation of the Virginia Barrier Islands until the time they were acquired and insured preservation by The Nature Conservancy.

In 1967 the sanctity of the Virginia Barrier Islands was threatened when developers considered building a bridge connecting Smith Island, in the south of the island chain, with the mainland. The ill-suited development typical of other coastal systems had come at last. Convention centers, airports, and second-home subdivisions were planned. The Nature Conservancy purchased the island from developers with funds provided by The Mary Flagler Cary Charitable Trust to insure the preservation of the island. This acquisition triggered the ensuing chain of purchases which ultimately led to the formation of today's Virginia Coast Reserve, a chain of thirteen islands preserving this coastal resource.

STUDY OBJECTIVES

The objective of The Nature Conservancy's involvement with the Virginia Barrier Islands is to insure the perpetual preservation of this unique barrier island-lagoon ecosystem.

The Conservancy's concern for the barrier islands has been exemplified through the Virginia Coast Reserve Study. The objective of this investigation was to establish a base line of information that would yield an understanding of the operationally significant factors governing the stewardship of the island system. The study was divided into four separate sections. Objectives were set for each portion of the research.

1. Objectives of the Legislative Compendium, Title Search and Acquisition Priorities Section
   a. Provide The Nature Conservancy with a clear image of its ownership and inholdings within the reserve system.

   b. Compile the legislation which pertains to the ownership of the islands, marshland and adjacent riparian and subaquatic rights to determine how it affects land stewardship.

   c. Establish a strategy for the further acquisition of key lands within this island-lagoon system that are worthy of preservation from an ecological or strategical perspective.

2. Objectives of the Ecosystem Description Section

   a. Identify the limiting ecological factors which must be known in order to administer the Reserve, preserving its unique qualities.

   b. Define the ecological components of the system to begin the establishment of a monitoring program which will expose the scientific community to the potential for innovative research possibilities within the Virginia Coast Reserve.

3. Objectives of the Social and Economic Analysis Section

   a. Establish economic baseline information about the two counties within the Eastern Shore of Virginia.

   b. Assess effects of the preservation of the Virginia Coast Reserve on the local communities of Accomack and Northampton Counties

   c. Assess the impacts of potential regional growth, land-use, and recreational needs on the Virginia Coast Reserve.

   d. Assess the indirect socio-economic benefits of the Virginia Coast Reserve associated with preservation of the system.

   e. Determine popular opinion regarding the preservation of the Virginia Coast Reserve.

4. Objectives of the Stewardship portion of the Virginia Coast Reserve Study

   a. Develop a list of the stewardship needs and procedures which offer maximum protection for the system.

   b. Determine agencies capable of accomplishing these goals and where ultimate stewardship responsibility should lie.

   c. Establish a preliminary management scheme accommodating preservation, research, education, and if appropriate, recreation.

   d. Determine the cost associated with this management scheme.

To achieve these objectives, the Virginia Coast Reserve Study coalesced the efforts of more than thirty professional administrative and research personnel. The experience and input of Eastern Shore residents also contributed to collecting this data.

LEGISLATIVE COMPENDIUM, TITLE SEARCH AND ACQUISITION

At the time of the acquisition of the Virginia Barrier Islands, the Conservancy became part of a parcel of difficulities including counter claims for ownership of the system, diverging interpretations in the chain of title to certain tracts, varying interpretations of existing island and wetlands-related legislation, and threats to the effectiveness of our preservation scheme from "inholdings" within the island system and lands owned adjacent to the reserve. We employed the full-time assistance of an environmental lawyer to catalogue, interpret and resolve these difficulties.

A complete title search was also conducted to determine the present ownership pattern of the barrier islands. This ownership information provided a basis from

which to assess the security of the Conservancy's present position as the controlling landowner within the island system, and of the intentions of insuring preservation of the complex. A review of the situation fostered the preparation of an acquisition strategy designed to fill the gaps in the present pattern of ownership.

At the same time, the complex environmental legislation pertinent to the administration of this marine wetlands area at federal, state and local levels was collected. The laws which may be used to insure the integrity of the reserve were compended. This allows their quick and efficient utilization in the administration of the reserve.

ECOSYSTEM DESCRIPTION

Information already existing pertinent to the natural history of the reserve has been collected. Additional basic field work was also completed to compliment this data.

The documentation of existing material included compilation of publications, maps, aerial photographs and other supportive material. The supply of existing comprehensive ecological data was scarce. Some information was available in the fields of geology, ornithology, and rudimentary plant community associations. A substantial body of material existed regarding the fisheries resources of the waters surrounding the island chain.

Supplementary ecological work was undertaken with the intention of complimenting existing data so that predictions and stewardship decisions based on a fundamental understanding of the ecology of the Virginia Coast Reserve system could be made.

SOCIAL AND ECONOMIC ANALYSIS

The barrier islands represent a valuable resource to the Eastern Shore of Virginia. They offer a livelihood to some by protecting marshland which provides a haven for marketable fish and shellfish. They offer attributes to residents of the "seaside" of the peninsula by buffering the shoreline from storm surges and winds. More intangible benefits are realized by a wider spectrum of the population. The islands are an integral part of the rural life style, the preferred quality of life, of the Eastern Shoreman.

These aspects, the benefits of the Virginia Barrier Islands to the local economy, lifestyle, and the residents' perception of the Eastern Shore, are analyzed in this section of the study. By the purchase of the barrier islands, the Conservancy has become the largest property owner in both Accomack and Northampton Counties. Addressing both the economic and social arguments for and against preservation of this huge system required the full-time assistance of a professional economist and the assistance of several contractual personnel from Salisbury State College, a local institution.

The economic analysis centered on the benefits and costs of barrier island preservation. This approach incorporated their tangible benefits and costs to the local communities and tangible and intangible benefits on a regional basis. Additionally, a detailed analysis of Virginia's Eastern Shore economy, in terms of the utilization of the local resource base, was conducted. The intent of this investigation was to assess the effect of barrier island preservation from the economic perspective of the Eastern Shore's citizenry.

The "quality of life" on the Eastern Shore is a well debated issue in local circles. The average citizens' perception of their lifestyle and general well being are clues

to the satisfaction or dissatisfaction with the style of life that The Nature Conservancy's natural area acquisition philosophy tends to preserve. The Conservancy was interested in determining whether its activities in the Virginia Barrier Islands were in accordance with or in opposition to the majority of sentiment of local residents. To assess these feelings, a broadly-based opinion poll of a representative sample of Eastern Shore citizens was conducted. Its aim was to gather data directly applicable to determining the "quality of life" dilemma here; were local residents happy with life as it is and the barrier islands as they are? The direct answers to these and associated questions have fostered conclusions about the Eastern Shore residents' perception of The Nature Conservancy's operations in this area and their wishes for the future of the Eastern Shore.

STEWARDSHIP

Effective administration of the reserve by any agency depends on the recognition of stewardship realities. In this section of the Virginia Coast Reserve Study, these were assessed and a scheme to deal with them is proposed.

Initially, a list of needs and procedures prerequisite to preserving the Virginia Barrier Islands was developed. The remainder of this section of the study dealt with how best to insure their fulfillment.

One of the greatest unknowns for the Virginia Barrier Islands preservation strategy was the ultimate managing agency for the system. It has traditionally been the Conservancy's policy to transfer some of its finest preserves to federal or state agencies interested in their management. Recently, a decision to internalize the management of selected preserves was made in accordance with The Nature Conservancy's model preserve "1980 Program". These conflicting policies had to be resolved in the best interest of the Virginia Barrier Islands.

The stewardship capabilities and policies of The Nature Conservancy and selected federal, state, and county agencies were examined. The interest each group had in the islands was assessed. Each agency's program was inspected to see whether it fit into the Conservancy's plan for the preservation of the Reserve. Finally, a review of their legislative, financial and enforcement abilities rounded out the picture.

The success or failure of The Nature Conservancy's own participation in this Virginia Coast Reserve management blend will be based on an operating budget. Present operating funds have been fully utilized in the preparation of this document. To continue operation requires the coordination of our management priorities and approximating an associated operating budget.

The stewardship option available to the Virginia Coast Reserve under the Conservancy's supervision is incorporated in this report. The scheme accommodates preservation, research and educational uses in differing proportions. This proposed stewardship plan addresses the number and functions of proposed Convervancy staff personnel to fulfill this preservation scheme, equipment requirements, office space and housing needs, future acquisition, and required research costs. The plan's implementation depends upon the identification of funding sources to power these programs.

Land Use History

LAND USE HISTORY

A STUDY OF MAN'S INFLUENCE

ON

VIRGINIA'S BARRIER ISLANDS

By

Maria Ann Graham

INTRODUCTION

The purpose of this research was to collect historical information on the Virginia Barrier Islands. In order to understand an ecosystem more fully one must be aware of man's past influence on the plant and animal communities. The Virginia Barrier Islands have been the scene of human activity for over four centuries and are thus ecologically disturbed, although relatively less so than most other Atlantic Coastal areas.

The following report will also be of value in determining future management policy. It was the sea isle flora and fauna that first attracted man, and hence, the islands have become a cultural part of Virginia's Eastern Shore. Local attitudes and traditional use of the barrier islands must be given serious consideration.

The report is divided into two parts. The first is a chronological history of man and the islands. The second part selects aspects of this history which are directly related to ecosystem development and magnifies them. The purpose of this organization was to avoid destroying the continuity of such important subjects as hunting, the recorded history of which extends through almost four centuries.

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A CHRONOLOGICAL HISTORY

THE 17TH CENTURY

I. THE ABORIGNES

When the English settlers arrived on the Eastern Shore of Virginia, they found it sparsely populated by several small Indian tribes. Some evidence suggests that these tribes may have been associated with the Powhatan Confederacy of mainland Virginia.[1] The Indians were primarily farmers and fishermen and secondarily hunters, although many references have been found to the harvesting of terrestrial fauna.

Early arrivals to the peninsula, in approximately 1620, are believed to have traded cloth for beaver, otter, and wildcat skins.[2] Clothing was often deerskin; and hawks'bills, eagle talons, and animal teeth were used as ornamentation. The Indians utilized the marine resources as well. They fished and caught clams and oysters in season.

> They lived mainly on fish, oysters and clams, as piles of shells near villages attest. Yet deer, bears, wolves, wildcats, beaver and small game were plentiful; and in one place I have seen that an Indian sold three moose skins.[3]

Corn and other vegetables were grown and stored for winter use.

The Accomac and Accohannock tribes were friendly to the newly settled English, and continued to be throughout their association.

> The Indians here were a timid, harmless, kindhearted people, so far as traditions and our court records show. They numbered about 2,000 in 1608, and were ruled by Debedeavon (the laughing king) and by Okiawampe until 1657, when the daughter of the latter became queen...He cautioned her, and enjoined it upon the Indians, to preserve the good will of their white friends, as he had done. What a travesty upon friendship was that of the confiscators, who were fast driving his people from the face of the earth![4]

By the year 1700, the Indians of the Eastern Shore were almost entirely gone. They had lost their tribal land and were occasionally enslaved. Perhaps the greatest blow came in 1677 when a smallpox epidemic swept the Indian community.[5]

1/ Weslager, C.A. 1959. The Accomac and Accohannock Indians from Early Relations. Published by the Eastern Shore of Virginia Historical Society.

2/ Turman, Nora Miller. 1964. The Eastern Shore of Virginia. 1603-1964. The Eastern Shore News, Inc. Onancock, Virginia. p. 40.

3/ Upshure, Thomas T. of Northampton County. 'Eastern Shore History'. An address delivered at the Accomack Courthouse on June 9, 1900. In Virginia Magazine of History and Biography. vol. IX p. 93.

4/ Ibid. p. 91.

5/ Weslager, C.A. 1959. p. 25.

During their more peaceful years, prior to the white man's arrival, the Indians may have made trips to the barrier islands. In many Atlantic coastal areas, tribes traveled to the seaside to fish and to catch clams and oysters. They constructed temporary dwellings and left large shell mounds as evidence of their presence. Hog Island is believed to have been a favorite spot for this activity.

> These were all small bands of Indians, but the Matchipungoes were a large tribe, and had several villages - one at or near Wachapreague, another lower down the neck, and yet another on the Woodlands and Brownsville farms in Northampton. Dr. Brinton says that the word Matchapungo means fine dust, or flies, and, as the name belonged to Hog Island as well as to the river and to the Indian tribe, we may reasonably infer, in the absence of anything to the contrary that the sand or mosquitoes on Hog Island gave rise to the name.[1]

Several former Hog Island residents claim that there is at least one Indian 'shell heap' on the island today. The former island road, running along the length of the island, went directly past the site three miles below the present Matchipongo Club building.[2]

Further reference has been made to an Indian burial ground on the north end which was accessible in the early years of 1900. It appears that the Hog Island residents found Indian artifacts at a spot now under the sea. "An Indian burying-ground, up toward the north end is entirely gone."[3]

Whether the Indians ever sojourned on any of the other islands is unknown; however, it seems likely that they did. Perhaps the long residence of settlers on Hog Island allowed time for exploration, and thus, on this island evidence was found.

> North and south stretches the long, white strip of sand as far as the eye can reach. Behind lies in shimmering beauty the mirror of Broadwater Bay. There is not a human habitation in sight - the happy hunting ground the redman saw in visions of the olden time.[4]

II. THE ENGLISHMAN

In 1608, one year after the settlement of Jamestown, Captain John Smith, the explorer and adventurer, landed on the island which today bears his name.[5]

1/ Upshure, Thomas T. 1900. p. 93.

2/ Bowen, Harvey. Taped Conversation. Tape #8. September 17, 1975.

3/ Eastern Shore News. April 4, 1957. In Mears Scrapbook vol. 4, p. 81. Eastern Shore Public Library.

4/ Dixon, Thomas Jr. 1907. The Life Worth Living - A Personal Experience. Doubleday N.Y. Quote found in Mackey, William J., Jr. 1965. American Bird Decoys. E.P. Dutton & Co., Inc. N.Y. p. 155.

5/ The island may have been named for Sir Thomas Smith, the first president of the Virginia Company, after Captain John Smith fell in disfavor.

Near the peninsula, making green splotches in the surrounding seas, are numerous islands, the description of which, given by the Indians in 1608, afforded Captain John Smith "exceeding pleasure". Smith himself speakes of them as "many Isles both great and small, some woody, some plain, most of them low and not inhabited".[1/]

Thus, with the discovery of Smith Island, Englishmen continued the ecosystem disturbance begun by the Indians. Henceforth, the evolutionary direction of the barrier island plant and animal communities would be changed.

The first industry of the Eastern Shore was salt making. In 1614 the London Company sent men to Smith Island for this purpose, and the enterprise continued into the 1620's. At one point there was some question about the efficiency of the method used. It was suggested that salt be made by evaporation using the heat of the sun instead of "by that toylesome and erroneous way of boyling sea water into salt in kettles as our people at Smyths Island have hitherto accustomed".[2/] Although the method was continued, the site may have been moved to a more convenient location on the mainland.

During the period when men were being employed at the salt works, settlement was beginning on the Eastern Shore. By 1632, Accomack plantation had a population of 300.[3/] "At that time farm after farm was being settled upon and improved, tobacco and corn were the main crops, and tobacco and beaver skins were the commodities that corresponded to our silver and gold, at the ratio of about ten to one."[4/] Cattle and other livestock were raised for local use, as well as for market.

The entire peninsula was originally called Accomack County, but was changed in 1643 to Northampton County. Twenty years later a division was made. Accomack became the northernmost county while Northampton encompassed the southern portion. The counties were again rejoined and the final, and present day, division came in 1674.[5/] The population had by this time reached 1000.[6/]

The ever increasing numbers of settlers soon found livestock grazing a problem. The islands were thus early employed as pastures for the previously unfenced and wandering cattle, sheep, and horses.

1/ Travels and works of Captain John Smith. Edited by Edward Arber. Edinburgh Vol. I & II. Quote found in Ames, Suzie M. 1940. Studies of the Virginia Eastern Shore in the Seventeenth Century. Russell & Russell. N.Y. p. 3.

2/ Kingsbury, Records of Virginia Company. Vol. III, p. 304. In Ames, Suzie M. 1940. Studies of the Virginia Eastern Shore in the Seventeenth Century. Russell & Russell. N.Y. p. 112.

3/ Turman, Nora Miller. 1964. The Eastern Shore of Virginia. 1603-1964. The Eastern Shore News Inc. Onancock, Va. p. 28.

4/ Upshure, Thomas T. 1900. p. 94.

5/ Turman, Nora Miller. 1964. p. 76.

6/ Ibid. p. 51.

The vast areas in the ocean island of Assateague, Chincoteague, Wallops and smaller islands had been patented more than three decades earlier (circa 1680). In order to hold his patent, the owner was required to keep only four men on it and pay the king's rent. This small number of men could tend a large herd of livestock where no fences were required.[1]

Below Wallops Island, Assawoman (Assawaman) and Metomkin Islands were patented in 1682. Some controversy seems to exist, however, regarding the details of the patent due to the various names used in reference to the islands.[2] One year before this, in 1681, Cedar Island was patented. Interestingly, in 1683 the patentees, William Burton and Thomas Bagwell, petitioned the court for a convenient road to a landing where one could embark to the island.[3]

A patent of 800 acres was granted to William Custis in 1686 on "Feaks his Island". The island was later left to Joanna Custis Hope who married Thomas Parramore.[4] The island was thereafter known as Parramore's Beach or Parramore Island. Other islands once located in the vicinity of Cedar and Parramore Island were claimed in 1687. Isaac's Beach was between 'Ceedar Island' and 'Feches' and is believed to have joined Feches. Also in that year William Custis was granted Cooney Island (Cod's Calfe Pasture or Cow's Calf Pasture).[5]

In like manner, the next island in the chain, Hog Island, was patented in the 1680's as was its neighbor Rogue Island.[6] Prouts Island, situated in the general area of today's Cobb Island, was patented by John Floyd. This 400 acre grant was made in 1687.[7]

According to Whitelaw, Mockhorn (Mockon or Machone) Island was patented in 1657.[8] Some controversy arises because according to old-timers, Mockhorn was not an island in the 1800's but was connected to the mainland (see PHYSICAL CHANGES, p. 79).

Still greater confusion arises in regards to the patenting of Smith Island. One source suggests 1614[9], another 1636[10], and a third 1691[11]. In any case, ownership

1/ Ibid. p. 104.

2/ Whitelaw, Ralph T. 1951. Virginia's Eastern Shore. Vol. I & II. Virginia Historical Society. Richmond, Va. p. 1139, 1140.

3/ Ibid. p. 880.

4/ Ibid. p. 780.

5/ Ibid.

6/ Ibid. p. 368.

7/ Ibid. p. 214.

8/ Ibid. p. 90.

9/ Turner, Col. James S.G. 1975. Personal Correspondence.

10/ Ames, Suzie M. 1940. Studies of the Virginia Eastern Shore in the Seventeenth Century. Russell & Russell, N.Y. p. 32.

11/ Whitelaw, Ralph T. 1951. p. 50.

came into the hands of General John Custis and remained in the Custis-Lee family for approximately 200 years.[1]

The islands were, throughout the remainder of the 17th century, primarily livestock pastures. Human habitation prior to 1700 was, for the most part, restricted to temporary arrangements. Sterling, however, claimed in 1903 that Hog Island was first settled by colonists in 1672. Twenty-two settlers were supposed to have lived on the island for a short time before mysteriously disappearing.[2] Two other references were found to this early village in 20th century newspaper articles.[3,4] But, as Sterling himself said, "the tale would bear telling and would make fascinating reading".

Whitelaw suggested that Thomas Coffin may have been the first inhabitant of Hog Island in the late 1600's or early 1700's. He then went on to say that the first sale of property for residence purposes was to Peter Dowty in 1692.[5] (The name 'Doughty' later became a predominant name on the island.) It is interesting to note that of all the islands, Hog Island appears to have been the most attractive to not only the Indians but to the early colonists also.

The pirate scourge of the Atlantic coast lasted for approximately half a century from 1680 into the 1730's, and hence in this period the Virginia Barrier Islands were drawn into this dangerous chapter of colonial history. One of the most notorious pirates of eastern Virginia was Edward Teach, alias Blackbeard. There is contention that he may have plied the waters around the Virginia Barrier Islands.

> He has been the embodiment of impregnable wickedness, of reckless daring, a nightmarish villain so lacking in any human kindness that no crime was above him.[6]

Some say that Blackbeard came from Bristol, England, and others say that he was a native of Accomack County.

> An early edition of The Virginia Magazine of History and Biography states that 'Blackbeard' the pirate was a native of Accomack County... The rendevous of his men were on Parramore's Beach, Revell's Island, Hog Island and Rogue's Island - The latter island received its name from being the hiding place of the band.

1/ Well-known owners included George Washington Custis, Robert E. Lee, and William Fitzhugh Lee.

2/ Sterling, Charles A. 1903. Hog Island Virginia. Copyright by Charles A. Sterling. p. 6.

3/ The Sunday Sun Magazine. Baltimore, Md. October 28, 1956.

4/ Barnes, Parker. "For the Barriers, An Ancient Conflict Continues". The Virginian-Pilot Lighthouse. January 10, 1971. p. C1.

5/ Whitelaw, Ralph T. 1951. p. 368.

6/ Williams, Lloyd Haynes. 1937. Pirates of Colonial Virginia. The Dietz Press. Richmond, Va. p. XIV.

7/ Horner, Dave. 1965. Ship Wrecks, Skin Divers, and Sunken Gold. Dodd, Mead & Co. N.Y. p. 26.

The islands and their inlets would indeed have served well as hiding places for the wandering rogues. Here they could restock their ships and keep watch for prospective plunder. There is little doubt that the area around Smith Island was particularly attractive. Its location at the mouth of the bay made it vulnerable, as the colonists soon discovered.

> In October (1699), Colonel John Custis of Northampton County wrote Nicholson (the governor) that pirates had landed on Smith's Island and killed some beeves. He pointed out that the island was a safe place for pirates to land and victual their ships.[1]

Smith Island was raided during the last decade of the 17th century, and cattle were slaughtered for food. The colonists responded by establishing a militia to keep watch at the entrance to the bay.[2] Lookouts were stationed on Smith Island; however, "more than a league off the coast, the lookouts stationed on it were powerless to give warning if a wind was blowing, for they had nothing but canoes to convey them to the mainland".[3]

Parramore Island may also have been a favorite landing spot for these despicable seafarers. The island was known after 1700 as Teach's Island; however, Whitelaw unromantically stated that there are no records to substantiate this tradition.[4] Furthermore, he pointed out that in a 1673 map the island was called 'Fetches Island'.[5]

Blackbeard was finally captured in North Carolina and given the ignominious distinction of having his head mounted on the bow of his captors' ship. He is still remembered locally. A point of land on Smith Island is named for him. Today we are reminded of this long ago episode by treasure hunters who periodically search for buried gold along the beaches of the Atlantic Coast.

At the close of the 17th century, the Virginia Barrier Islands had been 'discovered' as wonderful places to graze livestock. They were used as locations for salt making and most certainly for hunting and fishing. The impact of human activity intensified when the first settlers found life at the seashore appealing, or perhaps daring and profitable. The sloping shoals trapped many sailing vessels and continued to do so for the next two centuries. With an increase in the shipping business came a corresponding interest in pirating and a greater incidence of ship wrecks. The physical and biological character of the barrier islands was, and is, responsible for directing man's interest in them.

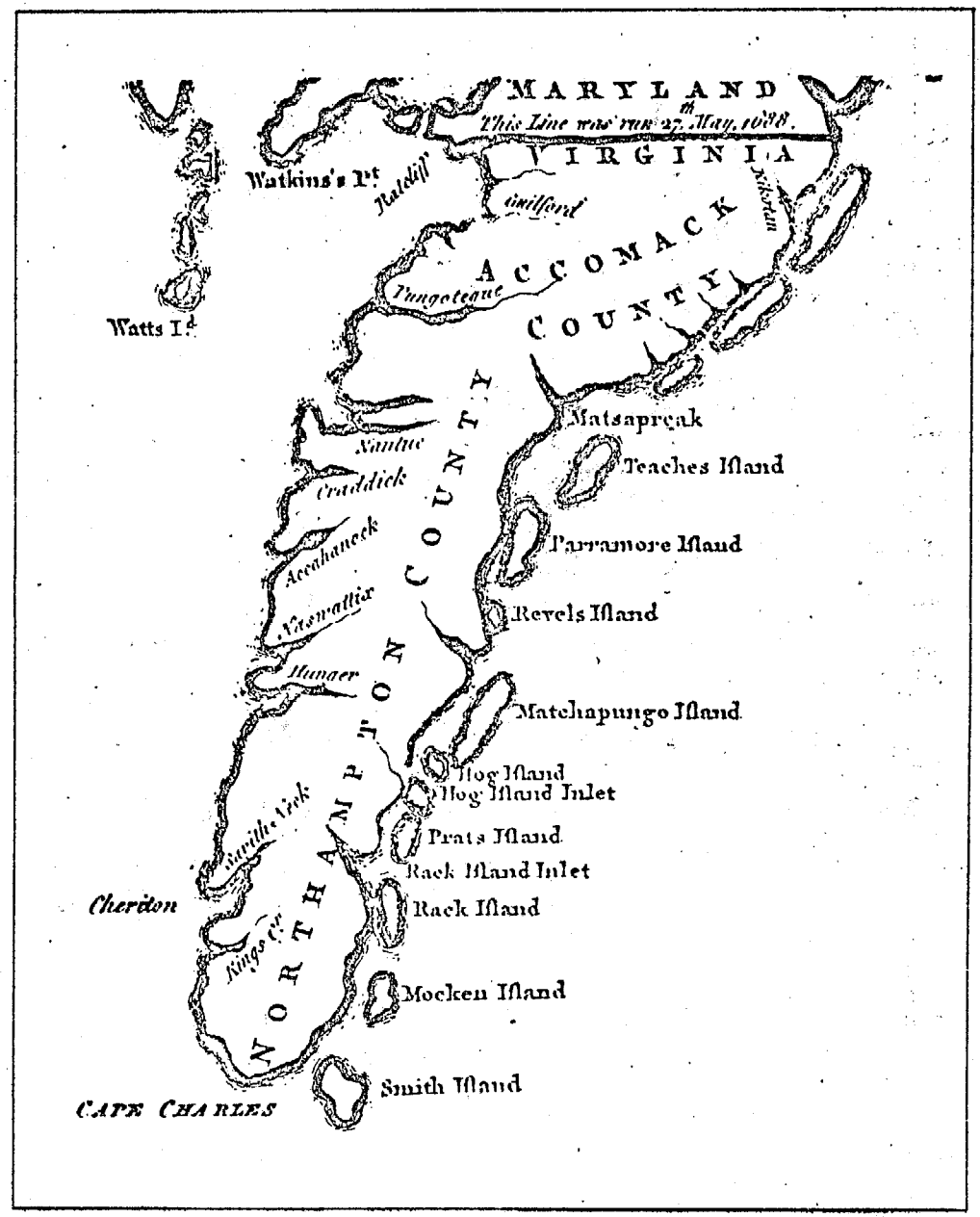
1/ Williams, Lloyd Haynes. 1937. p. 8.

2/ Turman, Nora Miller. 1964. p. 86.

3/ Williams, Lloyd Haynes, 1937. p. 51.

4/ Whitelaw, Ralph T. 1951. p. 39.

5/ Ibid. p. 780.



This map of the Eastern Shore of Virginia is reproduced from "A Map of the Most Inhabited Part of Virginia..." drawn by Joshua Fry and Peter Jefferson in 1751. Some of the barrier islands' names and configurations appear different than they are at present. Others have remained the same while others have changed only sightly, their former names being reflected in today's titles.

THE 18TH CENTURY

Relatively little information is available about the barrier islands in this century up until the time of the Revolution. Presumably livestock grazing continued and surely the colonists hunted and fished in their vicinity. Habitation of the islands in this period was insignificant if it occurred at all.

The islands appear again in the literature in connection with the American colonists' war for independence. Along the whole length of the Eastern Shore British sailors raided, and attempted to raid, the mainland for food and supplies.

> Early in the Revolutionary War, the British established an operation base on Hog Island. Small ships called tenders and barges raided the Eastern Shore to get food and livestock which were used to replenish the supplies of British warships in the area.1/

Thus, although Hog Island was defended, the British established a foothold on the island.

There was also concern for other islands in the chain and their potential use as bases from which to supply the enemy.

> When we consider the importance of the Eastern Shore as a food supply for both American and enemy soldiers, it is understandable why the Convention was concerned about the safety of livestock on the island earlier in 1776. Incidentally, the stepson of General Washington* owned Smiths Island and there is no doubt but that any livestock there was evacuated before Lord Dunmore's tenders got there seeking food for his warship.2/

The vulnerable location of the islands and the long-established tradition of livestock grazing made them attractive and ideal targets for the British forces. The ports of Accomack and Northampton were main ports of entry after the closing of the Chesapeake by the British, and hence further concentrated activity in this region.

Supplies from overseas were brought into Metomkin and Chincoteague Creeks. In order to protect incoming ships and to intercept British raiding barges, a fort was established on Parramore's Beach.3/ We do know from the memoirs of General John Cropper that Cedar and Parramore Islands were used to establish a defense on a small scale in the late 1770's.

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* Martha Dandridge married Daniel Parke Custis and was widowed. She later married George Washington who became the step-father to her children.

1/ Turman, Nora Miller. 1964. The Eastern Shore of Virginia. 1603-1964. The Eastern Shore News Inc., Onancock, Va. p. 131.

2/ Turman, Nora Miller. "The Eastern Shore 1775-1783". Column in the Eastern Shore News. August 28, 1975.

3/ Turman, Nora Miller. 1964. p. 131.

About 8 o'clock I landed a brass four pound gun on the north end of the island (Cedar), and proceeded with all possible expedition to the south end...

Saturday February 27

I am almost dead with fatigue. At ten o'clock P.M., Col. Parker came to the Latin House, and informed that Col. Corbin had landed a four pound iron gun on Parramore's Beach, and was endeavoring to prevent the going out of the tenders. I collected my neighbors and went on to Cedar Island with a four pound gun.[1]

Several times during the course of the war prisoners were taken on or near the barrier islands. An early reference to such a capture is the following in 1777:

The Court proceeded to examine the said Robert Pierson lately cast away on Hog Island in this County, on consideration whereof it appearing by his confession that the said Robert belonged to the schooner Molly of the British Fleet bound from Chesapeake Bay to New York, and was cast away by stress of Weather - Ordered that the said Robert be delivered to Col. Gist by the Sheriff as a prisoner of War.[2]

On January 10, 1782, Col. John Mapp wrote to Governor Harrison to say that a small ship was taken by a New York Privateer in the inlet near Hog Island.[3] Later in that same month a discussion was held to determine the possible exchange of the British men captured on Hog Island.[4]

Prisoners were still being taken the following year when Col. John Mapp again wrote, this time to Commodore Barron.

February 12, 1783:

I have in my possession near Sixty Prisoners of War. A Capt. of a Barge and four privates of the number were captured on Hog Island by my militia: the remainder are the officers and crew of the British Privateer called the Digby, mounting 18 guns, and lately run on shore near Cape Charles.[5]

A problem to be faced by both the British and American navy was navigation of the treacherous barrier island shoals. Marx, in Shipwrecks of the Western Hemisphere, supplied a long list of ships lost in the vicinity of Hog, Cobb, and Cedar Islands during the 18th century.[6] The establishment of Life Saving Stations was not to come

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1/ Wise, Barton. Reprinted 1974. Memoir of General John Cropper of Accomack County, Virginia. Virginia Historical Collection Vol. XI, 1892. p. 14.

2/ Revolutionary Soldiers and Sailors from Northampton County, Virginia. 1812. Compiled by Stratton Nottingham. Onancock, Virginia. p. 3.

3/ Calendar of Virginia State Papers. January 1, 1782 - December 31, 1784. Vol. III, p. 13.

4/ Ibid. p. 198.

5/ Ibid. p. 435.

6/ Marx, Robert F. 1971. Shipwrecks of the Western Hemisphere 1492-1825. World Publishing Company. N.Y. p. 166.

for another century.

During the Revolutionary War, or shortly thereafter, the settlement of Hog Island began. Sterling stated that Labin Phillips built a home on the island of red cedar which withstood salt air better than oak, pine, hemlock, or black jack.[1/] According to Whitelaw, people were definitely inhabiting Hog Island in the 1790's.[2/]

In the first half of the 18th century disturbance to island flora and fauna was primarily a result of livestock grazing practices. By the close of this period, however, other human activities were increasing in intensity, and they would continue to do so for another 150 years.

1/ Sterling, Charles A. 1903. Hog Island Virginia. Copyright by Charles A. Sterling.

2/ Whitelaw, Ralph T. 1951. Virginia's Eastern Shore. Vol. I & II, Virginia Historical Society, Richmond, Va. p. 454.

THE 19TH CENTURY

The 19th century saw the most active period of man's influence on, and use of, the Virginia Barrier Islands. This was the century of lighthouses, Coast Guard Stations, homes, schools, churches, swank hotels and elaborate hunt clubs; and although the interest peaked in the early years of the 20th century the roots of that interest were here.

I. THE COBBS

People had lived on Hog Island for many years, but it was Cobb Island that was the focal point in the 1800's. Today the story of Cobb Island is well known because the descendents of the original Cobbs are enthusiastic and keep the story alive.[1/]

Nathan Cobb was a ship builder in Massachusetts when in 1833 he determined to move his family south. His wife, Nancy, had tuberculosis and was thus unable to stand the rigors of a New England climate. Nathan, his wife, and their three sons - Nathan, Warran, and Albert, soon found themselves settled near Oyster, Virginia. The Virginia Barrier Islands had always been challenging for navigators and wrecks were frequent. Nathan Cobb saw a potential business in salvaging ships and consequently bought an island.

> On March 11, 1839, Nathan purchased Great Sand Shold(sic)Island from William and Elizabeth Fitchett for one hundred fifty dollars. There is a family story that part of the payment was a wagonload of salt, but the deed makes no mention of this consideration. The entire family moved to the island, and from that time it became known as Cobb's.[2/] *

Nancy Cobb died shortly after the move to the island. Nathan remarried, and along with his sons continued their enterprise of salvaging ships. The business was profitable, but the Cobb brothers also provided a valuable service in those years prior to the establishment of Life Saving Stations. Many cargos and crews were saved through their efforts.[3/]

As did the inhabitants of other islands, the Cobbs reaped the benefits of life in the midst of abundant natural resources. A new opportunity presented itself in mid-century with the growing demand for wildfowl in city markets. Thus with the Cobbs began the market hunting of the Eastern Shore's seaside (see HUNTING, p. 55).[2/]

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* See Part II section 6 for a conflict concerning the purchase of Cobb Island.

1/ Except as otherwise noted most of the information on Cobb Island's beginning comes from Amine Kellam, a great-granddaughter of Albert Cobb, and today the family historian

2/ Kellam, Amine. "The Cobb's Island Story." Virginia Cavalcade, Spring 1974. p. 22.

3/ A list of stranded ships which the Cobbs helped is presently available at the Harvard University Library. It was formerly in the possession of Arthur C. Cobb of Newton, Massachusetts.

Nevertheless, the most important Cobb Island enterprise was yet to come.

An interest in sport hunting was developing rapidly in the United States; and who should be better equipped to guide the city 'sport' than the man who had depended on wildlife for his livelihood? The Cobb brothers began to take on small hunting parties. By the close of the Civil War the resort business on Cobb's Island was flourishing.

> Nathan decided to build a hotel and a clubhouse. He also erected Tammany Hall, the Truitt House, and several smaller guest cottages; enlarged the living quarters of his domestic employees; and sold a few lots. Cobb's Island, originally purchased because of its strategic location for salvage operations, had become a hunter's paradise and then a year-round resort accepting summer visitors as well as winter sportsmen. One hundred guests could be accommodated, in addition to the fifty people who lived year-round in the island community.[1/]

Visitors to the hotel came from all over the United States as well as from Europe.[2/] At first they came to the Eastern Shore by steamboat and later by the newly constructed railroad system which was partially responsible for 'opening up' this area in the 1880's. The hotel provided bowling, billiards, band music, and "the bathing is said by judges to be the type finest on this coast"[3/].

> The island became almost as famous for surf bathing, fishing, and gull-egging as it was for wild-fowling in addition to being an elite small social center.[4/]

The island was so popular that it became necessary to establish a farm and grist mill on the mainland to supply the food needs of the islanders. Ice was cut on ponds in winter and stored for year-round use. During this period, a church was built and a Life Saving Station went into operation. One of the more distinguished resort guests in the 1870's was Jefferson Davis, the former President of the Confederacy.[5/]

In 1868, one could enjoy the healthy life of the seashore for $3/day, $18/week, or $60/month.[6/] The seven mile long, three mile wide Cobb's Island was famous.[7/]

> There is a peculiar, indefinable charm about this spot which everyone who lingers here twenty-four hours is sure to experience. It is a charm which

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1/ Kellam, Amine. 1974. p. 23.

2/ The hotel guest register is in the possession of Mrs. Amine Kellam.

3/ Peninsula Enterprise. 8/9/62. "75 years ago" column, July 30, 1887. In Mears Scrapbook Vol. 14, p. 37-38, Eastern Shore Public Library.

4/ Connett, Eugene ed. 1947. Duck Shooting. William Morrow and Co. N.Y. p. 153.

5/ Mackey, William J. Jr. 1965. American Bird Decoys. E.P. Dutton and Co. Inc. N.Y. p. 152.

6/ "The Shoreline". January 6, 1950. In Mears Scrapbook Vol. 4, p. 57. Eastern Shore Public Library.

7/ Mears, James Egbert. Chapt. XXVII. "The Eastern Shore of Virginia in the Nineteenth and Twentieth Centuries." Reprinted from The Eastern Shore of Maryland and Virginia. Edited by Charles B. Clark. Lewis Historical Publishing Co. N.Y. 1950. p. 620.

This is the main building of the Cobb Island Hotel complex. Other facilities included guest cottages, servant's quarters, and an outdoor bowling alley located beneath a grape arbor. The Cobb Island resort industry saw its heyday during the late 19th century. The original buildings were destroyed by storms in the mid 1890's. Photo circa 1890. Courtesy of Amine Kellam.

overcomes all the inconveniences and discomforts which abound, for while Nature has lavished her choicest gifts, man has done little or nothing. August 26, 1896.[1]

Within a year it was gone. Severe storms had been pounding the coast for a decade and the destruction of the buildings came inevitably in the mid-1890's.

II. THE CIVIL WAR

The barrier island resort business began in the years following the Civil War. The Eastern Shore of Virginia was early occupied by Northern Armies and thus played a small role in the war between the states. Some natives, however, escaped across the bay and later fought with the Army of Virginia. The seaside islands were not devoid of activity and are thus mentioned several times in the literature of the war years.

> Even if President Davis and the Confederate War Department were too preoccupied with major activities to give thought to wrestling Accomack and Northampton from the Federals, there were brave souls in subordinate positions who were unwilling that the stay of the Union invasionists on the Virginia Eastern Shore should be merely a pleasant holiday. These made occasional raids on United States Government property on the east side of the Chesapeake.[2]

The Smith Island Light was duly attacked in August of 1863.

> A bold and successful foray was made on Monday morning last on the lighthouse and Government property on Smith's Island, just outside the mouth of the Chesapeake Bay. A party of nine men in a boat issued out from concealment on Mockhorn Island and made for Smith's Island, where they landed. They gave themselves out as fishermen, but after asking many questions, informed the keeper of the lighthouse, William Webb Stakes, that they had come to destroy his light and carry off the movable property in his charge. Setting hard to work, they removed 400 gallons of sperm oil to their boat and deliberately, and, with some skill in the use of proper tools, took down and similarly carried off various parts of the lattern, reflectors, lamps, etc. They also possessed themselves of a valuable clock there, the supplies being valued at $2,000. They kept Mr. Stakes and family as well as four other families on the island under pledge to give no information till the third day after they had left. A part of their plunder they took in a new boat belonging to the Government, which they towed away to seaward. They told Mr. Stakes they were from Richmond, and that a similar raid would be made on Hog Island light, a few miles further up the coast. They paid for a dinner they compelled Mrs. Stakes to set for them with a $5 Confederate note.[3]

1/ The Richmond Dispatch. August 26, 1896. In Mears Scrapbook, Vol. 4 p. 59. Eastern Shore Public Library.

2/ Mears, James Egbert. 1957. The Virginia Eastern Shore in the War of Succession and in the Reconstruction Period. p. 223.

3/ Mears, James Egbert. 1957. The Baltimore Sun of August 12, 1863, quoting the Worcester County (Md.) Shield. p. 224.

The Cape Charles Lighthouse, Smith Island, Virginia, was a 150 foot tall structure built in 1864. In 1895 the light was lit for the first time. It was condemned in 1917. The site of the original beacon is now under the sea. Photo date 1885. Courtesy of the Mariner's Museum, Newport News, Virginia.

Protection was arranged for other barrier island lighthouses, and efforts were made to capture Capt. John Yates Beall, the leader of the Smith Island "guerrilas". A force of men arrived to protect the Hog Island light and were further instructed to "cross to the mainland and break up and take or kill this party of guerrillas"1/. It is interesting that in 1903 Sterling gave the following account of the Hog Island light:

> During the Civil War all of the islanders were true to their native State of Virginia, and it is safe to say that the gleam of the Hog Island light did not flash across the waters during the whole four years of internecine strife.2/

The Civil War was fought in other ways on the barrier islands. Blockade running was not uncommon. It is believed that the Cobbs may have taken part in this intrigue.3/ Certainly the islanders' skill with ships would have made them ideal for such an undertaking. "On the 24th (September 1863) all hands took to the larger schooner, the Alliance, and sailed southward to Cobb's Island. Here Beall obtained a capable pilot..."4/ Further evidence for the existence of this activity is found in an October 1863 issue of The Baltimore Sun.

> The schooner Swan, with assorted cargo, from Baltimore, arrived here yesterday under a prize crew. She was captured near Hog Island by a detachment of Third Pennsylvania Artillery. She was no doubt about to run the blockade.5/

Furthermore, it seems that the Eastern Shoremen who refused to take the oath of allegiance upon the arrival of the Union Army were held prisoner on Cobb and possibly other islands.6/

III. LIGHTHOUSES AND LIFE SAVING

The treacherous waters along the Atlantic Coast prompted the Federal Government to construct lighthouses as ship traffic in the 19th century increased. Human activity was thus further intensified on the barrier islands of Virginia. Later in the century, with first the establishment of Life Saving Stations and then the Coast Guard, a new dimension was added to island use.

The Cape Charles Light was the first lighthouse on the chain below Assateague Island. Located on Smith Island at the mouth of the Chesapeake Bay in 1828 it warned passing ships as its successor does today. There is a romantic legend that the body of a woman, washed up on the island in 1813, was none other than the missing Theodosia Burr whose father had been Vice President of the United States. Speculation was that she

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1/ Mears, James Egbert. 1957. Letter on September 26, 1863 from Fort Monroe to Capt. F. Von Schilling. p. 239.

2/ Sterling, Charles A. 1903. Hog Island Virginia. Copyright by Charles A. Sterling. p. 22.

3/ Kellam, Amine. Taped Conversation. Tape #5. September 12, 1975.

4/ Mears, James Egbert. 1957. p. 228.

5/ Ibid. p. 241.

6/ Robertson, Dr. John. Personal Conversation. September 29, 1975. Father was detained on Cobb Island until the end of the war.

had been "captured by buccaneers and made to walk the plank".[1] So it was that near her grave, on six acres deeded by George Washington Parke Custis, the new lighthouse was constructed.[2]

The 1828 lighthouse, the first of three on Smith Island, was built at a cost of $7,398.82.[3] The sea began to encroach and in 1856, $35,000 was appropriated for relocating the lighthouse.[4] The new light was completed in 1864 under the protection of a military guard because of the Civil War activity of the local rebels. Twenty years later, the sea was again threatening and jetty construction was begun. The jetties had little effect because on August 15, 1895 the newest and present day light was lit. The former site is under the sea.

The first lighthouse on Hog Island was completed in 1852 or 1853. Its location was two miles east of the 'new' 1896 lighthouse whose foundation in 1975 is in the ocean. The second lighthouse was built in a wooded section at a cost of $100,000.[5] The following is a sample of information noted in the Hog Island Light Station Journal by George Lanson Doughty:[6]

May 1, 1873 - concern that the light was not bright enough due to "bad oil".
November 15, 1873 - note that one could see Smith Island Light in good weather.
Winter 1880-1881 - many snowstorms and severe weather.
August 31, 1886 - shock of an earthquake felt.
June 3, 1893 - "President Cleaveland(sic) left the island today. Having been stoping(sic) at the Broadwater Club House for a fishing trip."
January 31, 1896 - new light lit for the first time.
February 6, 1896 - Brant "attacked" the light - shot 20.
February 14, 1896 - Letter from inspector B. Lamberton ordering wire to be placed around the lantern. "Keep the Brant away and wild fowl from your light...shoot if necessary."
February 18, 1896 - a second letter from Lamberton. "It is not reasonable to suppose that a law would be made to protect waterfowl at the risk of human lives at sea."
October 11, 1896 - "There is a severe storm from the North East. The Tide has nearly submerged the island."

Generally, throughout the era, the light was periodically inspected and supplies delivered. Many shipwrecks and life saving efforts were noted. Waterfowl were indeed attracted to the light as mentioned by Sterling:

> Often in the morning after a storm, over a hundred dead birds have been picked up, and there are more killed in this way than by the sportsmen.[7]

1/ Snow, Edward Rowe. 1955. Famous Lighthouses of America. Dodd, Mead & Co. N.Y. p. 155.

2/ Whitelaw, Ralph T. 1951. Virginia's Eastern Shore. Vol. I & II. Virginia Historical Society. p. 50.

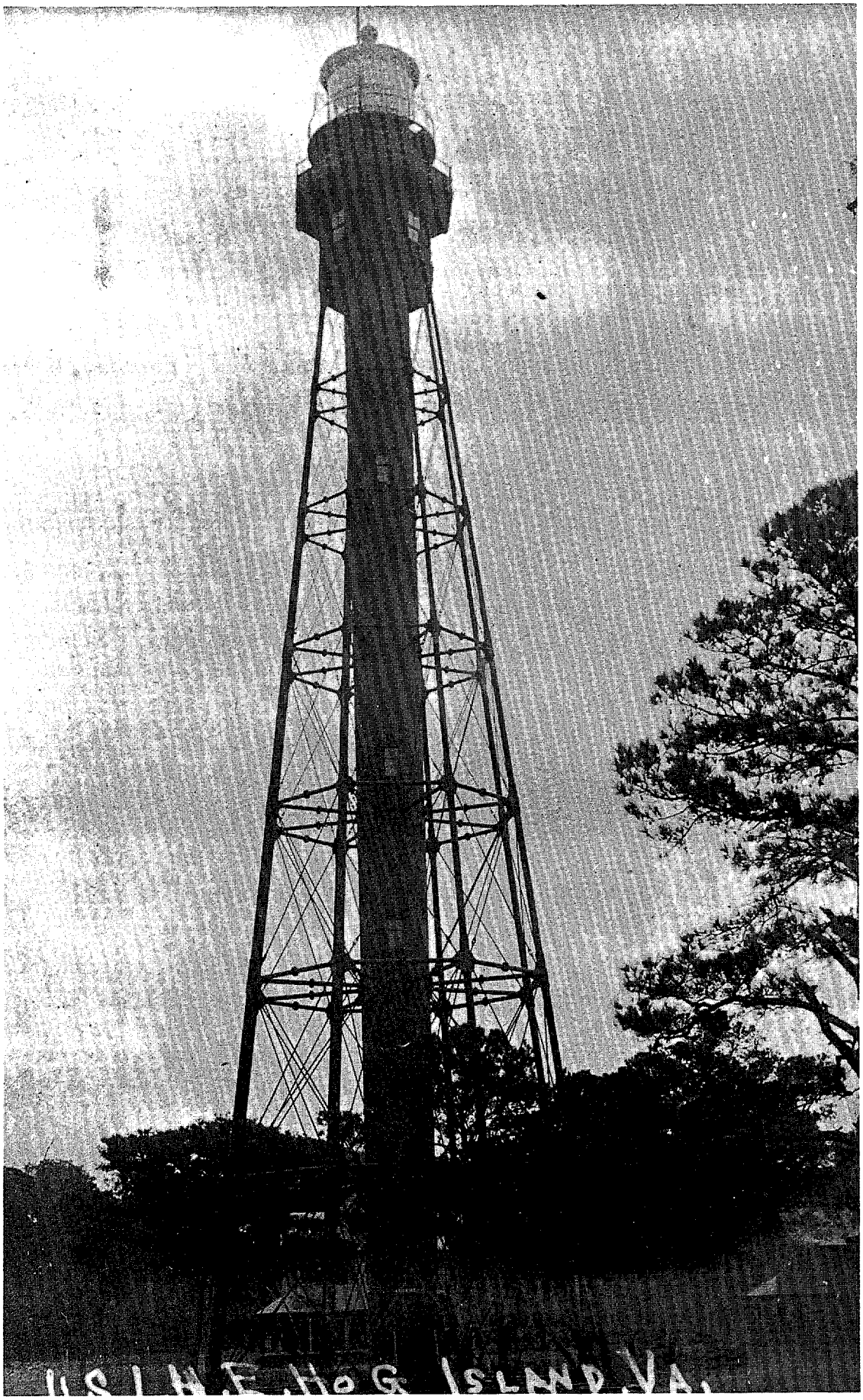
3/ Snow, Edward Rowe. 1955. p. 155.

4/ Ibid. p. 156.

5/ "Virginia's Drowned Village", Virginia Cavalcade. Winter 1957. p. 7.

6/ The journal is presently in the possession of Kellam Doughty, Deputy Sheriff of Northampton County. The journal dates from June 14, 1872.

7/ Sterling, Charles. 1903. p. 24.



The Hog Island Lighthouse was built in 1896. The light was last lit on March 17, 1948. It was thereafter considered a threat to aviation and it was destroyed in 1950. The foundation of the lighthouse is now seaward of the island's beach as a result of erosion. Photo courtesy of Ted Ward.

Operation of the 'new' light continued into the 20th century.

The construction of lighthouses on the Atlantic was a first step in efforts to save lives at sea. The second step was the establishment of Life Saving Stations at strategic locations along barrier islands. Inefficient, human-powered means of transportation in the 1800's made closely spaced stations a necessity.

In 1873 a Congressional Commission recommended three classes of station. For the area between Cape Henlopen, Delaware, and Cape Charles, Virginia, the Life Saving Station was chosen. This type of station was suggested for areas which:

1) were exposed;
2) had flat beaches with outlying sand bars;
3) had few inhabitants;
4) had no experienced crews to render assistance to ships in distress;
5) did not offer shelter and aid to the shipwrecked people.[1/]

The following is a list of stations (later known as Coast Guard Stations) authorized in 1874, however; some may not have gone into operation until a few years later:

Wachapreague Beach Station, located on the south end of Cedar Island, on the north side of Wachapreague Inlet.

Hog Island Station, located near the south end of Hog Island, 1½ miles southwest of Hog Island Light.

Cobbs Island Station, located near the south end of Cobbs Island, 7 7/8 miles southwest of Hog Island Light.

Smiths Island Station, on Smiths Island, ½ mile west of Cape Charles Light.

The last two authorized somewhat later:

Metomkin Inlet Station, located on the south end of Metomkin Island on the north side of Metompkin Inlet.

Parramore's Beach Station, located on Parramore's Island 2 miles south of Wachapreague Inlet and 11 5/8 miles northeast of Hog Island Light.[2/]

Shipwrecks were frequent because means of navigation and chartmaking were not as perfect as they are today. The Coast Guardsmen saved lives and in general provided a much needed service. One memorable shipwreck occurred in 1892 when a Spanish steamer, the San Albano, wrecked on Hog Island. The Coast Guard crew saved 25 lives.[3/] The shipwreck, still visible on Parramore Island, is believed to have occurred in the late 1800's, but unfortunately its identity is lost.

The men who manned the island stations throughout most of the year hunted, fished, carved decoys, and entertained their families who visited occasionally. The members of

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1/ Wroten, William H. Jr. 1970. Assateague. Penninsula Press, Salisbury, Md. p. 31.

2/ Turman, Nora Miller. 1964. The Eastern Shore of Virginia 1603-1964. The Eastern Shore News Inc. Onancock, Va. p. 198-199.

3/ Whitelaw, Ralph T. 1951. p. 369.

the Cedar Island Station organized summer treasure hunting expeditions in the 1890's and were often successful in locating Spanish, English, and Portuguese coins on Cedar's wooded north end.[1]

IV. RESORTS

Following the lead of the Cobbs but not heeding the warning of their ultimate misfortune, other hotels and clubs appeard on the Virginia Barrier Islands at the end of the 19th century. Most of the famous hunt clubs, covered in the Hunting Section on p. 5 had their origin prior to the turn of the century. Similarly hotels opened their doors to summer vactioners.

> Small hotels were operated during the latter years of the nineteenth century, for the accommodation of summer visitors, at Metompkin Beach and at Cedar Island, and on the latter during the first decades of the present century. Their patronage, for the most part, came from the Eastern Shore.[2]

The Cedar Island Hotel was owned by Mr. A. H. G. Mears and was auxiliary to his Wachapreague Hotel. Healthy salt air was the attraction along with sunshine, cool ocean breezes, bathing and fishing. Sail boat races in the bays were also a popular form of entertainment. One wonders, however, about the mosquitos in those days before screens and repellents.

Hog Island too had a brief foray into the hotel business. In 1898 a hotel was built by people from Atlantic City, New Jersey.[3]

> It is most singular that Hog Island, possessing so many superior attractions, should have remained so long unnoticed. Were it situated a hundred miles further north, near the populous cities, it would doubtless have become one of the most famous resorts of the New World. Atlantic City, Cape May, and Asbury Park all sink into insignificance when compared with this favorable isle.[4]

The Hog Island Hotel ran into difficulties and only lasted a few years into the next century, perhaps until 1912 or 1913. The inability to obtain a sufficient water supply may have been one of the primary reasons for its decline.

The Virginia Barrier Islands changed in the 19th century. They were no longer primarily used for grazing. The Civil War had come and gone; and the islands became desirable hunting, fishing and vacationing areas. Life saving efforts were based here and communities were growing. Land speculation increased and many of the islands changed hands. In 1871 Parramore Island went out of the Parramore family.[5] Earlier in the century Robert E. Lee came in the possession of Smith Island through his marriage into the Custis family. Prior to this an interesting use of the island was suggested by George W. P. Custis, a grandson of Martha Washington. He offered Smith Island as a location for holding captured Africans until they could be sent back to their native

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1/ Horner, Dave. 1965. Shipwrecks, Skindivers and Sunken Gold. Dodd, Mead & Co. N.Y. p. 13.

2/ Mears, James Egbert. 1950. p. 621.

3/ Bowen, Ralph. Taped Conversation. Tape #3. August 21, 1975. The Bowen family originated near Atlantic City, N.J.

4/ Sterling, Charles A. 1903. p. 26.

5/ Whitelaw, Ralph T. 1951. p. 780.

continent.[1/]

Focus was trained on the islands as the 19th century closed. The mainland of the Eastern Shore was entering a 'boom' period, and the islands were not excluded from high hopes of further development. Life on the islands was pleasant for the native and attractive to the city sportsman and vactioner. The potential for damaging storms did not over-shadow the appeal of seashore life; and thus the Virginia Barrier Islands entered the 20th century.

1/ The Kaleidescope. September 8, 1818. Source noted by Nora Miller Turman and conveyed in a personal conversation.

The Accomack Club was typical of the lavish sportsmen's clubs of the turn of the century. Located on Club House Marsh, the Club's members were primarily from the New York area. The boat moving across the foreground is powered by a naptha burning steam engine. Data circa 1900. Courtesy of Captain and Mrs. George Peppler.

THE 20TH CENTURY

By the turn of the century the seaside islands of Virginia were well-known and well-used by the sportsman. Hunting and fishing were excellent and hunt clubs had been established as retreats for the wealthy city dweller. Hotel and summer resort business seemed promising. The most dramatic human influence on the barrier island ecosystem, however, was on Hog Island in the early 1900's. The village of Broadwater was having its heyday.

I. HOG ISLAND'S COMMUNITY

Life on Hog Island is depicted today as having been idyllic. The people were 'good people' and the site of the town was perfect. The houses were located within a one mile area on the south end.

> "It was real pretty," the old man told me. "We all had trees and gardens. The island had woods on it then, higher than on Parramore now. The town was two miles behind the beach. We had to walk through the woods to get there."[1/]

Sterling described those woods as "patches of fine trees: pine, oak and red cedar".[2/]

The population prior to 1933 was approximately 250 permanent residents. Forty to fifty well-built houses were clustered to form the nucleus of the community. Most homes had five or six rooms, but many were larger. The structures were built to withstand the harsh conditions for which the sea was responsible.

> December 12, 1903
> The oldest house on the island, built 104 years ago, was torn down some days ago and the framing was as sound as the day it was built. It was red cedar.[3/]

Each house had the usual out-buildings for storage and livestock, as well as the essential "grunt house". Yards were fenced to keep livestock from destroying much-needed vegetable gardens.

Other buildings on the island included a school house, church, stores, Coast Guard Station and, of course, the lighthouse and keepers buildings. Reportedly, the keepers' homes were especially well-built and in the years following the '33 storm were sold, taken apart, and moved to the mainland. They were saved at the last minute as may be observed in a Life Magazine photo which shows the surf washing around their foundations.[4/]

1/ Leonard, Jonathan Norton. 1972. Altantic Beaches. Time-Life Books. N.Y. p. 114.

2/ Sterling, Charles A. 1903. Hog Island Virginia. Copyright by Charles A. Sterling.

3/ Accomack News. December 12, 1903. On file at Virginia Historical Society, Richmond, Virginia.

4/ Life Magazine. January 27, 1947. The photo also appears in The Best of Life.

Hog Islanders reminisce fondly of those years on the seaside isle when people were good friends and helpful neighbors. No one needed to lock doors or use banks, and there was always someone there to lend a hand. Some old-timers say that the island was the island of liberty.

> His ideal of freedom was probably what led him to become a Hog Islander. As one of them he lived the freest possible life, fared well and worked how he chose, when he chose - or not at all.[1]

The natural resources of Hog Island and its surrounding water made such a free life possible. Everyone had a summer garden. "The soil of the island was then rich and productive and the islanders grew vegetables, melons and flowers."[2] Considerable mention has been made of the "wonderful" watermelons produced on Hog Island. Potatoes and beans were also grown and pine needles were raked to provide winter storage for potatoes. Fruit from fig orchards and blackberry bushes was harvested in season. (In 1975 the same blackberry bushes are productive.)

In the first years of the present century, hunting for market was still profitable, but the interest had shifted to sport hunting. The well-known Broadwater Club hosted elite sportsmen at the turn of the century. Some native Hog Islanders thus made a livelihood by guiding sportsmen or performing other tasks associated with club hunting. The waterfowl and shorebirds also provided their families with a winter and spring food supply.

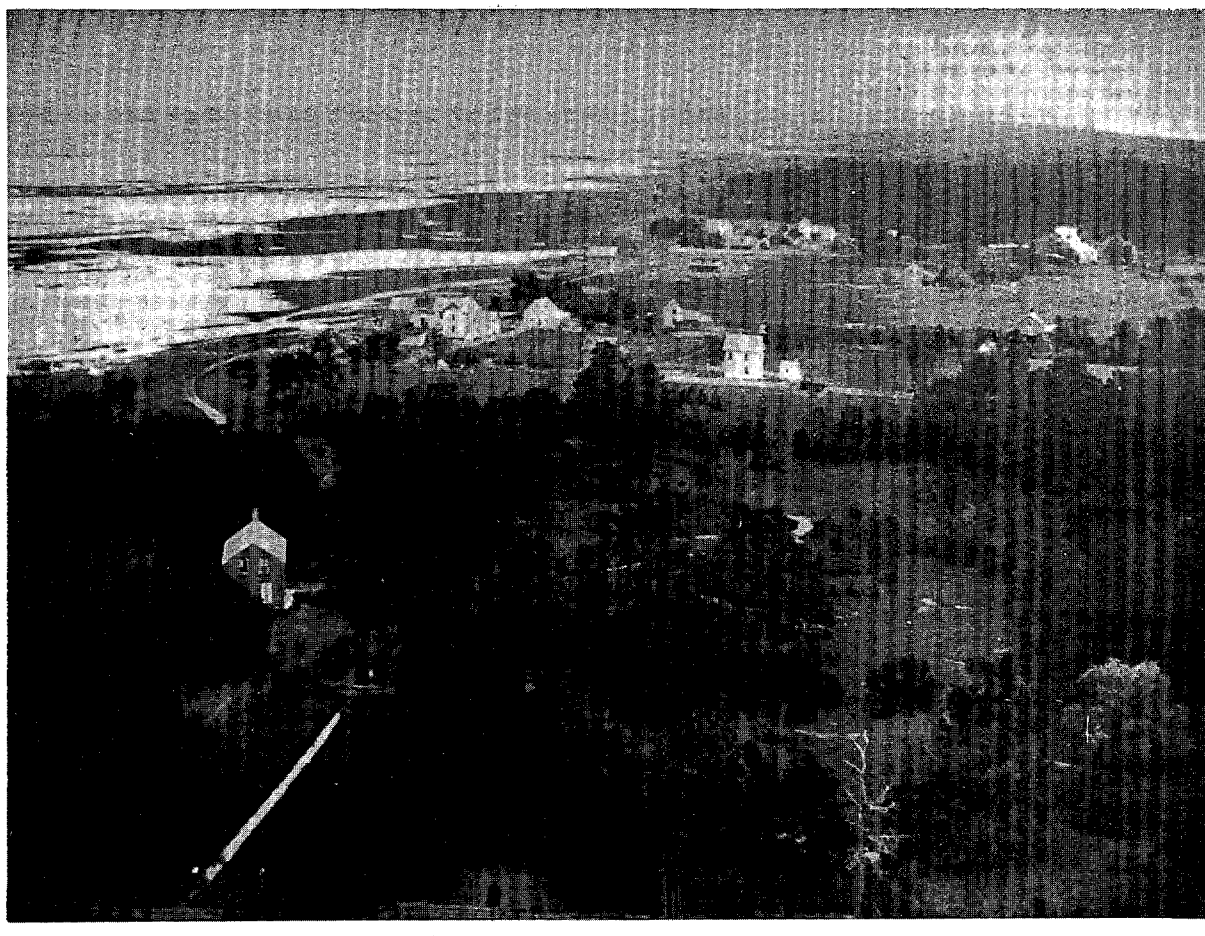
As one 'old-head' said, "you can't starve a waterman", and so it was on Hog Island. Most families harvested the fish and shellfish from the bays and waterways and thus supplied the needs of the community. "Over 90% of the Hog Island men went oystering in winter and clamming in summer."[3] Seafood was both sold in the marketplace and stored for winter use. The following are excerpts from a description of a Hog Island work day:

> Circa 1900
>
> My captain said, "Well boys, this is October, the wind has been to the southwest for three days, the sea should be smooth, and the fish should be close under the shore..."
>
> We were at Sandy Point at daylight.
>
> We were sailing in a twenty-two foot bank skiff powered with a five horse power one-cylinder Royal motor. With good weather, we could move along about seven miles an hour.
>
> As we moved out of the upper creek, Mr. Coon Phillips was getting under way in his oyster scow to go out on the Big Rock at the mouth of the creek to work on his oyster beds. Mr. Shep Doughty was getting under way in his Ben Jake Bateau for some destination out in the bay to work the tide, and as usual, in a sailboat, there refused to be any wind.

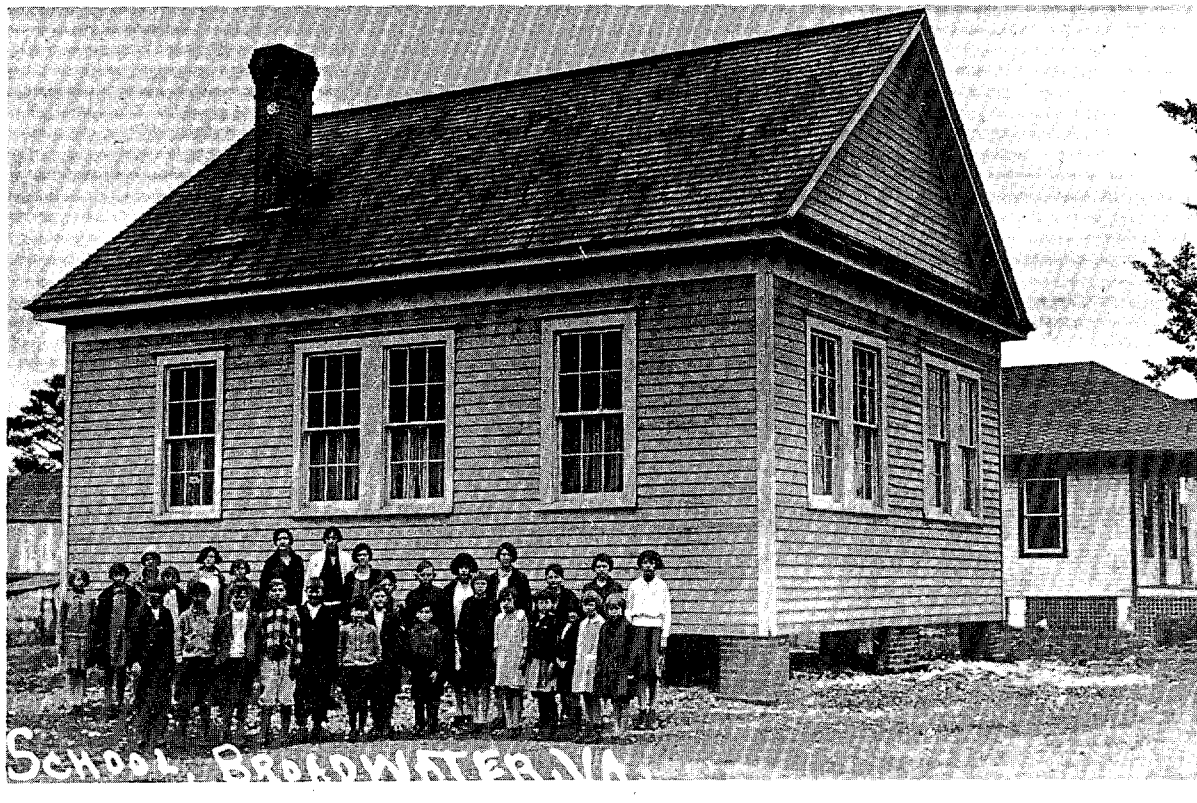
1/ Wharton, James. 1954. The Sea Islands of the Eastern Shore, Commonwealth 21 (Sept. 1954) p. 14.

2/ The Peninsula Enterprise. Accomac, Va. April 30, 1948. In Mears Scrapbook Vol. 4 p. 52. Eastern Shore Public Library.

3/ The Peninsula Enterprise. October 16, 1958. In Mears Scrapbook. Vol. 7 p. 2. Eastern Shore Public Library.



The Village of Broadwater, Hog Island, Virginia as it appeared in the early 1900's. This photograph was taken from the lighthouse on the southern end of the island facing northward. Photo courtesy of Ted Ward.



After the 1933 hurricane the Broadwater School House on Hog Island was barged to Oyster, Virginia where it was used as a clam house. It was only recently demolished. Photo, early 1900's. Courtesy of Ted Ward.

It was really a beautiful morning, and there was much activity at the sound end of the island. The last boat we passed was Mr. George Doughty on his way to Rogue's Island Sand to try to keep the people off of his clam ground.

The farther offshore we would go, the larger the fish would be.

The main catch was trout and croaker. If we could get our bait below the trout, we could catch croakers, but that was difficult to do. Most of the time if a person wanted bass he would just move to an old wreck and was sure to get them.*

It was a matter in those days to pick the kind and size you wanted, and we also knew when we arrived home, all of the fish had to be cleaned, washed in plenty of fresh water, drained, and salted for winter food.

...a short distance offshore there was a four-mast schooner becalmed. Our captain, Mr. Richard Carpenter, moved in close to give us some idea of just how large this ship was. After looking this ship over, I felt like we were on a corn cob in the middle of the ocean.

To make a perfect day, and give a boy a case of nerves, a large whale surfaced just a short distance away, and blew a spray of air and vapor, and then water in the air.[1/]

Another natural resource harvested from the marshes and creeks was the Diamondback Terrapin. On the island itself, pine trees were cut and sold for use as mine timbers.[2/] Hence, the islanders lived 'off the land' for many years, profiting from the abundant natural resources. "Indeed Nature has so bountifully endowed Hog Island that it discounts the fabled isle of Calypso."[3/]

Fresh water was obtained from a few good wells. Ponds were kept open for livestock and most of the people had cisterns and rain barrels which collected water for 'washing and such'. Fuel oil was brought in, but wood was also burned.

Everybody burned wood in stoves and fireplaces, and there was plenty of it. The whole island was a forest of old-growth pine, with enough scattered wood for fireplaces.[4/]

Although many of the Hog Islanders' needs were met by local natural resources, they were not lacking in the comforts of their mainland counterparts. The mail boat arrived daily from Willis Wharf carrying with it the mail for the Broadwater post office as well as supplies. Most people kept mail-order catalogues which soon became worn

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* When the Parramore Island wreck was laying off shore it was a favorite fishing spot.

1/ The Peninsula Enterprise. January 22, 1959. "Fishing for Food - Not Sport Fifty Years Ago". In Mears Scrapbook. Eastern Shore Public Library. (Possible that the source is the Eastern Shore News and not Peninsula Enterprise.)

2/ Bowen, Ralph. 1975. Taped Conversation. Tape #3. August 21, 1975.

3/ Sterling, Charles A. 1903.

4/ Eastern Shore News. April 4, 1957. In Mears Scrapbook Vol. 4, p. 81. Eastern Shore Public Library.

from frequent use.

The Methodist Church, built in approximately 1880, played an important role in the community. A minister from the mainland came on Sundays to preach, although it was once a two hour boat ride from Willis Wharf. The school opened its doors around 1900 and had an enrollment of nearly 30 students during some years. Young school teachers came to the island and almost invaribly married local fellows.

The island was not devoid of social life. When the automobile came on the scene, several Hog Islanders purchased Model T Fords for Sunday afternoon drives along the beach There may have been as many as twelve of these along the pavement-like beach on a nice day. Taffy and fudge-making parties were a common Saturday night pastime. Dances and banjo playing were not infrequent; but the big event of the year was the 4th of July celebration.

> The Ladies Aid of the church began in the spring to plan for the big Fourth of July dinner to be served beneath the tall pines on the by-road to the surf.[1/]

Life was not always easy, however. The winter of 1917-1918 was particularly harsh. For several weeks the bays were frozen making trips to Willis Wharf impossible. This was also the winter when two Hog Islanders received notice of their World War I call to duty, or more accurately did not receive notice until the bays were no longer frozen. The flu epidemic of 1918 compounded problems on this island with no doctor. Hog Island, however, was not totally without medical care. Dr. Sturgis made the long trip from the mainland, often in exchange for a good home-cooked meal.

Despite the short-comings, people were content with their life on Hog Island. Even the Depression had little effect on this community, so well supplied with food resources. Several fellows worked a few hours a week on Civilian Conservation Corps maintenance projects but, for the most part, 'made more money by going in the bay'. It was about this time when changes in the shoreline began causing concern among those who cherished life on the seaside isle.

"If the sea cast up this island and blessed it, it did not forget to use a stern hand at times."[2/] The first unmistakable sign came in the late 1920's - the abandoned 1852 lighthouse washed into the sea. Then came the great storm that signaled the end of the village of Broadwater. Although the islanders always had to contend with storms, the storm of August, 1933, was worse than any in living memory. The erosion, which had begun prior to '33, seemed to be accelerated as a result of the storm. Thus, during the remainder of the 1930's, Hog Islanders gave up, and one by one moved to the mainland.

The move in itself was fascinating. As was customary, people helped each other and moved families, home included, to the towns of Willis Wharf, Oyster, and Quinby. The houses were lifted off their foundations, placed on rollers and moved to the marsh to await high tide. The house was then carried by barge ('monitor') to its new location. If the day was calm and clear, one could make the crossing while relaxing in one's living room. The church was likewise moved and is presently attached to the small

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1/ Peninsula Enterprise (or Eastern Shore News). October 16, 1958. In Mears Scrapbook Vol. 7 p. 2. Eastern Shore Public Library.

2/ Wharton, James. 1954. Sea Islands of the Eastern Shore. Commonwealth 21 (Sept. 1954).

chapel at Oyster. The school house became a clam house in that same town until it was torn down a few years ago.

The people did not all move immediately after 1933. They lingered with an understandable hesitation to leave their island life. A second, not so severe storm in 1936 further prompted the decision to leave. A newspaper article in 1939 stated that there were twelve families with a total of forty people still inhabiting Hog Island.[1/] The last mail delivery to the village of Broadwater was made on Friday, February 15, 1941.[2/]

As noted earlier, the lighthouse keepers' homes were sold and taken down in the late 1940's. The lighthouse itself was decommissioned on March 17, 1948 because the sea had begun to undermine the structure once located a mile from the surf.[3/] Believed to be a menace to aviation, the 180 foot tower was destroyed within two years of its abandonment. A reminder today is the heap of rusting metal on Hog's south end, forgotten by the scrap-metal dealers. This same metal had been laboriously moved by a mule-pulled railroad car from dock to site in 1895. The lens had been displayed at the Mariners Museum in Newport News, but was recently returned to the Coast Guard Headquarters at Portsmouth, Virginia.

In the years since its habitation, Hog Island has been the scene of cattle and sheep grazing, hunting, fishing and camping. The Machipongo Club has used the old north end Coast Guard Station since 1965 for a hunting and fishing headquarters. Camping by groups of young people was noted within the last five years; but no one stays more than a few days on Hog Island now.

II. HABITATION AND USE OF OTHER BARRIER ISLANDS*

Although Hog Island was the center of human interest in the 20th century, most of the other islands also received their share of attention. Hotels had been built on a few islands while many had Coast Guard Stations, hunting clubs, and private homes.

Metomkin Island (or Beach) was the site of a small hotel at the turn of the century. Located less than a mile from the Coast Guard Station, it was mainly operated for local residents during the summer months. Vandalism was a problem and each year more sand drifted into the first floor. It may have been abandoned as early as 1910 and was entirely gone by 1925.[4/]

Cedar Island also had a small summer hotel in the early years of 1900. A passenger boat ran from Wachapreague to take guests to this resort by the sea. Bath houses and a bowling alley were constructed to add to the entertainment provided by nature. Precisely what year the Cedar Island Hotel business came to an end is unknown. Some sources claim that the building was destroyed by lightning, others that it washed away in a storm; but most agree that it was gone by 1933.

Hope for a revival of Cedar Island development plans was encouraged by Richard F. Hall in the 1950's. A 1951 advertisement in the Peninsula Enterprise stated that Mr. Hall

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* Note that hunt club, Coast Guard, and National Defense activities are located elsewhere in this text. Sportsmen's clubs are covered in Part II section 2. Coast Guard and National Defense follow this section.

1/ Peninsula Enterprise (or Eastern Shore News). March 31, 1939. Mears Scrapbook Vol. 7 p.2. Eastern Shore Public Library.

2/ Peninsula Enterprise (or Eastern Shore News). October 16, 1958. Mears Scrapbook Vol. p. 2. At Eastern Shore Public Library.

3/ Peninsula Enterprise. April 30, 1948. Mears Scrapbook Vol. 4 p. 52-53. Eastern Shore Public Library.

4/ Nock, Sara. Personal Conversation. October 9, 1975.

was selling oceanfront property on Cedar Island at $300 an acre. Eastern Shore residents were to have the first chance to buy.[1] People did purchase lots and were enthusiastic about development prospects.

> Mr. Richard F. Hall, its part owner, and a prominant promoter of seaside property, reports the sale of 2,200 building sites thereon. He has issued an illustrated pamphlet describing the advantages of the proposed community, which he has already named "Ocean City".
>
> Residents of Accomack County agree that if the Cedar Island highway and bridges go through it won't take long to build it up. It will be Virginia's first ocean resort on the Eastern Shore...Construction of the Ocean City road is one of the livest issues in the section. The owners of island lots, together with several thousand youthful mainland residents who want some surf-bathing near home, press for the work to start.[2]

Their hopes were never fulfilled - a 'broader tax base was not created'. Causeway building costs were prohibitive and potential water and sewerage problems were feared. Today several small beach cottages are still in use, but access to this island is still by boat only.

Parramore Island was primarily a hunting preserve for rich members of, first the Parramore Island Club, and then the Holly Island Club. Hotel or resort interests were never directed here because of the private and exclusive nature of the sportsmen's groups. A Coast Guard installation has operated on Parramore throughout the 20th century. A fine clubhouse and at least one caretaker's home were located on the island. In the early years of the 1900's a few Model T Fords served as means of transportation.

Since the mid-1930's the Schmidlapp family activity was limited to several vacation periods during the year. Friends were invited for hunting and fishing and of course relaxing at the converted Coast Guard Station/vacation home on the surf. The Holly Island Clubhouse and caretaker's home, although still standing, have long since become delapidated. The present-day caretaker travels to the island to fulfill his duties, and several vehicles are available there for his use along the beach and established roadways.

Others had greater hopes for Parramore during the 1950's. A controversy grew around the suggestion to use Parramore Island as a bombing range, much to the disappointment of the owners and local people (to be covered later in this section). Furthermore, an oil company suspected that oil might be found on the island, and wanted the rights to search for it during the mid-1950's.[3] Neither scheme became reality.

An attempt to sell some of Parramore's old-growth timber in the early 1960's ended in failure. The entire "raft" of logs was lost in a storm and thus never reached the market.[4]

Revel Island was the base for another large hunting club in the 20th century. A

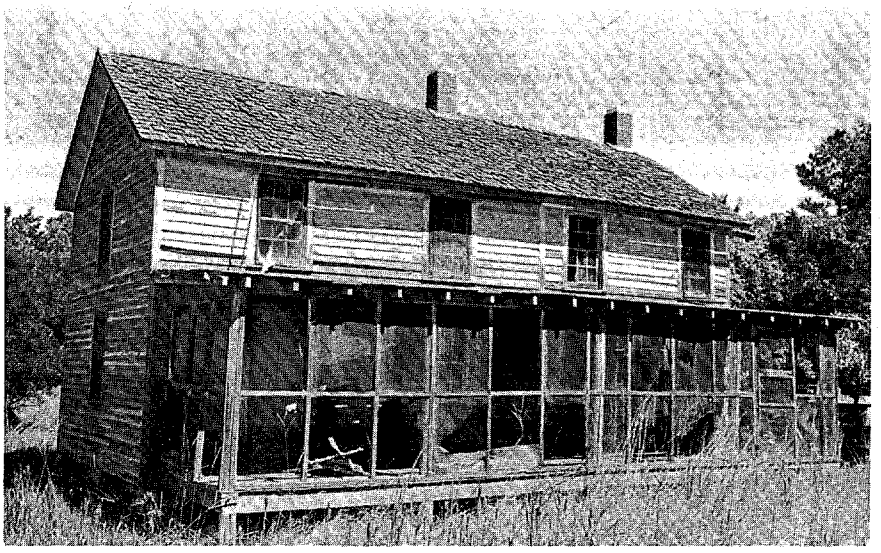
1/ Peninsula Enterprise. May 31, 1951.

2/ Wharton, James. The Islands of the Eastern Shore. Commonwealth 21 (July 1954).

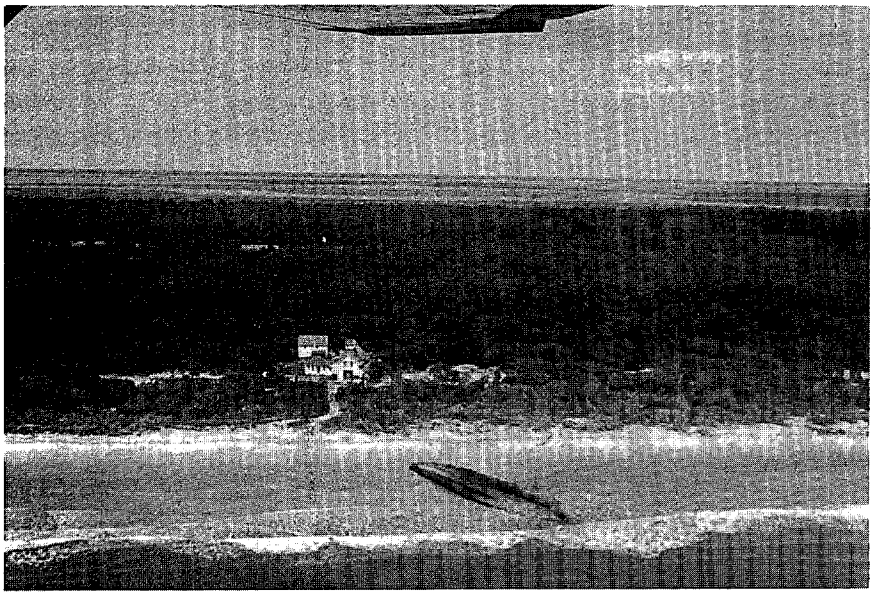
3/ Schmidlapp, Dr. Carl. Personal Conversation. October 2, 1975.

4/ Woodling, R. L. District Forester, Virginia Division of Forestry. As told to Gerard Hennessey. November 19, 1975.

The Holly Island Club was a private, exclusive sportsman's club which flourished on Parramore Island during the 1930's. With its demise, the era of large, lavish hunt clubs ended. Photo by Jim MacFarland 1975.



This dilapidated structure on Parramore Island once housed the island's resident caretaker. The Nature Conservancy may renovate this structure for use as an island research base. Photo by Jim MacFarland 1975.



The original Parramore Island Life Saving Station was located on the eastern shore of the island. It is presently used by the Schmidlapp Family and their associates as a vacation home. Parramore Island was purchased with the understanding that the former owners could retain the exclusive recreational use of the area for 20 years. The wreck in the foreground occurred offshore before 1900. It has only recently been washed ashore. Photo by Jim MacFarland 1975.

clubhouse and cottages were built there and a caretaker lived year round on the island until the club's demise in the early 1930's.

South of Hog Island, Cobb Island had seen its peak of activity in the 19th century. Nevertheless, a few members of the Cobb family ran a small hotel or boarding house on the island in the early years of 1900. It was short-lived, however, and was lost, as so many others were, in the storm of 1933.

Attempts to 'improve' Cobb Island during the last 25 years have had an effect on the biological and physical character of this island. A good well was drilled and ponds have been kept open with tractors. Cedar and pine trees were planted in the 1950's; and game animals were stocked periodically up until recently. An effort was also made to inhibit erosion by the construction of dune fences. Today use of the island is restricted to occasional weekend visits by the owners of the island's three trailers, and by the members of the former Laridae Corporation.

Mention was made of one home on Wreck Island, but more information was not available. In 1975, Wreck is owned by the Virginia Division of Parks.

Mockhorn Island was inhabited in this century by the Cushman family and then later by T.A.D. Jones. Both owners constructed comfortable homes as well as other out-buildings, and planted productive gardens. Mr. Jones employed a caretaker and his wife lived on the island and looked after his retreat. Gardens and cattle had to be cared for and visiting sportsmen entertained. A vehicle known as a 'weasel' was the caretaker's mode of transportation.[1/] Today Mockhorn Island falls under the jurisdiction of the Virginia Commission of Game and Inland Fisheries.

The Bungalow was a club located on Smith Island during the early years of 1900. It was another private hunt club which required a year around caretaker. The caretaker lived on the island with his family, raised a few head of livestock, and planted gardens. The watermelons were reportedly 'too big to steal'. A few vehicles were used on the island and occasionally an airplane landed on the beach. Many of the barrier islands had some source of fresh water but cisterns and rain barrels were put to good use.

Interest in the development of Smith Island was announced in 1951 by the owner, Arthur H. Darling.[2/] The King's Beach report clearly outlined more advanced development plans in 1968 by the Smith Island Development Corporation.

During the 20th century, the Skidmore family occupied the island which today bears their name.

Fisherman's Island, the most southern in the chain, was not inhabited but served as a quarantine area during World War I. If immigrants died of infectious diseases on arrival to the United States, they were cremated on Fisherman's Island. Today the island anchors the Chesapeake Bay Bridge Tunnel system, and is a National Wildlife Refuge.

A notorious activity of the 20th century no doubt involved some of the islands and their residents.

1/ Birch, Capt. Moe. Taped Conversation. Tape #12 & 13. October 9, 1975.

2/ Peninsula Enterprise. May 24, 1951.

> The desolation of the marshes and "sea-meadows" and defeating nature of the labyrinthine channels of all this section were a constant invitation to the rum runners of the Dry Years.[1]

Small boats met ships off the beaches and carried their contraband through the waterways to the mainland. Waiting trucks then took the illegal liquor to its ultimate destination.

III. THE VIRGINIA BARRIER ISLANDS AND NATIONAL DEFENSE

During the years of World War II, and for a few years thereafter, interest in the islands was directed toward defense of this portion of the Atlantic Coast. Several small boats had been destroyed by German submarines within eight miles of the beaches, confirming the need for added force on the islands. Coast Guard Stations became training areas. As many as 52 men were stationed on Parramore Island.[2] The beaches on all of the islands were patrolled day and night to guard against saboteurs.

On Metomkin Island a center was established for training K-9 dogs. These dogs, of various breeds, were able to detect the scent of a stranger who might have crossed the beach.

Some of the southern islands in the chain were used as targets for bombing practice during and immediately following the war.

> I am not sure how large the bombing range was, but it ran north from Smith Island and included at least Mink/Myrtle/Godwin's/Ship Shoal The US government obtained two permits from the State of Virginia in 1942 and 1945 to use the islands as a bombing range. The only problem was that much of the area for which the Commonwealth of Virginia granted permits was not owned by Virginia, but was in private ownership. After the war, the military attempted to decontaminate the range by cleaning up the old dud ordinance. They were successful on some of the higher ground, but on at least one of the islands, they concluded that the duds had sunk into the marsh enough that there was no way to sweep the island and render it safe. The bombing range was called Cape Charles Range.[3]

Small live charges were often used, and there is some evidence that Wreck Island beach was strafed. Hog Island Bay was also the location of a bombing target. Although there was concern among the local watermen, the feeling was that it was for the good of the country. In 1951, however, this attitude changed considerably. A controversy throughout the spring of that year began with the announcement by the Tactical Air Command at Langley that suggestions were being made for a bombing range centered at Ship Shoal Island. An aerial bombing, rocket firing and gunnery range danger zone was to be established in the Atlantic Ocean in a circle with Ship Shoal at its center.[4]

1/ Wharton, James. Sea Islands of the Eastern Shore. Commonwealth 21 (Sept.1954).

2/ Bonniwell, Earl 1975. Taped Conversation. Tape #2 & 3. August 19, 1975.

3/ Turner, Col. James. Personal Correspondence. August 19, 1975.

4/ Peninsula Enterprise. March 2, 1951.

In several succeeding issues of the Peninsula Enterprise local people expressed their opposition to the proposal.[1] On April 6th, the Navy enlarged the restricted area to include part of Smith Island,[2] while on September 6th, the restricted area around Myrtle Island was decreased.[3] If the target range was ever used in the 1950's, it was only for a short period of time.

During 1952 there was a government effort to obtain Parramore Island for a similar purpose. The people of Accomack County protested so vehemently that the plan was routed with the help of Senator Byrd. Another proposal was made in 1956 but it ended in a similar defeat.

A post-World War II incident of local interest occurred on Wreck Island. Two large troop transports went aground in a fog and were beached for almost a week before they could be removed.

IV. COAST GUARD FACILITIES IN THE 20TH CENTURY

At the close of the 19th century there were six Life Saving Stations located on the island chain from Metomkin to Smith Island. All stations were in operation by the end of the 1880's. These included the Wachapreague Beach Station, Hog Island Station, Cobbs Island Station, Smiths Island Station, Metompkin Inlet Station, and the Parramore's Beach Station, the last two of which opened slightly later than the first four. In approximately 1915 the Life Saving Service became known as the Coast Guard.

The Metompkin Coast Guard Station was located on the south end of the island until 1933. In that year the storm destroyed the building and it was deemed necessary to rebuild the station on the north end of Cedar Island. It was still known as the Metompkin Inlet Station when it was closed in 1963 with a staff of 14 men.[4]

The first Wachapreague Station was built in 1875 on the south end of Cedar Island. It may have been replaced in the same area (circa 1910). In 1933 it too was demolished by the storm and was then merged with the Parramore Island Station.

On Parramore Island the station was first located two miles south of the Wachapreague Inlet along the surf.

> The beach beyond is eroding, but this is something comparatively new. Not many years ago it was advancing rapidly out to sea. The lifesaving station, which was built in the days when launching boats through the surf was the technique used to help a ship in distress, was abandoned because the beach moved too far away from it.[5]

1/ Peninsula Enterprise. March 23, and March 30, 1951.

2/ Peninsula Enterprise. April 6, 1951.

3/ Peninsula Enterprise. September 6, 1951.

4/ Peninsula Enterprise. December 19, 1963. Mears Scrapbook Vol. 14 p. 36. Eastern Shore Public Library.

5/ Leonard, Jonathan Norton. 1972. Atlantic Beaches. Time-Life Books. N.Y. p. 113.

Whether this was the main reason for choosing a new site is unknown. Nevertheless, the new, more convenient and modern station was built in the mid-1930's on its present site. The Schmidlapp family uses the old station as their vacation home.

During the early 1900's, when the old station was still in operation, small cottages were located along the beach for families during the summer months. When children finished school on the mainland, the Coast Guardsmen's families packed their belongings and came to the seashore for a vacation. Small gardens were planted and surf-bathing and fishing were enjoyed. During other seasons the presence of game did much (and still does) to relieve the monotony of island life. Although the Coast Guardsmen have reported poaching on the island by others, they have also participated in illegal hunting practices.

The Parramore Island Station is the only station still in operation today on any of the barrier islands under study. Vehicle use is permitted on roads and beaches by those employed on the island.

Hog Island's first Coast Guard Station was located on the island's southeastern side in the 1890's. In 1933 a Coast Guard Station was lost from this site but whether it was the original building or a successor is unknown. The Hog Island Station was then rebuilt on the western side of the southern end in the mid-1930's. At this same time the Little Machipongo Station was opened on the north end along the inlet.

The building on the south end still stands today although it was abandoned after World War II. A boardwalk once ran from the main building to the now crumbling boat house. The observation tower is intact as of this writing, and one can still recognize the cross-like drill pole.

The Little Machipongo Station was destroyed by fire in 1958 and rebuilt in 1959. Activity there was short-lived and the installation was abandoned in 1963. Two years later it was purchased from the United States Government by the Machipongo Club, a private hunting and fishing organization.

Cobb Island was also the site of one of the original Coast Guard Stations. A second one may have been built around the turn of the century, but the abandoned structure on the island today was built in the mid-1930's. This home of the 'watchdogs of the sea' was closed in 1963. The neighboring delapidated structure is believed to be the old station.

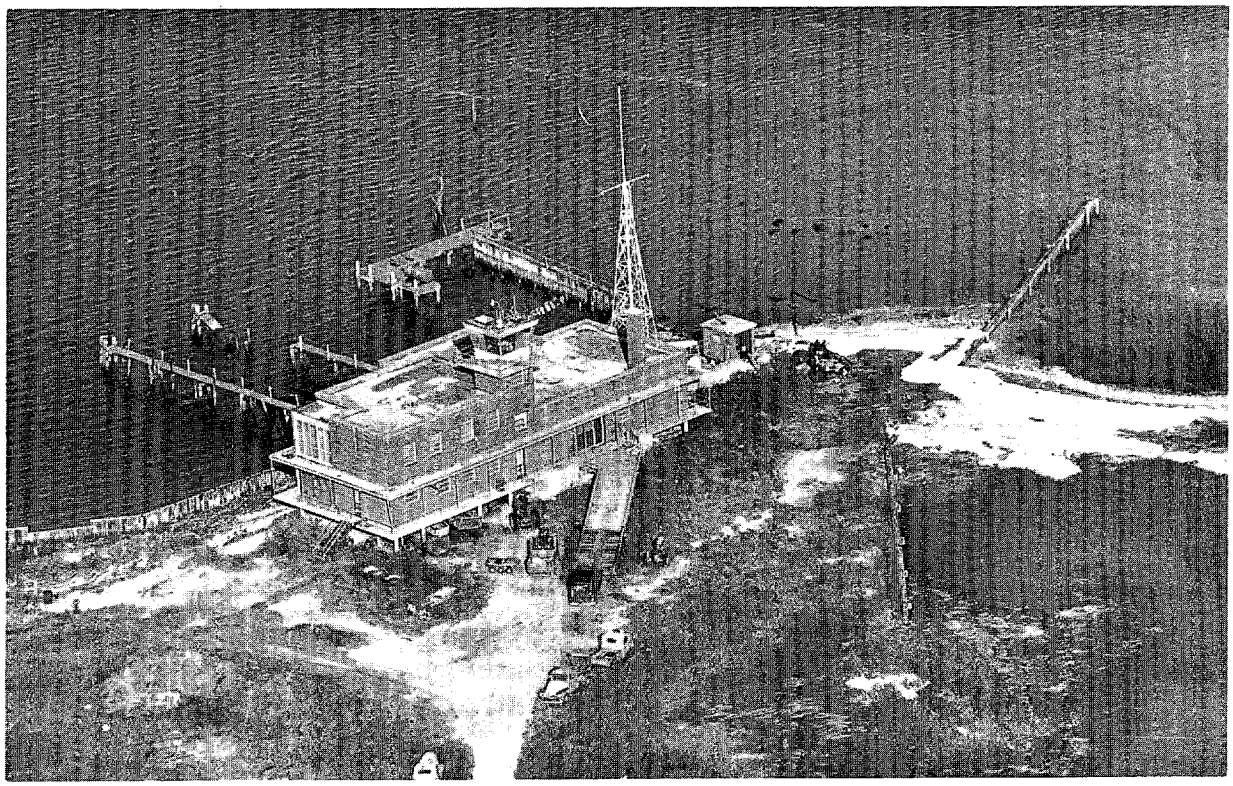
The Smith Island Station was located on lighthouse property in the late 1870's or early 1880's. A new Coast Guard Station was erected in 1916 and in 1927 both buildings were moved a mile back from the surf. The old and new Coast Guard Stations are gone today.

V. THE VIRGINIA BARRIER ISLANDS IN 1975

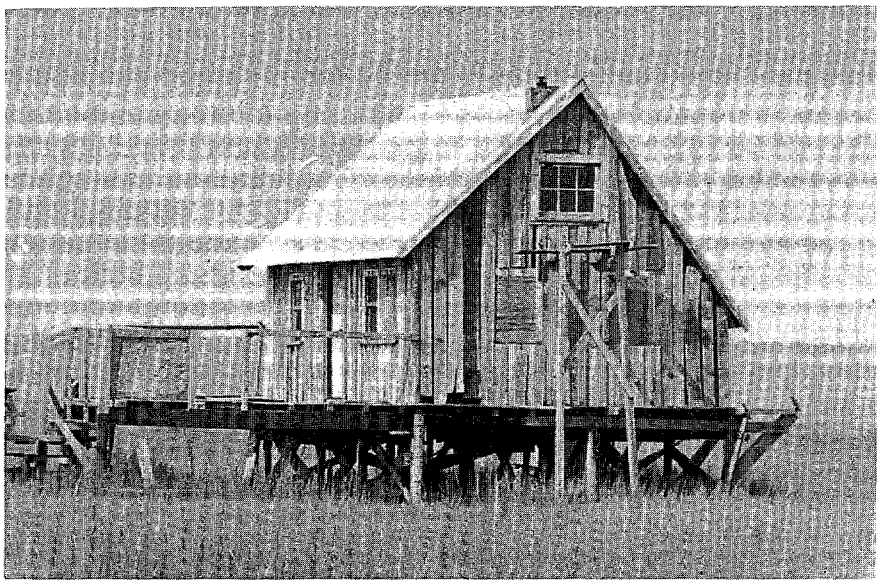
Today the islands are owned either entirely or in part by The Nature Conservancy. Full ownership of the following islands is recognized: Metomkin, Parramore, Revel, Sandy, Rogue, Cobb, Ship Shoal, Myrtle, Mink and Smith. 95% of Hog Island is owned and portions of Cedar and Godwin. Total acreage is in the vicinity of 30,000 acres.

The Nature Conservancy's management policy is geared to allow traditional, non-destructive use of the islands by people of the Eastern Shore. The goal of The Nature Conservancy is to protect the island system which has been such an integral part of life here.

The abandoned Coast Guard Station on the south end of Hog Island as it appeared in 1975. The observation tower and the cross-like drill pole (to the right of the station) are still intact. A boardwalk once connected the station with the crumbling boathouse. Photo courtesy of John Clark 1975.

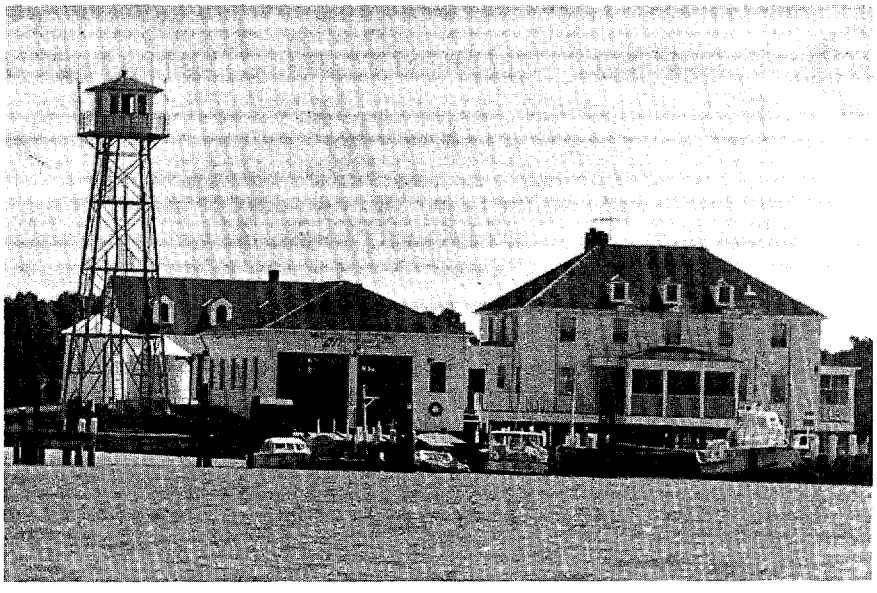


The original Little Machipongo Coast Guard Station at the north end of Hog Island was built in the mid-1930's. It was destroyed by fire in 1958, rebuilt in 1959, and decommissioned in 1963. In 1965, the station and the adjacent 5.4 acres were purchased by a private sportsman club. The club's ensuing indiscriminate use of the Conservancy's property has created a stewardship liability of the club's membership. Photo courtesy of John Clark 1975.



This squatter's cabin is located on the marshes west of Metomkin Island. Similar cabins on other marshes represent one of the many uses which have been conducted on the islands for years. The activities associated with such structures are often at odds with the protection of the islands' natural resources. Photo by Jim MacFarland 1975.

The U.S. Coast Guard Station, Parramore Beach, is the last active Coast Guard Station within the Virginia Coast Reserve. Stations located within the Reserve at the turn of the century were the Metomkin Inlet Station, Wachapreague Beach Station, Parramore Beach Station, Hog Island Station, Cobb Island Station, and Smith Island Station. Photo by Jim MacFarland 1975.



The use of motor vehicles presents a persistent stewardship problem on the islands. Their impact on sensitive plant and animal communities and disruption of stabilizing geological features validly precludes their legitimate use. The Conservancy's policy prohibits motor vehicles and aircraft from using the islands. Vehicles are often discarded on site, leaving a rusting hulk for years to come. Photo by Jim MacFarland 1975.

SELECTED HUMAN AND NATURAL INFLUENCES

This section magnifies those aspects of barrier island history which have influenced their ecological development.

SELECTED HUMAN AND NATURAL INFLUENCES

GENERAL FAUNAL HISTORY

We know that through geologic time the area of the Atlantic Coastal Plain has changed dramatically. Climate and ocean levels have fluctuated and ultimately determined the persistence of certain types of terrestrial and marine plant and animal life. The alterations brought about by these factors are relatively gradual when compared with the changes wrought by human manipulation of ecosystems. Little is known of the prehistoric fauna of North America and likewise little is known of the animal life of the seaside islands when settlement of the Eastern Shore was in progress.[1/]

Some evidence of prehistoric animal life has been found on the barrier islands in recent years. In 1973, Mrs. John Rogers found a portion of the jaw of the extinct Mastodon americanus on Cedar Island. Identification was confirmed at the Museum of Comparative Zoology of Harvard University. The mastadon lived on the North American continent during the Pleistocene Epoch, approximately one million years ago, and preferred a temperate or cold climate. "So many teeth of mastodons and bones of other animals have been discovered in the sea coast that it seems unreasonable to think upon transport by water currents or iceberg rafts, rather than to assume that the animal lived where the bones are found and it is possible that the ocean level must have been lower than it is now."[2/]

In a similar fashion, a walrus tusk was found on Parramore Island on August 27, 1955. Reference is also made to an earlier (1827) find of another portion of a walrus skull on the same island.[3/] The range of the Walrus is believed to have extended southward during the Ice Age.[3/] Hence, the discoveries are further evidence of a biologically different shoreline than we see today.

The Indians and early explorers and settlers of the Atlantic Coast also knew a different faunal population than we are presently studying. Surely many animals no longer live on the barrier islands and likewise some, especially bird species, exist today that would have been unfamiliar to the earliest human inhabitants. For example, a legend persists that when John Smith first landed on Smith Island a species of bear was found to live on the island. "He named the island upon which he landed Shooting Bears Island; as the small species of bruin which to this day (1903) abound in the cane-brakes of the Dismal Swamp were numerous on the new found isle."[4/] Although difficult to believe, it is possible that other plant and animal species once thrived on the offshore islands that today we would find equally surprising. Presumably man's interference was felt immediately on the delicate island ecosystem.

1/ Extensive research of historical documents of Virginia might turn up bits of information. This information in conjunction with a knowledge of the contemporary island flora would facilitate the compilation of a tentative species list.

2/ Schaff, Dr. Charles R. 1973. Letter to Mrs. John G. Rogers. Museum of Comparative Zoology. Harvard University, Cambridge, Mass.

3/ Steirly, C. C. Virginia Wildlife. January 1956.

4/ Sterling, Charles A. 1903. Hog Island Virginia. Copyright by Charles A. Sterling. p. 3

I. DISTURBANCE OF AVIFAUNA THROUGH HUMAN ACTIVITY

The group of birds most affected by the arrival of man have been those species prized as a food supply and more recently, as a focal point for sport hunting. Wild migrating waterfowl have used the Atlantic Flyway for thousands of years; but it has taken less than a century for the hunter and trapper, in cooperation with the bulldozer, to reduce the flocks that have only in the last few years begun to recover from the onslaught. Old-timers can still remember the flocks of brant that extended five miles long and one mile wide. Similarly, 3000 broadbill, covering acres of water, could be seen at one time.[1/] Residents of Hog Island claimed that they "couldn't sleep nights" for the flocks of geese, brant and ducks that fed in the marshes.[2/] (See HUNTING: SPORT HUNTING, p. 58).

A. Duck Trapping

Trapping ducks, especially black ducks and mallards, increased in intensity with the decline in market gunning. Traps were easily concealed, and the man in the marsh could harvest his birds under the cover of darkness. The trap is simply constructed with mesh wire fastened to stakes in the mud. A funnel leads inward toward the corn bait; and the duck is unable to return through the opening. This method of obtaining birds has one great advantage to the buyer - the birds are neatly killed and no pellets are scattered throughout the flesh.

Many an Eastern Shoreman, from Chincoteague south, made a living from duck trapping in the first half of this century. Chincoteague Islanders were particularly notorious for their skill in capturing the birds and eluding the game warden. Nevertheless, the more southern islands have not been excluded from this activity. Duck trapping on Parramore Island was discouraged if possible by caretakers whose job it was to see that the club members had something to shoot. The private ownership of this island was probably responsible for some curtailment of the trapping business; however, traps were set along the marsh edges and have been found as recently as fifteen years ago.

Residents of Hog Island trapped ducks to varying degrees for many years and were particularly protective of their territory. During the 1920's some outsiders (from Quinby) had to be chased away. Smith Island also has been a location for the illegal trapping business in recent years. Most certainly all of the barrier islands have served at one time or another as hiding places for traps in the battle of trapper versus game warden. The market continues to be made today by the connoisseur of wild duck. Some birds are sold locally, but others continue to be sold outside of the area to buyers ordering 'birds shot in the head'.

Human activity has not been entirely destructive in regards to waterfowl. Attempts have been made to encourage waterfowl nesting on several seaside islands, albeit not always with altruistic motives. Ducks need fresh or brackish water on which to feed and breed, hence the ponds on Parramore, Hog, Cobb, and Smith Islands are potentially valuable for this purpose. Hog Islanders kept ponds open for livestock and inadvertently improved duck breeding habitat. Furthermore, within the last few years ponds have been cleaned out on Cobb Island for the same twofold purpose.

1/ Bowen, Ralph. 1975. Taped Conversation. Tape #3. August 21, 1975.

2/ Eastern Shore News. Historical article about Hog Island. April 4, 1957. Mears Scrapbook Vol. 4 p. 81. Eastern Shore Public Library.

Ducks and geese of the Atlantic Flyway experienced a setback in the 1930's when a prime food source, the eelgrass, was eliminated by a blight. The result was to further compound the difficulities facing those persons interested in restoring dwindling wildlife to its previously stable condition.

B. Feather Hunting

Another group of birds tremendously affected by an increasing human population has been the shorebirds and other coastal avians. Migrating species were killed in great numbers along the whole Atlantic Coast for decades. Nesting birds were shot and exploited for their eggs or feathers. Shorebird shooting reached a peak around the turn of the century. Since then populations have begun to return in substantial numbers (see HUNTING, p. 55). Although the trade in feathers no longer exists, egg collection continues on a minor scale to the present day.

Dictates of fashion in the United States and Europe were responsible for the decline of many North American mammals and birds. The classic case is that of the beaver whose existence east of the Mississippi River was threatened due partially to the demand in Europe for beaver hats in the 19th century. Birds of the Atlantic seaboard were by the same design exploited for their feathers. Egret plummage was fashionable for ladies hats, and thus feather hunters brought these birds to a low ebb before restrictions were imposed. Today, however, the egret population is expanding along the entire East coast. Another bird similarly harvested was the tern:"...the beautiful little terns (known as strikers) were shot and their skins shipped north by the barrel to ornament millinery for thoughtless women who 'wouldn't hurt a fly'".[1]

C. Egging

Egging was a practice on the barrier islands and surrounding marshes from the time of the earliest settlers. Eggs were collected and eaten in the spring of the year and proved to be another example of the bounty offered by the sea isles. Egging became an established tradition which is still carried on by a few natives today.

The most desired eggs were those of the gull, tern, marsh hen, and willet. "None but those who have tasted can judge what a delicate morsel a spotted marsh-hen's egg is, or how savory that of the gull - surprisingly large for the size of the bird - or the sharp-pointed egg of the willet".[2] Not only were eggs gathered and eaten on the islands, but they were carried to the mainland as well. "The overseer had carried a bushel or so of these beautiful little eggs (marsh-hen) over to the main-land to sell, but luckily left enough for our consumption."[3]

By the last decade of the 1800's egging had become popular with the seaside residents of the shore and boat trips were made to Gull Marsh or other desirable nesting areas.

> At this time people went 'egging' on seaside islands in the spring in the same sporting spirit as they went gunning in winter. A gallon or a bushel of eggs might be collected in a half day. Some were frequently boiled and eaten on the island along with a packed lunch. The greater part of

1/ Connett, Eugene ed. 1947. Duck Shooting. William Morrow & Co. N.Y. p. 146.

2/ Pyle, Howard. 1878-1879. A Peninsular Canaan. Harper's Magazine. N.Y. Vol. 28, p. 809.

3/ Ibid. p. 814.

the harvest was brought home to be eaten by the family and shared with friends and neighbors after a real successful trip.[1]

The awakening awareness of the scarcity of game and non-game birds in the early 20th century hindered the practice of egging to a small degree. Birds which provided good sport were given priority in protection, and thus marsh-hen egging was discouraged. Nevertheless, it took many years to re-educate the native to this philosophy of conservation. An anonymous note written to a local game warden in 1907 informed him that parties were gathering eggs: "Yesterday a friend of mine showed me 30 marsh-hen eggs (I ate three of them) that a friend of his had received by express and given him."[2] Today the old-timers are emphatic about not disturbing marsh-hen nests, but continue to harvest a few of the relatively 'useless' bird's eggs.

In the first quarter of the 20th century, gull, tern, and skimmer eggs were collected by the bucket, barrel, wash tub, and lard tin full. The nests were closely observed so that only the first and second eggs were taken. If the nest contained three eggs, they were no longer fresh. A floating egg in a dish pan of brine was also discarded. The eggs, unlike our familiar chicken eggs, are very rich and consequently help make "delicious cakes". Apparently the game wardens did not concentrate on gull egging violations and so the tradition is still followed today. Due to the unusual flavor of the eggs, the practice will surely die out with a new uninitiated generation.

A form of avian exploitation that does not fit our other categories is guano use. "Cedar Island guano is highly recommended by our farmers, who have used it and Mr. T. J. Killmon, the agent here, is selling large quantities of it."[3]

The low point for populations of island bird life in the early 1900's has been followed by a period of rapidly increasing numbers of birds. In as early as 1938 an article in the Peninsula Enterprise pointed out that wild bird life was on the rise: "Cobb's Island is the most important seabird nesting place on the Middle Atlantic Coast."[4] Not only have indigenous species gained strength but other birds have expanded their range to cover this area. Egrets, ibises, and oyster catchers now nest along Virginia's Eastern Shore in growing numbers, bringing about further changes in the island ecosystem.

D. Birds of Prey

The tree covered barrier islands were at one time a haven for nesting osprey. The fish hawks found ideal breeding and feeding territory on and around the islands.

Hog Island -

A favorite resort of thousands of fish-hawks, which mate, brood, and rear their young at this spot, finding ample means of sustenance in the treacherous shallows of Broadwater shoals...On almost every tree on the borders of this swamp, standing stark and solitary, is seen a huge mass of twigs, indicating a fish-hawk's nest. Some of these are

1/ Turman, Nora Miller. 1964. The Eastern Shore of Virginia. 1603-1964. The Eastern Shore News Inc. Onancock, Va. p. 206.

2/ Anonymous letter. May 1907 to Mr. Dennis, on file at Kerr Place. Eastern Shore Historical Society.

3/ Peninsula Enterprise. March 27, 1886. In Mears Scrapbook Vol. 12. Eastern Shore Public Library.

4/ Allen, Robert P. National Association of Audubon Societies. Peninsula Enterprise. June 6, 1963. Column "25 Years Ago" (July 1, 1938). Mears Scrapbook Vol. 14, p. 50.

of enormous size, the interstices between the sticks in some cases being occupied by families of grackle, or common crow-blackbirds. The small, solitary, stunted trees that stand at the feet of the sand-dunes are also frequently burdened by one and sometimes two of these huge, unwieldy nests, and in some cases they are perched on the bare sand atop of some bald, melancholy knoll.[1]

One hundred years later there are seventeen active osprey nests on the islands under the jurisdiction of The Nature Conservancy. The 'old-heads' can remember a time in the 20th century when there were still many osprey on Parramore, Hog, and probably Smith Islands. An attempt in the 1960's to erect osprey platforms on Hog Island met with little success. Unfortunately, it will require more than nest sites to bring back a population that has been so biologically disrupted by human activity.

The barrier islands play an extremely valuable role as a feeding and nesting area for migrating hawks and falcons. The migration begins in late September and a few birds are still traveling through the region as late as December. Small birds and rodents are captured on the islands to sustain the hawks in their energy-expending migration southward. During the time of more extensive human occupation of the islands, the hawks supplemented their diets with chickens;and young boys had the pleasure of shooting the marauding birds. The predator has always been an assumed competitor of man and so this activity was encouraged and often rewarded.

The seaside islands have in recent years supplied the falconer with birds for his sport. The peregrine falcon appears annually along the beaches and is easily caught. An old method of capture requires the falconer to bury himself in the sand while holding on to a specially harnessed pigeon. The harness is such that the attacking bird becomes entangled in its loops. A more up-to-date method employs the same harness arrangement but the pigeon is allowed to fly above a moving vehicle. This second technique was practiced on Hog Island within the last five years. Birds have been captured on Cedar, Parramore, Hog, and Smith Islands within the last ten years.

Frequently many falcons are trapped while only a few are of the appropriate age and sex to be kept for training. The selected birds are then taught to hunt and recover crows, quail, or pheasant. The condition of the peregrine falcon population, however, makes this trapping activity illegal at the present time.

II. STOCKING GAME

The three-pronged approach of the early wildlife manager included limiting bags and seasons, predator control, and stocking game. The island faunal population was thus further disturbed by the introduction of game-birds and mammals. Organizations such as the American Game Protection Association and sportsmen's magazines promoted the stocking idea until it became widely accepted. One problem of the wildlife manager today is to eliminate the ingrained faith in stocking practices.

Some stocking programs were aimed at returning animals to areas where they once existed and flourished; however, others directed efforts toward providing exotic hunting. A note in 1912 to the Eastern Shore Game Protective Association from a game farm in England listed eggs available for brooding and raising. Mongolian, Chinese, ringed or ringless pheasants and Hungarian partridges were among the selections.[2]

1/ Pyle, Howard. 1878-1879. p. 808, 810.

2/ Note to T.W. Blackstone, Accomac 1912, from Essex and Suffolk Game Farm, England. On file at Kerr Place, Eastern Shore Historical Society.

In the interest of hunting, the barrier islands have been stocked with various game animals. The introduction to Parramore Island with the most far-reaching impact was that of the deer. The white-tailed deer on the Eastern Shore had become scarce within the first twenty-five years of the present century and only an occasional deer was spotted on the marshes and islands of the seaside. Although there is some question about the actual date of introduction, most evidence points to the late 1920's or early 1930's as the probable time. The introduction may have been made by the Holly Island Club in its last years. The Schmidlapp family, after their purchase of the island in 1934, possibly added a few "Oregon deer" to the population. The influence of these deer on the Parramore Island gene pool is unknown.

Deer have thrived on Parramore and have populated many of the other barrier islands. They have been observed traveling back and forth to Cedar, Revel, and Hog Island in the years following the peak of human habitation. Occasionally a deer is poached, but hunting pressure in general is minimal. Many local residents claim that the deer on the more southern islands (from Cobb to Fisherman's) are also escaping the hunting and population pressure on Parramore. Nevertheless, the close proximity of the mainland makes it highly probable that an exchange is occurring with this source and not Parramore Island.

Pheasant and quail have also been released on Parramore but have not fared well. The unsuitability of some species to island life was demonstrated in 1925 when one wealthy clubman introduced one hundred pair of Hungarian partridges. Within thirty days, they had disappeared without a trace. Hence, attempts to stock Parramore with exotics declined after the 1930's. An attempt to introduce one hundred quail in 1969 has met with little success.

The interest in stocking Hog Island developed after human population of the island had ceased; however, it is possible that some was accomplished prior to the '33 storm. The stocking effort was primarily concentrated in the last ten years. Pheasant and quail were introduced to the island between 1965 and 1970 on several occasions. Some reference has been made to the stocking of partridge in this period also. Within the last three years pheasant were again released on Hog Island along with several guinea chickens. Rabbit hunters carried rabbits to the island in order to improve that form of hunting.

The earliest confirmed report of similar activity on Cobb Island occurred in the 1940's at which time pheasant and jack rabbits were introduced. The jack rabbits have adapted well to the rigorous barrier island life. Although restocked later, the pheasant persist and according to natives live on the 'beach pea' found growing on the island. Chukkar partridge introduced five years ago have not survived nor have the Japanese pheasant released in approximately 1966. The most recent stocking of Ring-necked pheasant occurred two years later and these birds can still be observed on the island. Only two years ago quail were stocked on Cobb Island in still another endeavor to 'improve' hunting.

Vague mention has been made to stocking attempts on other islands, and it is reasonable to assume that game birds and rabbits have been carried to other seaside barrier and marsh islands. The emphasis on stocking in wildlife management has indeed had an impact on the barrier island ecosystem; however, the extent of this induced disturbance is difficult to assess.

III. PREDATOR CONTROL

Predator control was another wildlife management technique espoused by hunter-oriented game programs throughout most of the 20th century. Any bird or mammal which preyed on

game species was classified as 'vermin'. As a result of this thinking, fish and game departments and private groups spent millions of dollars in their war against vermin. Again, sportsmen's magazines and organizations encouraged the elimination of these competitors. Today increased knowledge of ecosystem function has to a large degree eliminated this form of management.

Prior to the colonization of the Eastern Shore, the barrier island predator population was surely somewhat different than we observe in 1975. It is not unlikely that wolves, bear, and big cats roamed this region but succumbed early to pressure from man. The only predator of concern to sportsmen in the present century are the fox, raccoon, hawk, crow, and house cat.

Though foxes have always been hunted for sport, they were hunted and trapped with a purpose on Parramore Island. The fox was considered a hindrance to any program of game breeding and stocking. The fox hunter not only removed the potential threat but procured a marketable hide. During the 1920's a specialist was hired to rid the island of foxes to facilitate the introduction of game birds. Only a few dens were ever found. Occasionally, since that time, fox have been spotted and sometimes hunted. Hunting is frequently accomplished with the aid of a dog; or snare traps are set in likely places. As one old-timer put it, "there's more 'an one way to kill a devil than beatin' him to death".[1/]

During this same period the campaign against predators on Parramore Island included crows, house cats, and raccoons. People from the mainland had discovered that the island served as a wonderful depository for unwanted cats and kittens. A boat to the island frequently carried felines which were released and allowed to forage freely. Before game stocking could be achieved in the 1920's and 1930's, the cats were trapped and destroyed. The battle against crows was waged with strychnine-injected eggs. Raccoons have up until recent years been trapped or poisoned with strychnine bait; however, this program is unsuccessful. 'Coons are presently abundant on the island.

Natives of Hog Island can recall very few foxes or raccoons on their island. Broadwater club members and villagers in general may have made life on this island difficult for the predator prior to 1900. The few foxes that did appear in the first quarter of the 20th century were quickly trapped and rarely hunted with dogs. Today a few raccoons and an occasional fox or house cat hunt the island.

The only disclosure made about predator control on Cobb Island concerned house cat trapping. It seems that feral cats were killing ducks around the ponds, and were hence themselves eliminated by local trappers. There may be a few house cats on Smith Island at the present time, but other predators are rarely observed. Hunting or trapping foxes was seldom done on Smith Island even in the early 1900's.

The elimination of species, either inadvertently or purposely, brought about a change in ecosystem structure during the 20th century. Concurrently, the addition of species through stocking further disturbed the natural course of plant and animal relationships. In like manner, the islands' supply of other marketable fauna encouraged man to extend his influence to the marshes and waterways.

IV. TRAPPING

The old-timers today can remember periods of mink, muskrat, and otter trapping, but indications are that the peak of this activity had already passed at the close of the

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1/ Capt. Moe Birch. Taped Conversation. Tape #12, October 9, 1975.

19th century. The naming of Mink Island would suggest that these fur-bearers were once numerous on the seaside. Infrequently mink are spotted on Hog, Mockhorn, Smith and, of course, Mink Island. Rarely are otters seen today. At one time a trapper found their numbers sufficient to supply a profitable business. The muskrat was trapped along the Eastern Shore primarily for its hide and secondarily for its meat. Once in a while, a few enterprising natives still trap these rodents.

V. TERRAPINS AND OTHER TURTLES

The diamondback terrapin, a salt marsh turtle, is another form of seaside life harvested for its food value. During the late 19th and early 20th centuries, the terrapin was considered a delicacy, demanding a high price in city markets. Once again, the local people utilized their natural resources to supplement incomes. Just as the waterfowl market hunters became skilled in their work, so also did the terrapin hunter.

> Of the terrapin little need be said. It is not by any means a numerous tribe, which fact accounts for the high price it always commands, and which places it beyond the reach of any but the wealthy. As sportsmen are not in the habit of hunting for it, and would not be likely to be rewarded with success if they did, they are referred to terrapin hunters themselves for further information.1/

The market price of the terrapin was $2.50 a piece in the first decade of 1900.2/ Within a few years the scarcity of the Diamondback pushed the price much higher as shown in the following story about Hog Island's famous banjo-playing resident, Sud Bell.

> Let Brooks Mapp, well-known Accomac Attorney, tell you about Sud's visit to a New York broker who, enthralled by his playing, had invited him to come see him. Sud walked into his lavishly appointed office carrying a bulging suitcase and announced, "I've brought you a present from the Eastern Shore." At that moment the suitcase came apart and its contents, about twelve lively diamond-back terrapins, began crawling over the floor and under the furniture. The New Yorker's heart was touched; at that time terrapins were worth $100 a dozen. He called in his office staff to help retrieve them and told Sud to go over to the Racquet Club, using his name, and wait for him. An hour passed; the telephone rang; it was the club secretary. "We have a man here," came the querulous voice. "He says you sent him. He's got turtles running all over the place. And he's playing that banjo in our quiet reading room. Shall we throw him out or keep him?"
>
> The broker replied: "Hold everything! I'll be right over!"
>
> When he got there the terrapins had been packed away, but Sud, his banjo in action, was surrounded by a group of clapping, singing, stomping members, and the crowd was growing by the minute. The staid old Racquet Club was in the process of being thrilled to the rafters.3/

1/ A Paradise for Gunners and Anglers. Passenger Department Philadelphia, Wilmington and Baltimore Railroads Inc. 1883. p. 36. On file at Kerr Place. Eastern Shore Historical Society.

2/ Culley, Jennings. April 1968. The Islands. The Commonwealth p. 42.

3/ Wharton, James. September 1954. The Sea Islands of the Eastern Shore. The Commonwealth. p. 13.

The terrapins were caught in the marshes surrounding the islands and shipped alive in boxes. Some natives actually started their own turtle farms. The farm consisted of a finely meshed fence in a marsh area. Turtles laid their eggs within this enclosure and when the young hatched, they were unable to escape through the fence and were raised in captivity. One such enterprise was carried out on Revel Island in the late 1930's and an earlier one may have been in operation on Smith Island.

Other turtles disturbed by man include the snapping turtles found in the island ponds. Occasionally a working waterman, who planned to be out for a few days, would capture several snapping turtles in Parramore's Goose Lake to supply him with fresh meat for his journey.

Large sea turtles reportedly came ashore on Smith Island to lay eggs as recently as the first quarter of the 20th century.[1/] Changes in the physical geography of the island, climate, and perhaps human activity seems to have eliminated these reptiles from this northern portion of their former breeding range.

Human activity has indeed had an impact on the fauna of Virginia's Barrier Islands. Despite man, some animals have nonetheless managed to persist in great numbers. The bothersome mosquito, which once sent Cedar Island Hotel guests into the surf at night, is thriving. Similarly, in 1878 "the wooded portions of the island are in many cases swampy, and tangled with a thick growth of vines and underbrush - excellent harborage for that most abominable of nuisances the wood-tick..."[2/] One hundred years of man's presence has not affected these creatures noticeably either.

1/ Hogg, Granville. Taped Conversation. Tape #13. October 16, 1975.

2/ Pyle, Howard. 1878-1879. p. 810.

HUNTING

Hunting activity in the United States can generally be divided into three overlapping phases: hunting for survival, for market and for sport. Hunting on the Eastern Shore and on the barrier islands has paralleled this national trend from the time of the earliest settlers to the present day. Because of the strategic location of the barrier islands in one of the major North American flyways, migrating waterfowl and shorebirds have played an important role in the development of man's association with the islands and their adjoining marshes.

The earliest arrivals to the Eastern Shore in the 17th century were for the most part farmers and stock raisers who hunted and fished to help meet the food demands of growing and active plantations. Game on the Peninsula was probably sufficient to meet these needs, thus making trips to the islands less important than in the years to come. Nonetheless, a few references to hunting on the sea isles are available. In 1675 John Custis set up a notice at the Northampton court threatening to sue those inhabitants of the county who, in contempt of the laws, were ranging and shooting upon the islands of Smith and Mockhorn. He claimed that they disturbed his cattle.[1/] A few years later in 1681 a patentee of Hog's 3350 acres put up a similar notice prohibiting hunting.[2/] Thus it appears that livestock grazing in the 1600's was a more influential factor in island utilization than was hunting.

Faunal disturbance from hunting was relatively minor throughout the 17th, 18th, and early 19th centuries. The few inhabitants of the islands were scattered and could hardly make a dent in the abundant waterfowl with their less than efficient weapons. For the people of the mainland, a trip through the marshes and across the bays had to be made slowly by sailing boats, hence hindering their employment of island resources.

I. MARKET HUNTING

When it became obvious that man was not going to die in this new land, a new phase of wildlife use came into being. Killing game to survive was no longer of dire necessity, and gradually a business began to evolve. "It was the intoxicating profusion of the American continent which induced a state of mind that made waste and plunder inevitable".[3/] The early market hunter took advantage of the seemingly endless abundance to make a living, as did his contemporaries in every area of the growing American economy.

The first references (mid-1800's) we have to market hunting on the Virginia Barrier Islands concern the Cobb family of Cobb's Island. "It was only natural that the Cobbs should engage in market hunting, since game was plentiful and the limit per person was restricted only by one's skill with a gun."[4/] Nathan Cobb and his three sons,

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1/ Ames, Susie M. 1940. Studies of the Virginia Eastern Shore in the Seventeenth Century. Russell and Russell. N.Y. p. 32.

2/ Ibid. p. 33.

3/ Udall, Stewart L. 1963. The Quiet Crisis. Avon Books N.Y. p. 66.

4/ Kellam, Amine. 1974. The Cobb's Island Story. Virginia Cavalcade (spring) p. 22.

A hunter would normally cover himself with dried eel grass or similar material. Decoys would then bring shorebirds to within shooting range. Birds were harvested by market hunters and sportsmen alike in an age when bag limits were far less restrictive than today. These activities had a telling impact on species survival. The hunter shown here was George Doughty. Photo circa 1890. Courtesy of Kellman Doughty.

Nathan Jr., Warren, and Albert built an active business with their bag of 150 birds a day. Evenings were spent cleaning and packing game to be sent northward on passing ships.[1] Black duck, brant, canvasback and redhead brought 50 cents a piece on the New York market.[2] It seems likely that the inhabitants of Hog Island were also involved in this form of hunting which included spring shorebird shooting.

Through the years, market gunning evolved a high degree of specialization. Special equipment was needed and in order to be successful, the 'gunner' had to know the unique behavior of his target, which varied from species to species. During this period decoy carving developed into a truly American art. One of the earliest and best was Nathan Cobb Jr. (1825-1905). Other Cobb Island decoy makers were Albert Cobb, Elkanah Cobb, Arthur Cobb, John Haff, J.E. Tatum, and Capt. Joe Crumb. Thomas, George, and John Doughty were the Hog Island counterparts. And in the late years of the 1800's, members of the Smith Island Life Saving Station were active also, including Robert Andrews, Alma Fitchett, and Henry Downes.[3]

Hunting with a shotgun over decoys continued to be a popular method while more intricate ways of killing in large numbers began to appear. The punt gun and battery were two widely used guns devised especially for this growing business. The punt gun had one large barrel that was loaded once on shore. The hunter then paddled stealthily in a small boat toward his flock of floating targets. One shot was all that was needed by an expert. The battery was a 'finger-like' gun comprised of several barrels joined in a block of wood. This gun was often used in conjunction with a light mounted on a small skiff for night hunting. A special boat known as a sink box layout was used on the bayside, but there is some question as to whether it was also popular on the seaside.

These methods allowed the market hunter to kill ever increasing numbers of ducks and geese as well as wound and cripple many more. Nevertheless, gun manufacturers continued to develop more efficient shotguns and hence, they remained favorite weapons of the sport and market hunter. In the 1870's the breechloader gained in popularity:

> Chincoteague - 1883
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> Our young gunners were making sad havoc with the birds in this vicinity, and our crack shot, Oliver Hagon Wimbrough, with his breech loader, is astounding the sports by his marvelous execution of the feathered tribe. It is said that in one day's gunning he brought down more than Mr. Taylor could pick up, but now that a cargo of ice has arrived at this port there is no damage of the game spoiling for the want of facilities to ship the same to the N.Y. markets.[4]

Later in 1887, John Browning invented the first repeating shotgun, "the market hunter's dream".[5] Hence the gun manufacturers continued to make hunting easier.

1/ Ibid. p. 22.

2/ Connett, Eugene ed. 1947. Duck Shooting. William Morrow & Co. N.Y. p. 150.

3/ Bull, Roy. Chapter on Eastern Shore of Virginia in R.H. Richardson ed. Chesapeake Bay Decoys. Crow Haven Pub. Cambridge, Md. p. 169.

4/ Peninsula Enterprise. April 17, 1883. Mears Scrapbook Vol. 6. p. 48. Eastern Shore Public Library.

5/ Walsh, Roy E. 1960. Gunning the Chesapeake. Tidewater Pub. Cambridge, Md. p. 91.

One local fellow is said to have shot 76 brant simply by unloading the gun once (5 shots).[1] John Browning went one step further in the early years of 1900 and "gave the market gunner his greatest tool" - the automatic shotgun.[2]

> The technique of flock shooting with an automatic shotgun and the judicious use of corn constitute the deadliest method of duck destruction ever devised.[3]

The market was created in northern cities (New York, Philadelphia, Baltimore) by a demand for the delicacy of wild duck. Geese and shorebirds also came in for their share of exploitation during this period. "For they shot the seemingly stupid shorebirds even more unmercifully than the ducks, simply because they traveled in larger flocks and could be shot in warm weather with so little effort."[4] This type of hunting was done along the island beaches and frequently required the use of decoys. The birds shot most zealously were called the red-back sandpiper (or dunlin), dowticher (or robin snipe), yellow legs, curlew, willet, plover, calico-back (or turnstone) and the knot. The fact that the birds were killed in the spring limited marketing in the days without refrigeration, and hence, the 'beach birds' were subjected to the most pressure from sportsmen.

The men involved in this marketing enterprise were simply making a living off the land as were many thousands of Americans in the 19th century. It was a way of life on the Eastern Shore, and for some of the islanders it alternated with fishing and clamming in the summer for providing the means of support for families. Many of the old-timers today can remember their fathers thus engaged. Later when legislation restricted this form of hunting an ongoing demand in the cities stimulated the illegal gunning which has become so infamous.

Many factors combined to put an end to market hunting on the scale that it had reached by the end of the 1800's. The birds were getting scarce and prices reflected this scarcity. They rose from 50 cents to $2.50 for a redhead. Destruction of breeding habitat, market hunting and the growing pressure of sport shooting served to shock legislators and the sport hunter into making laws and forming groups for the protection of wild game.

II. SPORT HUNTING

Hunting for sport grew in popularity at the time market hunting was flourishing. The Eastern Shore, and especially the barrier islands, became famous for their fall and winter wildfowl shooting, as well as for spring shorebird shooting. Again, the Cobbs were at the forefront of a new enterprise and their hotel on Cobb Island became well-known to the hunting enthusiast.

> If ever a locale deserved to be described as a sportsman's paradise, Cobb Island in the second half of the nineteenth century was that place. Gifted by nature to an unbelievable degree, this bit of land off the

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1/ Parson, Tom. Taped Conversation. Tape #11. October 1, 1975.

2/ Walsh, Harry M. 1971. The Outlaw Gunner. Tidewater Pub. Cambridge, Md. p. 25.

3/ Ibid. p. 29.

4/ Connett, Eugene. 1947. p. 153.

Virginia Shore had no equal on the Atlantic coast as a stopping place for every variety of wildfowl: shorebirds, geese, and brant lingered through the fall and winter, and it was unexcelled for the sporty shooting provided by the Hudsonian curlews, who stopped there in great numbers.[1/]

Hence, the club on Cobb Island became the first in a series of clubs located on the barrier islands. Guests came from all over the United States and Europe to take part in the increasingly prestigious sport of hunting. "They were literally swamped with wealthy sportsmen who did not ask price - only a place to sleep and someone to take them out where they could shoot until their desire to relax and kill was satiated."[2/] The Cobb family skill in making decoys became an asset to this new business of guiding hunting parties. The activity on Cobb Island peaked before the turn of the century and its decline was speeded by a period of particularly severe storms in the 1890's. At least one smaller club was organized later, but never gained the acclaim of the original hotel.

In this same period Cobb's neighbor to the north, Hog Island, was the location of a private hunting club whose most noteworthy guest was Grover Cleveland. The club, located on the south end, was owned by a group of businessmen who came throughout the year to hunt and fish. It seems that in 1886, William J. Doughty sold a tract of land to Joseph L. Farrell who bought additional land and formed the Broadwater Land and Improvement Co. This parcel was then leased to the Broadwater Club.[3/] The town on Hog Island took the name Broadwater also.

The clubhouse was a large, twelve bedroom structure, lavishly furnished and outfitted. During the active periods of the year, cooks, guides, and other servants catered to the well-known members "including Grover Cleveland, who braved the bleak waters of Hog Island Bay for duck shooting".[4/] The sportsmen came to hunt ducks, geese, shorebirds, and an occasional fox, guided by the native Hog Islander. The club is said to have had a large grass field on which the 1895 University of Pennsylvania football team trained.[5/] There is some question as to when the club actually discontinued its activity, but it is possible that discord among members forced its closing as early as 1912. In any case, the building was later torn down and supplied the lumber for a few local homes.

Another old club on the seaside was the Accomack Club located on the marsh behind Parramore Island, known today as Clubhouse Point. This club was incorporated January 12, 1887 and its members were primarily from the New York area. The opening of the railroad on the Eastern Shore was partially responsible for the 'discovery' of this region as a sportsman's paradise, and indeed it was in 1887. Local men served as guides and women cooked and waited on the harried New Yorkers who came to relax and hunt. One of the most exciting forms of entertainment for the natives and club members was the sailboat regattas held in front of the club house (complete with clam chowder and prizes).

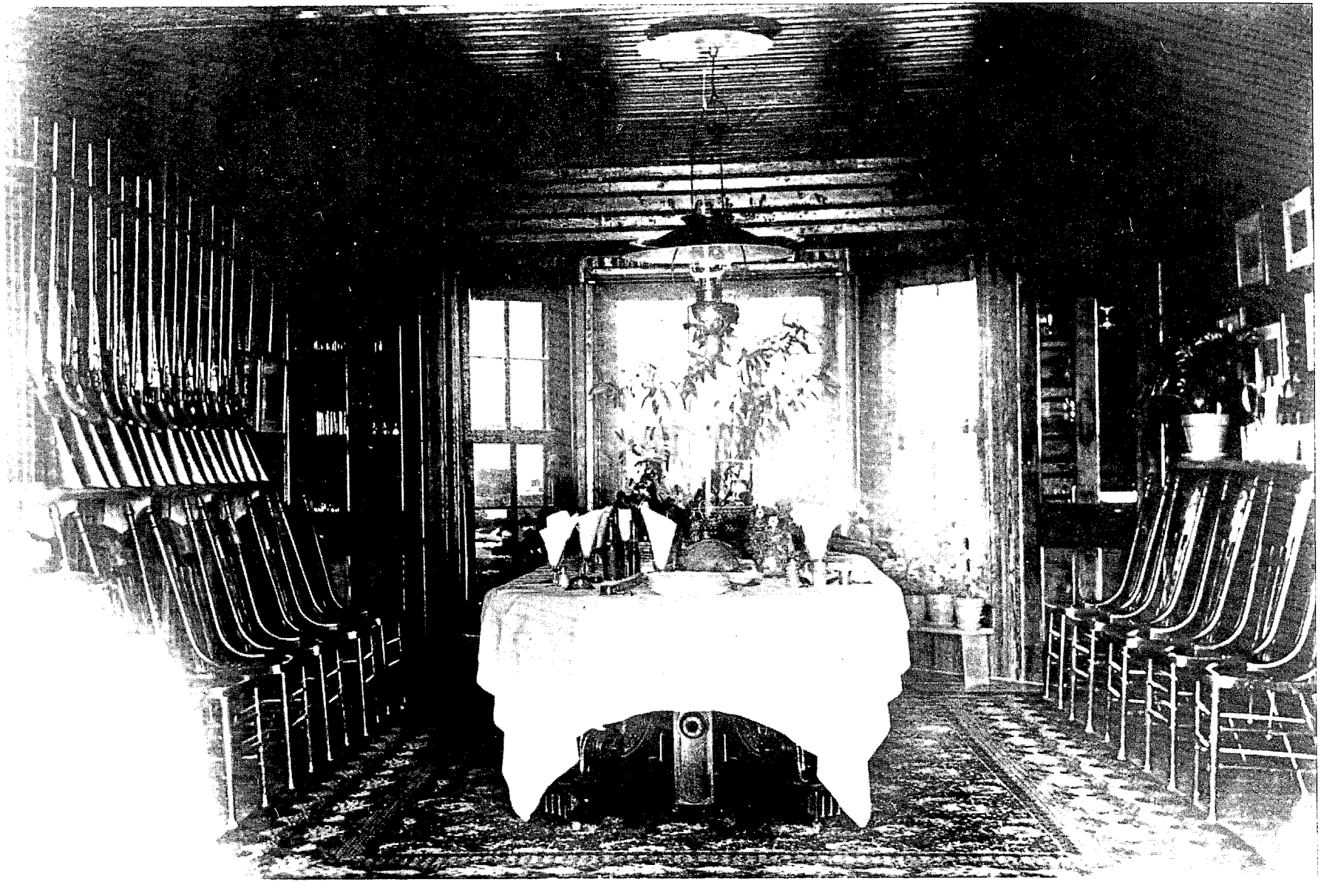
1/ Mackey, William J. Jr. 1964. The decoys of Nathan Cobb Jr. Antigues. August 1964. p. 192-193.

2/ Connett, Eugene. 1947. p. 151.

3/ Willis, Kit. 1974. Hog Island. Shatters (a publication of the Eastern Shore Community College) Vol. 1 No. 2, P. 38.

4/ Mears Scrapbook. Vol. 4 p. 43. Eastern Shore Public Library.

5/ Bowen, Harvey. Taped Conversation. Tape #8. September 17, 1975.



The interior of the Accomack Club clearly shows the sumptuous elegance of the island sportsmen's clubs of the ear. Photo date circa 1900. Courtesy of Captain and Mrs. George Peppler.

As was the case with many of the clubs of this period, several factors came together to end the gay days of the rich sportsman on the barrier islands. Game began to get scarce and the hunter could see his bag getting smaller each year. In an attempt to save what was left, wildlife enthusiasts pushed for hunting regulations, and seasons and limits came into being. But perhaps the greatest hindrance to this form of hunting was the onset of the Depression. Nature joined forces with the economy to bring down the buildings that for a few seasons had stood empty. The Accomack Club saw its last full year in 1929 and in 1936, a storm completed the work begun by the great hurricane of 1933. Only the water tower remains today to remind us of the spot that had known such a heyday.

The Revel's Island Club was another splendid club of the time. Although slightly younger than the Accomack Club, its activity extended through most of the same period. Predominantly known as the Revel's Island Club, it may have been officially called the Old Dominion Gun and Tackle Club.[1/] Members were from the Pittsburgh area. Aside from the main building, two cottages were built later by members to accomodate extra guests, perhaps because at certain times wives were not welcomed at the club. The Revel's Island Club was used primarily for duck hunting and sporadic shorebird shooting.

This club too succumbed to the pressures experienced by the Accomack Club, however, the building was not entirely lost in the storm. Lumber from the main house was used to build structures on Chincoteague.

Parramore Island with its forests and glades was not to be overlooked as a site for a sportsman's haven. In approximately 1920 the PIA (Parramore Island Association) Club was built on the north end of Parramore along the inlet. The best known member of the 125 member club was Mr. Chrysler of automobile fame. Again, they came to shoot ducks primarily and to fish occasionally. At some time in the late 1920's or early 1930's, a storm washed the underpinnings from the main house and it was moved to the location where it can still be seen today (along the marsh south of the present Coast Guard Station).

During the same decade, the club and island were sold and became known as the Holly Island Club. In the same fashion as their neighboring clubs, the Holly Island Club employed local guides and men to run the boats. Throughout most of the year, a caretaker lived in the small house still standing near the boat landing.

The ponds on Parramore Island afforded ideal duck hunting conditions. Migrating waterfowl need fresh or brackish water in which to feed and were thus virtually forced into the hunters bag. To facilitate congregation of birds even more, the ponds were heavily baited with corn, and several local fellows were hired to complete this task daily. Parramore is also known for its live decoy use. Tame ducks and geese were anchored with weights to lure their unsuspecting wild relatives to a spot in front of a blind, and ultimately to the club dinner table. The live decoys were kept in the enclosed area still visible in Goose Lake. To make hunting still easier the North-South road was built to connect the glades which previously were reached by walking in from the beach. Reputedly, telephones were installed at ponds to communicate with the club house.

Financial problems overcame the Holly Island Club in the 1930's also, and thus ended the large and lavish clubs of the era. Nevertheless, other smaller and often privately owned clubs began in this period and drew attention to the favorable climate and location as well as the abundant resources of the barrier islands.

1/ Walker, Mrs. Wade. Personal Conversation. September 22, 1975.

To the south, Smith Island had a clubhouse, known as the Bungalow, belonging to Mr. O.S. Campbell. The 23 room house was built in about 1911 on the land bought from Robert E. Lee's grandson. Mr. Campbell, believed to be a member of the New York Stock Exchange, invited guests for winter duck hunting.[1/] The ponds on Smith were baited with corn that could be purchased for $1 a cartload; and contests were held for killing birds. The 'sport' to kill the most ducks and geese won a new shotgun.[2/]

The Bungalow's recreational facilities included tennis, golf, and fishing along with good hunting, but once again, financial problems arose and the building was sold in 1927. The sea had also taken its toll of the island as evidenced in 1922 when the entire structure had to be moved 1800 feet back from the encroaching surf. Later the house was divided in sections and moved off the island.

Other small clubs were established on Skidmore Island, Mockon, Elkins Marsh, and, of course, Hog and Cobb Islands. Mockon or Mockhorn was owned by the Cushmans who began a wildlife refuge by planting food and experimenting with other forms of manipulative management. Hog Island had two or three small clubs run by local people and Cobb had one remaining club, all of which were seriously curtailed by the storms of the 1930's.

The most recent efforts to re-establish the old-style clubs were made by Mr. T.A.D. Jones on Mockhorn in the 1940's and by the present day arrangement of the Machipongo Club on Hog Island. Mr. Jones entertained his friends on Mockhorn Island by offering good shooting in season. He is reported to have been a sportsman who observed bag limits, although encouraging wildfowl with corn and live decoys was not frowned upon. A large house and caretaker's cottage stood on the 'walled island'.

In this same category, the Schmidlapp family bought Parramore Island as a retreat and a place to entertain friends with hunting and fishing. Although the Holly Island Clubhouse still stands, the Schmidlapps converted the old Coast Guard Station into their vacation home.

Today the Machipongo Club is the last vestige of the sportsmen's fellowship that had once been an all important force on Virginia's Barrier Islands. The club consists of a group of West Virginians who bought the Coast Guard Station on Hog's northern end in 1965. Members are primarily fishermen who do some duck and rail shooting.

So it was that for decades the barrier islands were a hunters' haven. Their location made them ideal for duck and goose hunting as well as for shorebird shooting. Deer hunting is relatively recent and limited in extent. After the introduction of deer on Parramore a few were shot each year (poached as well as legally) and occasionally, one would wander elsewhere to the joy of a lucky native. It was the waterfowl then that suffered. "It took nearly a century of unmerciful slaughter to make a noticeable dent in the countless thousands of waterfowl that once frequented the Eastern Shore, especially the Seaside marshes."[3/]

1/ Hogg, Granville. Taped Conversation. Tape #13. October 16, 1975.

2/ Martin, G. Taped Conversation. Tape #6. September 3, 1975.

3/ Connett, Eugene. 1947. p. 157.

The market hunter, the careless sportsman, and an expanding human population combined to bring many species of American waterfowl to the brink of extinction. The ducks, geese, and shorebirds that once blackened the sky were no longer coming in such great numbers. State and Federal regulations on hunting methods and seasons, in conjunction with a new emphasis on sportsmanship in hunting technique, have made the comeback in game populations of the late 20th century possible.

At the time when the island hunt clubs were beginning in earnest, laws in Virginia were taking the first steps to end market hunting.

> Be it enacted by the General Assembly of Virginia, That it shall not be lawful within the jurisdiction of the counties of Accomack and Northampton for any person to shoot at, or kill, or capture any wild water fowl, at any time during the night; or to kill or shoot at them with a gun which cannot be conveniently raised and fired at arms length from the shoulder without a rest; or, at any time to capture them in traps or nets, or by other contrivances. If any person violate any of the provisions of this section he shall be guilty of a misdemeanor, and, in either case, be fined one hundred dollars in each offence, and imprisoned in jail until the fine be paid, but not exceeding ninety days; all guns, vessels, boats, or other appliances, and all traps, nets, and other contrivances used in the commission of the offence shall be forfeited to the Commonwealth. In any prosecution of any person under this section, the possession of swivel guns, reflectors, traps, or other contrivances for the violation of these provisions shall be prima facie evidence of his guilt; and in all cases of conviction one-half the fine shall be to the informer.[1] Approved March 5, 1894.

Another Act of The General Assembly in 1896 set a season from September 15 to January 15 for shooting marsh hens, and no eggs were to be taken after June 1.[2] Furthermore, Sterling in his 1903 book on Hog Island stated that "the law allowing the shooting of wild fowl only on alternate days and from sun up to sun down, has put a stop to the indiscriminate slaughter of the noblest of wild birds, the brant, by brainless clubmen, unprincipled pot hunters and market gunners..."[3] These early laws were helpful, but it would take more drastic measures to curtail the kind of hunting that had become a part of the culture of the Atlantic seaboard.

In 1913 a duck and goose season from November 1 to January 1 had come into effect; and a closed season for swan, curlew, willet, gray-back, calico-back, dowitcher, knot, plover and other beach birds had been instituted.[4] Market hunting received its greatest blow when Congress adopted the Lacey Act in 1900 which controlled the transportation of wild animals across state lines. The Federal Migratory Bird Treaty Act in 1918 more specifically regulated the hunting of our dwindling wildfowl resources. Throughout the early 1900's and to the present day, many local, state, and national

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1/ The Eastern Shore Game Protection Association of Virginia. 1901. Constitution, Charter, Laws. On file at Eastern Shore Historical Society, Kerr Place. p. 11.

2/ Turman, Nora Miller. 1964. The Eastern Shore of Virginia. 1603-1964. Pub. by The Eastern Shore News Inc. Onancock, Va. p. 206.

3/ Sterling, Charles A. 1903. Hog Island Virginia. Copyright by Charles A. Sterling. p. 25.

4/ Richardson, R. H. ed. Chesapeake Bay Decoys. Crow Haven Pub. Cambridge, Md. p. 113.

regulations have been proposed and accepted to protect game and non-game species. Unfortunately, without proper law enforcement facilities, laws are useless.

The geographical location of the barrier islands made early attempts to enforce federal regulations by game wardens difficult, if not impossible. Sailboat travel throughout the area by a few game wardens did little to curtail the local violators. The people here had grown up with a tradition which condoned killing enmasse and for profit. The waterfowl belonged to them, and hence their children grew up with a new tradition - outwitting the game warden. It was with this frame of mind that duck trapping grew to its immense proportions on both the bayside and seaside. Only in recent years has duck trapping been thwarted by local wardens, and allegedly been given up with resignation by most of the local people.

Legislation was only a part of the solution to the game problem. A joining together of sportsmen, to promote a new attitude toward hunting, was instrumental in turning the tide for American wildlife. "...the hunters not unparadoxically, are more than anxious to keep these animals alive in order to have something left to kill".1/ One of the most influential of these early groups was the American Game Protection Association which had a chapter on the Eastern Shore in the late 19th and early 20th centuries. The organization exemplified the new trends in wildlife management and the increasing emphasis on sportsmanship:

Objectives:

1) The Association of Sportsmen, with a view to procuring and securing the enforcement of a wise and judicious system of laws for the preservation of the game of this Shore.

2) Restocking, as far as the means of the Association will permit, such portions of the shore as are depleted of game.

3) Offering rewards, as far as the means of the Association will permit, for the killing of hawks, foxes, and other game-destroying animals.

4) The encouragement of an interest on the part of the people in preserving game. Observing the game-laws, and informing upon and securing the punishment of the violators of such laws.

5) The assembling together of gentlemen, fond of field sports, from all portions of the shore, for friendly enjoyment, mutual acquaintance and cooperative effort, for the general objects above set forth.2/

How much heed was paid to the Association by the native is unknown. Conversations with old-timers have revealed that knowledge of the organization is non-existent. Perhaps a lack of enforcement power diminished potential strength on the Eastern Shore. It appears however that there was cooperation with local government.

> Owing to the reports of flagrant violations of the law prohibiting the trapping and "lighting" of waterfowl, resulting in their wholesale slaughter for market purposes, the Board of Supervisors in response to the

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1/ Matthiessen, Peter. 1959. Wildlife in America. Viking Press N.Y. p. 144.

2/ The Eastern Shore Game Protective Association of Virginia. Constitution, Charter, Laws. James E. Goode, printer. Richmond 1894.

representative of the Eastern Shore Game Protective Association at its meeting on Wednesday last rescinded a former order of the Board permitting the shipment of such game out of state.[1]

The strength of the organization of sportsmen was felt more fully by the out-of-state hunt club member. A fee of first $5 and then $10 was charged for the privilege of hunting on the Eastern Shore. The reaction of the vacation hunter is made clear in the following letter to the editor of The Eastern Shore News:

> It is natural to ask why this class (non-resident gunners) should be ostracized, if they should be, when all other classes who come to the county for business purposes are welcomed and patronized. No class will ever leave as much money for what it takes from the county as does this class.[2]

The uniting of sportsmen in groups such as the American Game Protective Association was an important factor in changing attitudes toward wildlife, but more specifically toward game animals. The trend in management supported stocking and predator control and hence the barrier island faunal population was further manipulated by human activity (see SELECTED HUMAN AND NATURAL INFLUENCES, p. 45).

Federal and state game regulations on seasons and bags, combined with an education program by sportsmen's groups and publications, have begun to direct the hunter to a greater awareness of conservation. Nevertheless, the Eastern Shore with its deep-rooted traditions and close family ties holds tenaciously to many of its old ways. Fathers and grandfathers shot over the limit or out of season, used live decoys, and lured birds in with corn. Likewise, they trapped to supplement their incomes and kept a watch for the game warden. It is not unusual then that today we have the native still fostering the belief that the waterfowl and shorebirds of the barrier islands and marshes belong to the Eastern Shoreman. He may shoot and trap for his family and friends and perhaps make a little on the side as well. "In this day of sophisticated living, fifty years after the laws were enacted, market gunning still flourishes...estimated at a Congressional hearing that it reaches nearly one-half million ducks a year."[3]

1/ Eastern Shore News. January 20, 1906.

2/ Eastern Shore News. January 27, 1906.

3/ Walsh, Harry M. 1971. p. 160.

LIVESTOCK GRAZING

The Eastern Shore of Virginia was first settled in the early years of the 17th century. The new arrivals were farmers and stock-raisers who depended heavily on meat from cattle, hogs, and sheep for their own consumption as well as for the market. Likewise, horses were a necessity for survival. A grazing problem was anticipated and materialized in this region without fences. The recognition of the barrier islands as the perfect pasture proved to be the solution to the problem. Hence, man began his first serious disturbance of the natural island flora and fauna.

> No land of the Eastern Shore was quite so desirable to the stock-raiser as one or more of the islands that bordered its coast, for on those grass-covered, sea-fenced areas, cattle, whether for dairy purposes or for sale, could be raised very profitably.[1/]

The realization of the islands' value occurred sometime after 1670 as evidenced by the patenting, one after the other, of the islands. Machipongo Island was patented in 1672 and soon became known as Hog Island, presumably because hogs foraged throughout its forests and marshes.[2/]* In like manner, Metompkin and Cedar Islands were patented in 1681 with the stipulation that the patentees, William Burton and Thomas Bagwell, and their heirs should have the liberty to land cattle upon any part of the island as often as desired.[3/] Smith Island was also prized for this purpose.

> Until this year (1691) the island probably was considered worthless as no patent for it was found until one was issued to General John Custis as 2,600 acres.** About this time the barrier islands became recognized as valuable for cattle ranging and all of them were taken up in a very few years.[4/]

Although conditions were rigorous for the domestic herds, the arrangement was ideal for the owner. The animals could be released and allowed to roam freely. Later they could be recaptured at the owner's convenience. The only problems occasioned by this practice involved the few marauding seafarers who stopped ashore to supply their ships with fresh meat.

In all probability, livestock grazed on most of the barrier islands, from Chincoteague to Smith Island, continuously throughout the 18th and 19th centuries. Their presence

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* The name of the island was often spelled 'Hogg' suggesting that it may have originated from a family name.

** See The Englishman, p. 10, for discrepencies in patent dates.

1/ Ames, Susie M. 1940. Studies of the Virginia Eastern Shore in the Seventeenth Century. Russell & Russell. N.Y. p. 32.

2/ Anonymous. Virginia's Drowned Village. Virginia Cavalcade. Winter 1957. p. 7.

3/ Ames, Susie M. 1940. p. 33

4/ Whitelaw, Ralph T. 1951. Virginia's Eastern Shore. Vol I & II Virginia Historical Society. Richmond, Va. p. 50.

on Smith Island in 1807 is confirmed by the following letter:

> I very much fear we shall be obliged to go to war with the imperious English, their conduct is not to be born with, they have landed on Smiths Island since the Presidents Proclamation & robbed & plundered Beef & Sheep; we now have a Gard of 40 or 50 men there to receive them should they come again.[1]

We know nothing of the vegetation of the islands prior to the arrival of Europeans to the Atlantic coast; but one can assume that some plants may have been eliminated by the grazing and foraging stress placed on the island ecosystem. The sporadic and less intense livestock raising of the 20th century also had had an effect on plant community structure.

The grazing of cattle, sheep, hogs, goats, and horses in the late 1800's and up to the present time has been concentrated on Parramore, Hog, Cobb, Smith, and Mockon Islands; and to a certain extent Assawoman, Cedar, and Revel Islands.

The size of Parramore Island and the quality of its vegetation made it a more desirabl island for livestock raising than some of its sandy northern neighbors. As is the case with Chincoteague Island, ponies were allowed to roam and become wild along the beaches and among the trees of the island. A local newspaper article in 1890 advertised "pony penning on Parramore's Beach next Wednesday - transportation free from Wachapreague - ponies to be sold at public auction".[2] Whether all the ponies were removed at this time is unknown; however, 75 were stocked at the period 1897-1917 along with as many as 600 cattle and 800 sheep.[3] The livestock fed on grass and the leguminous beach pea. The island again changed hands in approximately 1917, but the new owner did not purchase the animals. By 1919, however, all of these had been removed with the possible exception of a few horses.

Another stocking effort in the 1920's was a failure. An attempt was made to introduce Texas longhorn cattle. They were unable to cope with the relatively low nutritional value of the vegetation and the insects of the seaside isle. Natives remember the removal and slaughter of cattle in Wachapreague at some point in this period, but whether it was the long-horns or some earlier cattle is unknown. Also vague mention was made to the trapping of a few wild hogs for meat in the first quarter of the 20th century.

Throughout the late 1920's and 1930's interest in the island focused on hunting and improving the island for that purpose. Fifteen years passed before livestock was again introduced. Deer had, however, been placed on the island in the interim. In 1940, 100* goats were released on Parramore with the hope that they would clean out the heavy underbrush within the forest. The goats thrived and multiplied until 1950 when their numbers had reached into the thousands.* Watermen marveled at the white-dotted shoreline as they passed the island.

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* Figures range from 20-100 introduced goats, and from several hundred to several thousand captured.

1/ Bowdoin, Peter. August 6, 1807 letter in Whitelaw, Ralph T. 1951. p. 297.

2/ Eastern Shore News. September 16, 1975. "75 Years Ago" column (September 6, 1890). Mears Scrapbook Vol. 17 p. 38. Eastern Shore Public Library.

3/ Powell, Herbert. Taped Conversation. Tape #1. August 14, 1975.

The goats were sold to Texans who arrived and attempted to round them up on horseback (cowboy-style), much to the amusement of the local people. The roundup was finally accomplished with sheep dogs. Some of the goats were used for meat and range stock, others were sold for antirabies serum.[1] Henceforth, except for an occasional straggler Parramore Island was devoid of domestic livestock.

The grazing situation was somewhat different on Hog Island due to the human habitation of the island. Surely the earliest settlers brought livestock with them, and some indications are that that may have been in the 1600's. The villagers, throughout the late 1800's and up until the 1930's, kept cattle, sheep, horses, and frequently a few hogs and goats. The animals roamed freely and thus fences were constructed around buildings and gardens for fencing out (not fencing in). Each fall a few of the cattle were slaughtered and the meat was divided among the inhabitants. Similarly, the sheep were rounded up in a joint effort each spring for shearing.

The stock browsed in the forest and along the marshes. Although the vegetation supplied sufficient nourishment, evidence suggests that animals did not grow as vigorously as their mainland counterparts.

> On the west of the island is a great stretch of waste, comprising sea meadows, shoals, sand dunes, shallows, and mudbars extending some four miles to the banks of Great Machipongo Inlet. On this waste land there are patches of swamp-grass and fields of sea-meadow grass, which, coarse and short as it is, yet gives sustenance to herds of small wiry cattle.[2]

An Eastern Shore News article in 1957, on the history of Hog Island, mentioned that the flocks of sheep on the island kept the 'woods clean as a penny'.[3] Interestingly, some Hog Islanders claim that the livestock did keep the underbrush down and for this reason fires never started within the forest.

Estimates of the number of livestock prior to the 1933 storm include 100 cattle, 100 Chincoteague ponies, 300-500 head of sheep, a few hogs and goats, and, of course, chickens.[4] Many of the animals drowned in the storm and most of those that survived were removed gradually to the mainland during the remainder of the 1930's. Today Hog Island is the only island on which livestock are grazed in the same wild manner as they were in the 17th century.

Grazing pressure on Cobb Island during the late 1800's and early 1900's was minimal. No doubt the Cobb family kept a few head of livestock for their own use, but the food required for their booming resort business was obtained from their mainland farm.[5] More recently, 300 sheep and 100 cattle were released on the island, found to be too many, and subsequently removed.

As was stated in the first part of this section, cattle were pastured on Smith Island in the 1600's. Cattle, horses, sheep, goats, chickens, and turkeys have been kept

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1/ Life Magazine. Cowpunchers get Virginia's Goats. January 23, 1950. p. 30.

2/ Sterling, Charles A. 1903. Hog Island Virginia. Copyright by Charles A. Sterling. p. 6.

3/ Eastern Shore News. April 4, 1957. Mears Scrapbook Vol. 4 p. 81. Eastern Shore Public Library.

4/ Simpson, John. Taped Conversation. Tape #12. October 1, 1975.

there periodically up until the 1960's. During the time of the Bungalow Club, the herds of cattle and flocks of sheep numbered in the hundreds. Fifteen to twenty horses roamed the island for a few years after the other livestock and prior to the 1933 storm.[1] One of these horses had originally been kept for buggy rides along the beach. A small goat herd established around 1950 is rumored to have been eliminated by the high tides of the March 1962 storm.

Of the other islands in the chain, Mockhorn is said to have had several hundred cattle during the Cushman ownership in the 1920's and early 1930's. Many of these were lost in the 1933 storm.[2] A few animals have, from time to time, been kept on Cedar, Wreck, Fisherman, Skidmore, and Revel Islands, and on Elkin's marsh.

Due to the extent and longevity of grazing practices on a few of the barrier islands, we can assume that disturbance to vegetation was inevitable. Unfortunately, we are not able to assess accurately the full impact of this human-related activity.

1/ Kellam, Amine. Taped Conversation. Tape #5. September 2, 1975.

2/ Martin, G. Taped Conversation. Tape #6. September 3, 1975.

RESOURCES OF THE SEA

The waters surrounding the Eastern Shore of Virginia provided the earliest settlers with food. Fish and other seafood were harvested and preserved for local use throughout the year. A commercial fishery soon established itself and products of the sea were exported to Europe by the American colonists. The following is a description of marine life, and although not directly related to the islands, it depicts nicely the changes which have occurred in the sea since man's arrival in Virginia.

> Another attempt to correct the waste in fish life was occasioned by the pollution of the waters of lower Chesapeake Bay by the killing of Whales. A petition to the Governor in 1698 requested:
>
> Wee the Councill and Burgesses of the present General Assembly being sensible to the great mischiefs and inconveniences that Accrew to the Inhatitants of this his Maj'ts Colony and Dominion of Virginia By killing of Whales within the Capes therof Doe in all humility take leave to Represent the same unto your Excellency And withall to acquaint you That by the means there of Great Quantityes of Fish are poysoned and destroyed, And the Rivers also made noisome and offensive, For prevention of which Evills In regard the Restraint of the killing of Whales is a Branch of His Majestyes Royall Prerogative.
>
> Wee humbly Pray that your Excellency will be pleased to issue out a Proclamation for biding All Persons whatsoever to strike or kill any Whales within the Bay of Chesapeake in the Limits of Virginia which wee hope will prove Effectuall meanes to prevent the many Evills that Arise there from...[1/]

By approximately 1840, the seafood industry was well established. Oysters were being marketed in northern cities and conservation measures were taken by the General Assembly. Oyster sales were prohibited between May 1 and September 1. Similarly, laws were enacted which specified appropriate use of seines or nets. Turtles could not be marketed nor could their eggs be disturbed between March 1 and October 1. Lawbreakers forfeited their nets, seines, tongs, and boats, and paid a fine.[2/]

Not only was commercial fishing an important enterprise, but sport fishing was also becoming a tradition by the mid-19th century. For example, Cobb Island after the Civil War was famous for its hunting and fishing.

> Advertisement for the Cobb Island Clubhouse:
>
> Open all year for sportsmen. BRANT, DUCK and GOOSE shooting in winter over live decoys. Shooting and good fishing in summer. Surf bathing unexcelled.

1/ Pearson, John C. 1942-1943. The Fish and Fisheries of Colonial Virginia. William and Mary College Quarterly Historical Mag. Vol. 23, no. 3, p. 281. Original Petition: Council Papers of Virginia 1698. Printed in the Virginia Magazine of History and Biography XXI, no. 1 p. 76.

2/ Turman, Nora Miller. 1964. The Eastern Shore of Virginia 1603-1964. The Eastern Shore News Inc. Onancock, Va. p. 174.

> The veteran sporting journalist, Major Alex. Hunter, says of the place: That "it is the finest brant shooting grounds on the Atlantic coast, and the finest sea fishing in the summer north of the Gulf of Mexico". And what he says goes.[1]

"Lovers of piscatorial sport" found an abundance of sheep's head, striped and black bass, bluefish, weakfish, kingfish, drum, flounder, blackfish, bay "makeral"(sic), and horse "makeral"(sic), perch, spot, sunfish or moccasin, pike, and "catty".[2] Shark fishing was a favorite at the Cobb's resort, especially with one well-known guest.

> Governor Fitz Lee will not soon forget his shark fishing; how, when the monsters were drawn up along side the boat he mauled them to death with a ponderous club. He could command a sharking fleet as well as a division of cavalry...that place suits him better than any other seaside resort he has visited.[3]

Drum fishing too was popular and 100 pound drum fish were taken with harpoons from the Hog Island beach.[4]

Commercial fishing was an active enterprise in this period. During the 1880's commercial interests were engaged in the manufacture of fertilizer and extraction of oil from the menhaden catch. Reportedly, a plant was located on Cedar Island at this time.[5] Clamming continued to be a profitable business and the famous Virginia oyster grounds were productive.

Other marketable marine fauna included the Diamondback Terrapin and the soft crab, both of which were considered delicacies in the Philadelphia and Baltimore markets.

By the turn of the century, many Eastern Shoremen were making a living by harvesting the natural resources supplied by the bays, inlets, and open seas. The waterman whose life was ruled by tides, seasons, and weather gradually became a predominant feature of this seaside culture. The work was hard and the hours long. Equipment and transportation were not as efficient as today. Poling or sailing were the only means of reaching fishing, clamming, or oyster grounds. Although some sport fishing went on, primarily with the vacationer, the local people fished for a livelihood.

Seines and various other nets were used as well as hand lines. The rod and reel arrived with the sportsman. One of the more interesting methods of commercial fishing

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1/ Advertisement in Charles A. Sterling. Hog Island Virginia. 1903.

2/ A Paradise for Gunners and Anglers. Passenger Department. Philadelphia, Wilmington, and Baltimore Railroad Co. 1883. Kerr Place File. Eastern Shore Historical Society. p. 20.

3/ Peninsula Enterprise. August 9, 1962. "75 Years Ago" column. (July 30, 1887). Mears Scrapbook Vol. 14, p. 37. Eastern Shore Public Library.

4/ Pyle, Howard. 1878-1879. A Peninsular Canaan. Harpers Mag. Vol. 28, p. 810.

5/ Mears, James Egbert. 1950. The Eastern Shore of Virginia in the Nineteenth and Twentieth Centuries. Chapter 27. Reprinted from The Eastern Shore of Maryland and Virginia. Ed. Charles B. Clark. Lewis Historical Publishing Co. Inc. N.Y. p. 583.

on Virginia's seaside involved the construction of traps. These traps, known as pounds, were located off the beaches of the barrier islands and were the basis of the pound fishing industry. This form of fishing was begun on the seaside in the early 1900's and proved to be successful through the 1930's.

Several fishing companies in Wachapreague and Willis Wharf employed the method of trapping fish in huge quantities. The traps consisted of large poles set in deep water which then served as a frame for netting. Each day pound boats with crews of approximately twelve men left the mainland to empty the nets. Catches usually included sea trout, croaker and other local fish. Occasionally, sea turtles were caught and killed.

Markets for the fish, throughout the 1920's and 1930's, were in cities such as Philadelphia and Baltimore. Old-timers remember trucks leaving Wachapreague daily for many months of each year. Often if market conditions were not good, fish would be held in pens constructed on the 'inside' of the islands. Later when the market improved the fish were easily recaptured. Fishpen Gut, located in the marsh between Wachapreague and Parramore Island, was used for this purpose.

Pound fishing had its drawbacks, however, and it was not long before fish were not as numerous as they once had been. Furthermore, the storms so frequent in this period were destroying the traps. To compound the problems of the pound fishing companies, accidents occurred in which several lives were lost. All of these factors came together to bring about a decline in this commercial venture. In the period 1935-1970, there was a 66% decrease in the number of licensed pound nets.[1/]

Another commercial fishery of the 20th century was shark fishing. Shark meat was sold as 'steak fish' and the livers were used for vitamin extraction. The 3-9 foot sharks were caught with nets at night. This fishery was not extensive and thus, within a few years, interest declined.

The shellfish industry of the Eastern Shore was a source of income for the native, and particularly the Hog Islander in the years prior to the 1933 storm. The prices during the Depression, however, would lead one to think otherwise. Clams were $1 per thousand and oysters 10¢ a bushel.[2/] Although oysters and clams are still profitable, the scallop population has declined to a point which precludes commercial exploitation. Harvesting scallops was a relatively short-lived business in the bays of the seaside. Interest in scallops began in the 1920's, but the bivalve population was seriously effected during the 1930's when a blight destroyed the eel grass to which the juvenile scallop attaches itself.[3/]

Fishing on Virginia's Eastern Shore is a way of life, especially for those living in close proximity to the bays and waterways which surround the barrier islands. Although fishing for market is not on the scale that it once was, many of the old commercial fishermen use their expertise by 'taking out parties'. Other 'old-heads' fish daily simply because it is customary to do so. Their catches are given to friends

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1/ Richards, C.E. Ch. VII. Recreational Fishing. From Burrell, Dias, and Castagna. 1972. Study of Commercial and Recreational Fisheries of The Eastern Shore. Unpublished manuscript. Virginia Institute of Marine Sciences.

2/ Simpson, John. Taped Conversation. Tape #12. October 1, 1975.

3/ Castagna, Michael. Virginia Institute of Marine Sciences. Personal Conversation. November 7, 1975.

and relatives.

Sport fishing, on the other hand, is drawing more people to the seaside each year. Private boats are launched or party boats are rented for bay, inlet, ocean, and beach fishing. There was once great hope for the barrier islands regarding this later form of fishing.

> Surf casting from the beaches is supurb wherever engaged in. One of the great drawbacks to the Eastern Shore - something which in time will be corrected - is that there is hardly a point anywhere along the wonderful outer shores where one may drive his car, park and cast his bait into the surf.[1/]

1/ Wood, Leonora W. 1952. Guide to Virginia's Eastern Shore. Dietz Press Inc. Richmond Va. p. 67.

STORMS AND THE BARRIER ISLANDS

The position and nature of the Virginia Barrier Islands along the Atlantic coast make them highly vulnerable to hurricanes, tropical storms and the unpredictable 'Northeaster'. Throughout history, storms in this region have effected the physical configuration, vegetation, and human use of the sea islands. Unfortunately, records are often incomplete and inaccurate, making the pinpointing of exact storm dates impossible.

The size of the island, type of vegetational cover, and the direction of the storm combine to determine the extent of the damage inflicted by a particular storm.

Although storms have made life difficult on the sea isles, people have been willing to contend with this uncontrollable force to reap the benefits of life on an island. Habitation of the islands south of Chincoteague and Assateague was sporadic in the early years of the 19th century, but people on those two northern isles were already experiencing the horrifying uncertainty of life so close to nature.

> Many traditions of the island are handed down from mouth to mouth by the natives, but few of them being able to read or write. It is thus we receive a full account of the great storm and accompanying tidal wave of the year 1821; telling how the black wrack gathered all one dreadful day to the southeast; how all night the breathless air, inky black, was full of strange moaning sounds, and pine needles quivered at the forecasting hurricane that lay in wait in the southward offing; how sea-mews and gulls hurtled screaming through the midnight air; how in the early morning the terrified inhabitants, looking from their windows facing the ocean, saw an awful sight; The waters had receded toward the southward, and where the Atlantic had rolled the night before, miles of sandbars lay bare to the gloomy light, as the bottom of the Red Sea to the Israelites; then how a dull roar came near and nearer, and suddenly a solid mass of wind and rain and salt spray leaped upon the devoted island with a scream. Great pines bent for a moment, and then, groaning and shrieking, were torn from their centuried growth like wisps of straw and hurled one against another; houses were cut from their foundations and thrown headlong, and then a deeper roar swelled the noise of the tempest, and a monstrous wall of inky waters rushed with the speed of lightening toward the island. It struck Assateague, and in a moment half the land was a waste of seething foam and tossing pine trunks; the next instant it struck Chincoteague, and in an unbroken mass swept across the low south marsh flats, carrying away men and ponies like insects; rushing up the island, tearing its way through the stricken pine woods.[1]

Whether the south-lying islands were as drastically affected at this time we do not know. Again, the intensity of such a storm may vary throughout the region. Nonetheless, the southern islands experienced their share of destruction during the 1800's.

The earliest mention of a storm and its results on the islands now under The Nature Conservancy's jurisdiction is as follows:

1/ Pyle, Howard. 1877. Scribner's Monthly. no. 13 (April) p. 743-744.

> A severe storm in this year (1851) cut a wide channel through the island (Smith), making two islands out of it. The upper part became known as Myrtle Island...[1]

Storms play an important role in determining the physical configuration of the islands and their surrounding waterways. This in turn influences the vegetation of the islands as evidenced by the above description of the pine trees in the Chincoteague storm. It is believed that the cedar trees, for which Cedar Island was named, were destroyed by a storm in 1857.[2]

The 1800's was also a difficult time for livestock raising on the barrier islands. We can only guess at whether the indigenous fauna experienced the same mortality rates as the grazing cattle and sheep. The following is a portion of a newspaper account of a storm in 1878:

> We were visited on Tuesday night last with one of the severest wind storms ever experienced in this section, and unquestionably the highest tide within the knowledge of any one now living, the water reached a point at least 3 feet higher than the great September blow of 1822*...On Cedar Island nearly all the stock perished, Cap. O.A. Browne being a heavy loser. His loss there will be fully seventy-five cattle, and as many sheep...No report has reached us from Revel's or Hog Island, but on the former, it is feared that Charles M. Dunton, Esq. has lost heavily in stock.[3]

Thus, although the islands afforded good grazing conditions most of the time, a certain risk had to be taken in dealing with an area so susceptible to the vagaries of nature.

For the most part, a barrier island is exactly what its name implies - a barrier between the mainland and the pounding surf. The quiet inner bay waters then allow the build-up of marshes to occur undisturbed. Infrequently, however, a storm is so severe that even the island falls short of its task. The 1878 storm was apparently such a storm.

> It may have been, that the sea broke entirely over the beach, and was driven by the wind on the mainland...had something of the nature of a tidal wave.[4]

The potential for inundation of an island depends naturally on its height above sea level, thus some of the Virginia Barrier Islands are more vulnerable than others.

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* Dates on storms are often incorrect by a year or more. It is possible that the 1821 storm at Chincoteague is the same storm as one mentioned here in 1822.

1/ Whitelaw, Ralph T. 1951. Virginia's Eastern Shore. Vol. I & II. Virginia Historical Society. Richmond, Va. p. 51.

2/ Richardson, Preston. Wachapreague, Va. 1958 school notebook in which the student noted interviews with old-timers.

3/ Eastern Virginian. Saturday October 26, 1878. On file at Virginia Historical Society. Richmond, Va.

4/ Ibid.

In 1878 the Cobb's Island Life Saving Station was carried from the foundation and damaged. Ten years later, "a high tide in 1888 engulfed the nearest island to the south, called Cobb's. But it left Hog at least above water. This proved to the latter's folk the superiority of their location."[1] Little did the islanders know that this was to begin a decade of devasting storms that would end the good life on Cobb's Island; and later, Hog Island would have its turn.

There is considerable discrepancy as to the exact date of the final blow to the famous Cobb's Island resort. A series of storms and perhaps a decline in strength of the family leadership combined to bring an end to the business and the buildings. Some references give 1893, others 1896, and still others 1898, as the year of the 'tidal wave' which destroyed the hotel and surrounding structures. Sometime in October of 1896 seems to be the most likely choice.

A search through the Hog Island Lighthouse journal revealed the following brief statement on October 11, 1896: "There is a severe storm from the North east. The tide has nearly submerged the island."[2] Why then did the storm have such a tremendous effect on Cobb Island and an obviously lesser impact on Hog Island? The explanation can only lie within three factors: height above sea level, vegetation cover, and relative direction of the storm.

The Hog Islanders, who once thought that their high, tree-covered, island was safe from the sea, began to notice a gradual erosion of the south end. The storms had begun to take their toll. A storm tide in October, 1903, which covered the whole island, was a foot deep at the highest point.[3] Another storm in September, 1928 supposedly made the largest dent in the island's eroding southern section.[4] It was the hurricane of August, 1933, however, that is undoubtedly the single most significant event in the history of human use of the barrier islands.

The Great August Storm washed over all of the islands, with perhaps the exception of Parramore, the wind and the waves carrying livestock, trees, and buildings into such mainland towns as Wachapreague and Willis Wharf. Contrary to recently published accounts of the storm, this was merely the beginning of the end for the village of Broadwater. One house on Hog Island washed away because no one was there to open the doors and windows to allow the sea to wash through without sweeping the house from its foundation. No one drowned. The trees and direction of the storm are believed to be responsible for diminishing the storm's impact. Much livestock was lost and erosion was extensive, but the people stayed. They knew, however, that the end of their happy island life was nearly upon them and hence gradually, over the following few years, began to move to the mainland.

The '33 storm was felt on the other barrier islands also. On Cedar Island, the Coast Guard Station was demolished and the old hotel building was washed down. On Cobb Island, Mr. George Cobb was drowned and the Coast Guard Station and small clubhouse

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1/ Anonymous. Virginia's Drowned Village. Virginia Cavalcade. Winter 1957. p. 9.

2/ Journal of Hog Island Light Station, Va. kept by George Lanson Doughty. Began June 14, 1872. Presently in the possession of Kellam Doughty, Eastville Deputy Sheriff.

3/ Sterling, Charles A. 1903. Hog Island Virginia. Copyright by Charles A. Sterling. p. 29.

4/ Newspaper article, probably Peninsula Enterprise. March 31, 1939. Mears Scrapbook Vol. 7 p. 2. Eastern Shore Public Library.

destroyed. Along the whole length of the seaside, oyster watch-houses were washed away. Furthermore, the inundation of the islands was destructive to both flora and fauna; and the extensive movement of sand westward by storm currents resulted in the burial of bottom dwelling organisms in the bays. Nevertheless, the most far-reaching damage was that done to the beaches by a swiftly moving sea.

"A great storm in 1933 flattened the town; carved up the island. Only the dead stayed."[1/] Although the end of Broadwater was not quite so dramatic as suggested here, the results were ultimately the same. Another storm in 1936 convinced the remaining wishful thinkers that habitation of the barrier islands was risky and potentially expensive. By 1940, the threat of storms and the noticeably increasing rate of erosion ended the many decades of island habitation. A Northeast storm, known locally as the Ash Wednesday Storm, in March, 1962, served as a present day reminder of the hazards of seaside life.

1/ Culley, Jennings. April 1968. The Islands. The Commonwealth p. 39.

PHYSICAL CHANGES*

The physical appearance of most of the barrier islands has changed strikingly since man's first association with them. Storms have done their damage; but other unexplained changes in erosion patterns have occurred which cause old-timers to shake their heads about the future of the islands. Certainly the drastic alterations of Hog Island within the life-time of many natives is sufficient justification for their pessimism.

The transformation in the appearance of Hog Island occurred swiftly. For example, in newspapers of the turn of the century, advertisements for the new store in Broadwater were common; hence, people obviously felt secure in the potential longevity of their community. The following is taken from a newspaper in 1903:

> Hog Island, bathed in the mellow light of the moon, is indeed a paradise (when the mosquitoes don't bite) nestling in the bosom of old ocean like a gem, from the Life Saving Station on the sands with its band of stalwart seamen, to the top of the tall light tower, which sends its comforting gleams to the distressed mariner, is full to overflowing with a mysterious interest, which gives the impression of prodigious strength, with calm peaceful security...1/

The islands, however, had been eroding and building up for centuries. The people either did not notice, or perhaps simply decided to take a chance on, the precarious nature of their island existence. Nevertheless, the evidence was there in 1878 when Pyle noted that "in some places the sandhills were eighty feet high, covering every vestige of trees they have buried..."2/

Hog Island from 1900 to the early 1920's was approximately eight miles long and two miles wide at the widest point on the south end. Fully half the island was forested as Parramore is today, and the beach in some places was almost a mile wide. In other places, some of the old-timers can remember as young boys watching huge sand slides as dunes cracked and fell into the surf. The old brick lighthouse, which once stood on the eastern edge of the forest, was surrounded by lapping waves. The foundation of the new lighthouse, built in 1896 on the western side of the island and destroyed in 1950, is now under the sea.

The erosion was gradual yet persistent up until 1933. By the time of the great August storm of that year much of the forested areas had dwindled. The sea had begun to wash in around the roots, thus, "the lordly trees which once sheltered the community

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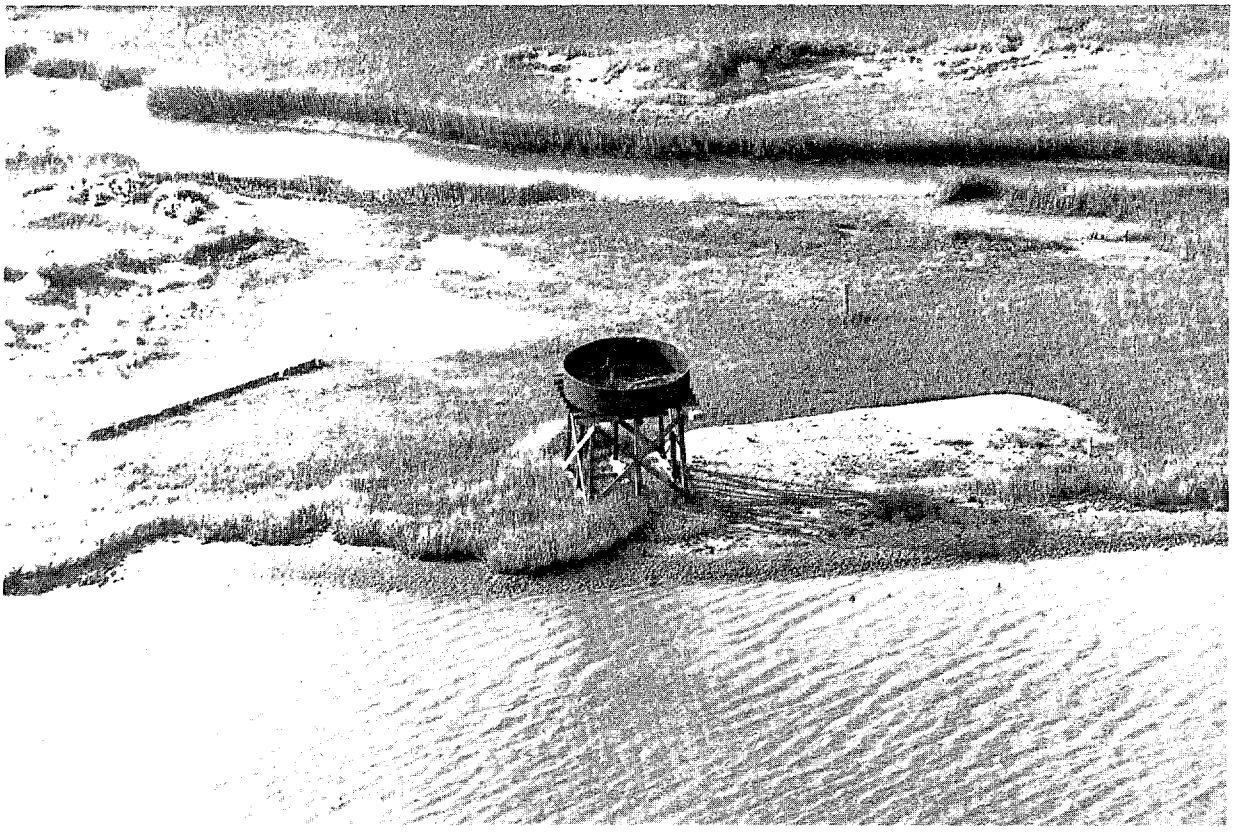
* Expert geological analysis will appear elsewhere in the Virginia Coast Reserve Study. This section merely outlines some of the historical evidence of physical changes in the barrier islands.

1/ Accomack News. Saturday, September 19, 1903. On file at the Virginia Historical Society, Richmond, Virginia.

2/ Pyle, Howard. 1878-1879. A Peninsular Canaan, Harpers Mag. N.Y. Vol. 28, p. 810.



The water tower is all that presently remains of the Accomack Club on Club House Marsh, inland from the north end of Parramore Island. The Club saw its last full year in 1929. In 1936 a storm demolished what remained of the damaged structure left by the 1933 hurricane. Photo courtesy of John Clark 1975.

In a slow but relentless process, the Atlantic gradually erases all evidence of man's assault on the islands. These abandoned vehicles on Cedar Island are a temporary testimonial to man's failure to tame this barrier island system. Photo credit Curtis Badger.

of Broadwater have become a graveyard too. Sand dunes march implacably over what was once a carpet of pine needles..."[1] The storm sparked the human exodus which was finally complete in 1941. As late as 1939, however, hope was being held out for the continuation of the Hog Island community.

> There's no immediate danger for the inhabitants. The homes and stores are on the western side of the island, and, as you know, the Atlantic washes the east side.[2]

Today the location of the village is under water. The site of the famous Broadwater club is gone too. During the 1950's low tides revealed the headstones of the village's graveyard. A gruesome reminder of the cemetery's existence occurred in 1956 when the petrified torso of a man, buried 25 years earlier, was washed from his grave.[3]

> Like the pine forest, the little church around which the graves clustered, stood almost two miles from the beach within living memory. Near it were the half-a-hundred homes, sportsman's club, hotel and other buildings comprising the only village in America to flourish for a century and then be engulfed by the sea.[4]

The accelerated rate of erosion after the '33 storm was obvious to the native Hog Islander, but measurements made by the Coast Guard during the 1940's confirmed these observations. The distance from the lighthouse to the ocean was measured each month from 1943-1947 and it was found that 2,700 feet were lost during that time.[5] 'Local thinking' attributes some of this increased erosion to the decline of the eel grass. Natives claim that the eel grass used to wash up on the beaches and serve to trap and hold sand.

Fifteen years ago an attempt was made to build up the beaches with dune fencing. At that time the south end of Hog Island was split by a small channel which has since filled in. Because the erosion of beaches seems to occur cyclically, the possibility of such stabilizing efforts bringing about the change is slim.

The other barrier islands experienced similar periods of erosion, but because they were not so heavily populated, documentation is not as complete. Indirect evidence of the changes in Metomkin Island was given by a turn of the century vacationer on the island. Each summer for several years more and more sand had to be removed from the small hotel as the beach washed westward.[6] Similar reports suggest that Cedar Island has shifted its location several times since 1900.

1/ Wharton, James. 1954. The Sea Islands of the Eastern Shore. Commonwealth 21 (Sept.) p. 15.

2/ Peninsula Enterprise. March 31, 1939. Mears Scrapbook. Vol. 7, p. 2. Eastern Shore Public Library.

3/ Baltimore Sun. November 25, 1956.

4/ The Sunday Sun Magazine. Baltimore, Md. October 28, 1956.

5/ Matthews, Greer. Taped Conversation. Tape #6. September 8, 1975.

6/ Nock, Sara. Personal Conversation. October 9, 1975. Family owned the hotel in the first decade of the 20th century.

Natives remember relatively little about changes in Parramore Island. One immediately assumes that height and vegetational cover have served to protect it, but one must also remember that Hog Island was once similarly endowed. Fear of erosion prompted the planting of dune grass after the '62 storm. The beach, which served as a landing strip for the owners in the 1930's, is today studded with tree stumps.

Pig Island, which is no longer visible, was a small (approximately 500 acres) island located to the south of Hog Island. Similarly, Prouts Island located in this same vicinity, has joined to the north end of Cobb Island. Whitelaw has the following to say about Prouts Island:*

> Patent(1687) to John Floyd for 400 acres called Prout's Island. In the years following, sales for parts of the island were noted, but no effort was made to trace each component part. 1815 Patent to H.W. Cobb for 210 acres of Prouts Island. As time went on, storms cut a channel through the upper part of the island and the north part thus cut off became Prout's Island, while the remainder was called Cobb's Island. The former is now entirely gone.1/

During the early years of the 20th century, Cobb and Prouts Islands were still separated by an inlet which gradually accreted before 1920.

Cobb Island has changed in size and shape many times throughout the 19th and 20th centuries. A building up of the island occurred in the mid 1800's. "In 20 years, Cobb Island grew from the size of a corner lot in suburbia to an island of 260 acres".2/ It declined again in size during the stormy period of the 1880's and 1890's. "Why is it that the sea has never washed Cobb's Island destructively, until within the past 6 years?"3/ This question asked in 1897 may well have been asked by the Hog Islander in 1937.

Attempts were made in the mid-20th century to stablize the constantly changing north end of Cobb Island. A 3/4 mile board fence was constructed because the sand was washing over valuable oyster grounds. Reportedly sand then built up to the top of this fence. Within the last five or six years, another attempt was made, but this time with snow fencing.4/ Whether this project or a smaller effort on Hog Island made any appreciable change in island structure is unknown. Local people feel that a long shelving beach is the only assurance of a relatively stable island.

Mockhorn Island, although not a barrier, has also been subject to change by the forces of the sea. According to one old-timer, Mockhorn and Skidmore Island were connected to the mainland one hundred years ago.5/ They became islands only when channels

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* Some controversy exists here as to the purchasing and naming of Cobb's Island, see Part I section 3.

1/ Whitelaw, Ralph T. 1951. Virginia's Eastern Shore. Vol. I & II. Virginia Historical Society. Richmond, Va. p. 214.

2/ Culley, Jennings. 1968. The Islands. The Commonwealth. April. p. 41.

3/ Sturgis, Rev. J.R. Peninsula Enterprise. November 13, 1897.

4/ Bowen, Harvey. Taped Conversation. Tape #6. September 17, 1975.

5/ Martin, G. Taped Conversation. Tape #6. September 3, 1975.

separated them from the main portion of the Peninsula. During both the Cushman and Jones ownership of Mockhorn, walls were built around the island at tremendous cost. The walls were built to hold back the sea.

The barrier islands in this southern sector also have been altered over the years. An island known as Bone Island has, within the last fifty years, partially washed and partially fused with Wreck Island.

> Towards the end of the last century when its neighbor Cobb's Island was a popular summer resort, lots were sold here by the Bone Island Development Association, but erosion since had been severe and there is not much left today.[1/]

Not only have islands fused but they have been divided as well. Old-timers claim that from Wreck Island to Smith Island was once a continuous island. New inlet, Ship Shoal, and Little Inlet are thus approximately one hundred years old. Similarly in the 1930's Bungalow Inlet and Redhouse Inlet were cut through Smith Island but have since filled in.

The only serious attempt below Wallops Island to stabilize beaches with jetties occurred on Smith Island. The second Cape Charles Lighthouse was finished in 1864 and by 1885, Congress appropriated $10,000 for a jetty. Unfortunately, before the rock structure was complete, large portions were destroyed in a storm. In the interim, it was decided to build a new lighthouse. Four jetties were, however, completed by 1891.[2/]

Tradition holds that Fisherman's Island, sometimes called Linen Island, was formed from a shipwreck nucleus. Natives, who have watched the transformation of many of the barrier islands, can recall driving horses and carts over to this southernmost island.

The Virginia Barrier Islands are not on firm bedrock foundation as are the well-known islands of New England. They had, however, built up to a height in the early 20th century which could support fertile soil and consequently productive gardens and orchards. Yet, shifting ocean currents continue to move islands elsewhere.

> Miles away, you see the white breakers on the distant shoals. Those shoals are on the old foundation of the island. There it uplifted its forest of cedar and pine. And, as we do now, so then, its aborigines fished its waters and trod its shelving shores.[3/]

Sands may be eroded in one area and accreted in another along this portion of the Atlantic coast, but most old-timers will argue otherwise. For the most part, they are convinced that the 'ocean will be beatin' on the mainland' someday.

> Yes, the sea is eating through Hog Island, as it will eventually eat through other islands that protect the mainland of the Eastern Shore

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1/ Whitelaw, Ralph T. 1951. p. 213.

2/ Snow, Edward Rowe. 1955. Famous Lighthouses of America. Dodd, Mead & Co. N.Y. p. 156.

3/ Sturgis, Rev. J.K. Peninsula Enterprise. November 13, 1897. Mears Scrapbook vol. 4 p. 53. Eastern Shore Public Library.

and when that barrier is gone the surf will reach out for its first taste of the peninsula and gradually may eat its way until it joins in wedlock with the Chesapeake Bay...but don't start worrying, for it will probably take a million years.[1/]

Whether the islands will be gone within a time-frame to cause us concern is open to conjecture. Nonetheless, man has learned through hard experience the folly of putting any hope in their permanence. And, as pointed out by Leonard in 1972, "history should give pause to anyone who is minded to build on Virginia's lovely but fickle offshore islands."[2/]

1/ Peninsula Enterprise, March 31, 1939. Mears Scrapbook. Vol. 7, p. 2. Eastern Shore Public Library.

2/ Leonard, Jonathan Norton. 1972. Atlantic Beaches. Time-Life Books. N.Y. p. 115.

FIRES

Fires are frequently a human-related phenomenon which have the potential to change the biological character of an area in a brief period of time. The barrier islands have burned periodically during the present century and undoubtedly in other centuries as well. The following section has been compiled totally from the recollections of natives, hence all references are to fires since 1900. There was no mention of fire in any of the literature searched in connection with the islands.

Parramore Island fauna and flora were effected by two fires in the 1920's. In both cases, it is believed that the fires started through carelessness rather than from a natural source. The first and most severe began on the south end and burned up to the east-west road now leading to the Schmidlapp house. The caretakers of the island were forced to elicit help from the mainland to fight the two day fire which was finally contained by the road. Although the fire could be seen at night from Wachapreague, damage to the large trees was apparently minimal. Its primary effect was to destroy underbrush.

The second fire within ten years on Parramore began at the north end road and stopped short of the clubhouse. This fire was brought under control by a few men when it reached areas with little burnable vegetation. Since 1936 there have been no fires of any significance on Parramore Island.

During the time of the flourishing Hog Island community, there were no major fires. There was, however, an occasional grass fire. A suggestion was made that these may have been started to improve grazing conditions for livestock. Similarly, mention was made in the section on livestock, p. 69, that the lack of underbrush, attributed to animal browsing, was a factor in the low incidence of forest fires on the island. A couple of houses in the community burned, one of which was the result of a "chimley" fire. The rain-barrels kept at each house served as good sources of fire-fighting water.

West of Hog's south end, Rogue Island has been very much changed as a result of fire. According to local sources, the island was once heavily wooded with cedar and pine. A fire, accidentally started by a group from the Coast and Geodetic Survey, is said to be responsible for bringing the island to its present vegetational condition.

The most common answer to questions about fires on Cobb is that the island burns almost annually. Grass fires seem to be frequent and occasionally a small house was burned. The last extensive fire on Cobb, however, occurred approximately fifteen years ago. At that time, blame was placed on the back-firing of a truck in heavy grass. The fire reportedly was visible from the mainland.

Wreck Island too has not been excluded from the influence of fire. During the days when boat travel to the waters around Wreck was slow, watermen often stayed for days in make-shift homes on the island. During the summer, island grasses were burned in an attempt to rid the area of mosquitoes and thus make life there more bearable.

A fire on Smith in the mid-1960's burned a small house. Prior to that, the only fire mentioned on this southern island occurred 40-50 years ago. At that time, one fire burned from one end to the other and destroyed most of the large timber in the process.

The general feeling among the local people is that fires on the barrier islands have been insignificant. The fact remains, however, that any disturbance to plant and animal life of this nature perturbs the ecosystem in accordance with the magnitude of the disturbance. Certainly the burning of timber has a far-reaching effect on community structure, while perhaps the destruction of grasslands may only be felt for a year. Again, human activity has been responsible for directing the course of ecosystem development.

Climate and Soils

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THE CLIMATE AND WEATHER OF THE VIRGINIA COAST RESERVE

The barrier islands are part of the Delmarva Peninsula, a region which has a humid mesothermal climate. The area lies in the zone of prevailing westerlies where most pressure systems track from east to west. Extensive periods of bitter cold or tropical heat are infrequent. Winters are rather mild; however weather systems are usually more intense then. During this season, rapidly moving storm fronts and outbreaks of cold polar air occur. Summers are long and warm, characterized by stable high pressure cells dominating the area. Summer low pressure systems occur infrequently and are weak.

The barrier islands' Atlantic exposure and low profile frequently subject the Virginia Coast Reserve to storms. Winds are usually strongest from June through November. It is during this period that hurricanes may occur. At least ten have affected the islands between 1901 and 1955. Hurricanes originate from June to September over the Atlantic in the vicinity of the Bahama, Windward, or Leeward Islands. They move inland across the southern states or northward, paralleling the coast toward the Delmarva Peninsula. Storms' centers usually pass off shore, affecting the area by excessive percipitation, high tides, and rough seas. Later during the season, the western Caribbean spawns more hurricanes. Most of these pass over large land areas before reaching this region and have lost their intensity.

Summer hurricanes are complimented during the fall and winter by northeast storms. These occur as low pressure systems moving up the coast. They generate storms caused by their counterclockwise cycling of moisture ladened air. Northeasters are typified by heavy rain, strong northeast winds, high tides, and rough seas. These conditions may last for two to five days.

Reliable weather data for the barrier islands themselves is scarce. Mainland stations along the adjacent peninsula provide good estimates of island conditions.

Temperature and precipitation information is summarized in Table 1. Rainfall is uniformly distributed with a light peak during the summer months, reflecting the influence of the subtropical climate. Snow is not uncommon on the islands; however, accumulations do not occur. Visibility from Assateague Island has been reported limited to less than five miles for 20-40% of the time. Similar conditions prevail over the rest of the Virginia Barrier Islands. Most clear weather occurs on the islands during the summer. Table 2 provides additional climatic information for the Delmarva Peninsula.

References

Department of the Army, Corps of Engineers, 1976. Draft Environmental Impact Statement (Delmarva Waterway). Philadelphia, Pennsylvania.

Natural Resources Institute, Univ. of Md. 1970. Assateague Ecological Studies Part I. Environmental Information. Contribution No. 446.

Smith Island Development Corporation, 1968. King's Beach Report. Draft Copy. Typewritten manuscript owned by The Nature Conservancy, Arlington, Virginia.

TABLE 1

Precipitation Normals and Temperature Means for Mainland Sites Near the Virginia Coast Reserve[1/]

LOCATION	Period of Record	Annual	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEPT	OCT	NOV	DEC
Precipitation Normals (in.)														
Cheriton, Va.	1941-70	40.78	3.0	3.35	3.72	2.71	3.02	3.34	4.30	4.29	3.81	2.94	3.06	3.21
Painter, Va.	1941-70	42.25	3.30	3.27	4.01	2.94	3.24	3.60	4.47	4.24	3.48	3.39	3.07	3.24
Temperatures Means (°F)														
Cheriton, Va.	1941-70	59.5	40.4	41.2	47.9	57.5	66.7	74.6	78.6	77.4	72.3	62.8	5].3	42.5
Painter, Va.	1941-70	57.9	38.9	40.1	46.5	56.2	65.3	73.2	77.3	75.8	70.2	60.4	50.5	40.7

[1/]Department of the Army, Corps of Engineers, 1976. Draft Environmental Impact Statement (Delmarva Waterway), Philadelphia, Pa.

TABLE 2

General Climatic Data for the Delmarva Peninsula[1/]

Normal Daily Maximum Temperature:	January	45°-50°F
	July	85°F
Normal Daily Minimum Temperature:	January	30°-40°F
	July	65°-70°F
Mean Annual Number of Days Minimum Temperature:		
32°F and below		30-60 days
90°F and above		5-20 days
Mean Daily Temperature Range:	January	15°F
	July	15°-20°F
Mean Annual Temperature Range:		30°-40°F
Mean Date of last 32°F temperature, in Spring		April 1-15
of first in Fall		Nov. 15-Dec. 1
Mean length of freeze-free period		210-240 days
Mean annual total precipitation		32-48 inches
Mean annual number of days with 0.01 inches or more rain		120-140 days
Mean annual total snowfall		6-12 inches
Mean annual number of days with 1.0 inches or more snow		1-5 days
Mean annual number of days with ice pellets		4-8 days
Mean annual number of days with freezing rain		1-2 days
Mean annual number of days with thunderstorms		20-40 days
Mean annual number of days with hail		under 1 day
Mean annual number of days with heavy fog (1/4 mi visibility or less)		20-30 days

[1/] Department of the Army, Corps of Engineers, 1976. Draft Environmental Impact Statement (Delmarva Waterway), Philadelphia, Pennsylvania.

THE SOILS OF THE VIRGINIA COAST RESERVE

I. GENERAL

Soils information had been previously gathered for the islands of the Virginia Coast Reserve in 1917. At that time, the United States Department of Agriculture's Bureau of Soils catalogued the soils of the islands into four groups: dune sand, coastal beach, tidal marsh, and Norfolk fine sand.1/ Soils classifications have been refined considerably since then.

Observations of similar coastal areas of Virginia indicated that soils likely to be observed would be in the Newhan, Corolla, and Duckston series on the islands, and mineral soils high in sulfur content in the tidal marsh areas. The soils found in these regions are part of a definable soil series. The series is the category of soil classification most often used in a soil survey. The Newhan, Corolla, and Duckston series constitute readily definable bodies or segments of soil that can be mapped and classified.

Tables 1 and 2 indicate a provisional taxonomic key for the identification and classification of the soils. Soil phases are used in soil surveys to show differences within a soil series that influence use and management. For example, Newhan fine sand, 2 to 10 percent slopes is one phase of the Newhan series.

In some survey areas, categories of classification other than the series are used. For example, sulfaquents are a higher category of classification than the series. Although various sulfaquents can be defined to a series level, it was not desirable or necessary to differentiate series of sulfaquents in this survey.

The purpose of initiating the soil survey was to further develop the baseline of scientific data available for the Virginia Coast Reserve. The soil survey was conducted from April 28, 1975 to May 9, 1975 by soil scientists of the United States Department of Agriculture's Soil Conservation Service. Soils phases were mapped on field sheets. This information was later transferred to an overlay format. Soil scientists observed and recorded the morphological features of each soil. They observed plant growth of both native and cultivated plants; the moisture regime of the soils, slope of the soils and other soil characteristics including pH and soil texture. The observations and knowledge of soil properties, together with available research data were used to predict limitations or suitability of soils for present and potential uses.

II. DESCRIPTIONS OF SOILS AND USE INTERPRETATIONS

IDENTIFICATION LEGEND OF THE SOILS AND SYMBOLS USED ON FIELD SHEETS

Map Symbol	Soil Name
33	Beaches
3B	Corolla Fine Sand, 0 to 6 percent slopes
3BO	Corolla Fine Sand Overwash phase, 0 to 6 percent slopes

1/ Stevens, E. H. 1920. Soil Survey of Accomack and Northampton Counties, Virginia U.S. Government Printing Office, Washington, D. C.

FIGURE I

HYPOTHETICAL ISLAND CROSS SECTION ILLUSTRATING THE RELATIONSHIPS OF SOILS, TOPOGRAPHY AND MAPPING UNITS

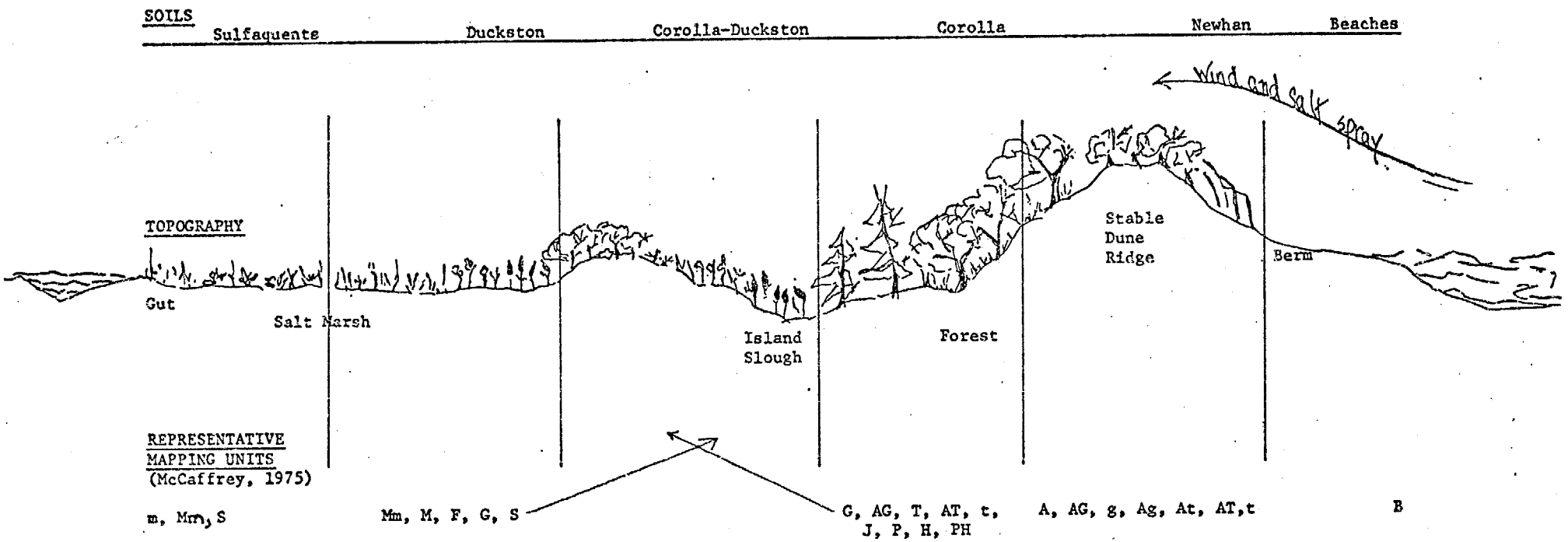

TABLE 1

TAXONOMIC KEY FOR SOILS ON THE VIRGINIA COAST RESERVE

Order	ENTISOLS			
Suborder	AQUENTS		PSAMMENTS	
Great Group	Psammaquent	Sulfaquents	Udipsamments	
Subgroup	Typic	Typic	Typic	Aquic
Family	Mixed,thermic	Mixed,thermic	Mixed, thermic	Mixed, thermic
Series	Duckston	Undifferentiated	Newhan	Corolla

MISCELLANEOUS LAND TYPES

Beaches

TABLE 2

CLASSIFICATION OF SOILS ON THE VIRGINIA COAST RESERVE

Series	Current Classification
Corolla	mixed, thermic Aquic Udipsamments
Duckston	mixed, thermic Typic Psammaquents
Newhan	mixed, thermic Typic Udipsamments
Sulfaquents	mixed, thermic Typic Sulfaquents

Map Symbol	Soil Name
3B-4	Corolla-Duckston Complex, 0 to 6 percent slopes
4	Duckston Fine Sand, 0 to 2 percent slopes
4-3B	Duckston-Corolla Complex, 0 to 6 percent slopes
93B	Newhan Fine Sand, 2 to 10 percent slopes
93D	Newhan Fine Sand, 10 to 35 percent slopes
93B-3	Newhan-Corolla Complex, 0 to 10 percent slopes
44	Sulfaquents, 0 to 2 percent slopes
	Special Symbols
I	Intermittent Water

The barrier islands surveyed constitute a unique, highly dynamic, extremely fragile ecosystem. These aspects of this area are noted in the descriptions of the soils and mapping units. Associations of soils, topography, vegetation mapping units and other characteristics are shown in Figure 1 and Table 3.

A. BEACHES (33)

The beaches mapping unit occurs on the ocean side of the islands and adjacent to inlets. Beaches consist of long narrow sandy strips between mean low lying sandy areas which are inundated daily by tidal action. They include a slightly higher "berm" which is less affected by normal tidal action. Sand sediment size of the beaches varies as does the wide range of shell fragment size and content. The beaches are highly transitory, being affected by tidal action. In some areas, this mobility is obvious. Characteristics for beaches and other soil types are presented in Table 4.

Tidal flooding of the beaches is a severe limitation to all uses other than beach-related recreation activities.

B. COROLLA SERIES

The soils in the Corolla series are nearly always level or gently sloping. They are poorly or moderately well drained with a seasonally high water table.

Typically, the surface layer of a Corolla soil is dark grayish-brown fine sand about 5 inches thick. The next layer is grayish brown, loose, fine sand about 27 inches thick. Below this layer are several feet of dark grayish brown loose fine sand. Free water commonly occurs in the Corolla soils at depths of 20 to 40 inches. Locally, Corolla soils are recognized in areas where beach or dune sands have migrated over the wetter Duckston soils. In these areas, buried dark gray surface layers occur at depths

TABLE 3

CHARACTERISTICS OF THE SOILS OF THE VIRGINIA COAST RESERVE

Soil Type	Map Symbol	Permeability in/hr	Available Water Capacity (in/in)	pH	Corrosivity Steel	Corrosivity Concrete	Suseptibility to Wind Erosion	Flooding	Water Table
Beaches	33	---	---	--	high	low	moderate	tidal flooding	variable
Corolla fine sand over-wash phase (0-6% slope)	3B0	20.0	0.04-0.06	5.6-7.8	high	low	severe (inadequate vegetation) moderate (adequate vegetation)	frequent brief duration	2-4 ft. moderately well-poorly drained
Duckston fine sand (0-2% slope)	4	20.0	0.04-0.06	5.6-7.8	high	low	slight	frequent long duration	0-1.0 ft.-poorly drained
Newhan Fine sand	93B	20.0	0.04-0.06	5.6-7.3	high	low	severe (inadequate vegetation) moderate (adequate vegetation)	none (except during high intensity)	6 feet excessively drained
Newhan fine sand (10-35% slope)	93D	20.0	0.04-0.06	5.6-7.3	high	low	severe (inadequate vegetation) moderate (adequate vegetation)	none	6 feet excessively drained
Sulfaquents	44	---	---	6.6-8.4	high	high	none	frequent, continuously saturated with salt water	very poorly drained

TABLE 4

USE RESTRICTIONS FOR SOILS OF THE VIRGINIA COAST RESERVE

Soil Type	Map Symbol	Sanitary Facilities: Septic tank Absorption Flds.	Sanitary Facilities: Sanitary Landfill (trench)	Community Development: Dwellings w/o basement	Community Development: Small Comm. Buildings	Community Development: Local Rds. & Streets
Beaches	33	severe floods	severe floods, seepage, wetness	severe floods	severe floods	severe floods
Corolla fine sand, over-wash phase (0-6% slope)	3BO	severe floods, wetness	severe floods, seepage, wetness	severe floods, wetness	severe floods, wetness	severe floods, wetness
Duckston fine sand (0-2% slope)	4	severe floods, wetness	severe floods, seepage, wetness	severe floods, wetness	severe floods, wetness	severe floods, wetness
Newhan fine sand (2-10% slope)	93B	slight (pollution is a hazard to ground water)	severe, seepage	0-8% slight, 8-10% moderate slope	0-4% slight, 4-8% moderate slope	0-8% slight, 8-10% moderate slope
Newhan fine sand (10-35% slope)	93D	severe slope, (pollution to ground water is a hazard)	severe slope, seepage	severe slope	severe slope	severe slope
Sulfaquents	44	severe floods, wetness	severe floods, wetness, seepage	severe floods, wetness	severe floods, wetness	severe floods, wetness

TABLE 4 CONTINUED

USE RESTRICTIONS FOR SOILS OF THE VIRGINIA COAST RESERVE

Soil Type	Map Symbol	Source Material Roadfill	Sand	Gravel	Topsoil	Excavated Ponds
Beaches	33	good	fair	unsuited	poor texture, excess salt	severe floods
Corolla fine sand, overwash phase (0-6% slope)	3BO	fair, wetness	fair, excess fines	unsuited	poor, too sandy, shells	severe salty water
Duckston fine sand, (0-2% slope)	4	fair, wetness	fair excess fines	unsuited	poor, too sandy, wet-ness	slight, salty water in places
Newhan fine sand (2-10% slope)	93B	good	fair, excess fines	unsuited	poor, too sandy	severe, deep water
Newhan fine sand (10-35% slope)	93D	fair, slope	fair, excess fines	unsuited	poor, too sandy	severe, deep water
Sulfaquents	44	poor, wetness	variable un-suited		poor, wetness, too sandy	slight

TABLE 4 CONTINUED

USE RESTRICTIONS FOR SOILS OF THE VIRGINIA COAST RESERVE

Soil Type	Map Symbol	Recreation			
		Camp Areas	Picnic Areas	Playgrounds	Paths & Trails
Beaches	33	severe floods, too sandy, soil blowing	severe floods, too sandy, soil blowing	severe floods, too sandy, soil blowing	floods, too sandy
Corolla fine sand, overwash phase (0-6% slope)	3BO	severe floods, too sandy, wetness	severe floods, too sandy, wetness	severe floods, too sandy, wetness	severe floods, too sandy, wetness
Duckston fine sand, (0-2% slope)	4	severe floods, wetness	severe floods, wetness	severe floods, wetness	severe floods, wetness
Newhan fine sand (2-10% slope)	93B	severe, too sandy	severe, too sandy	severe, too sandy	severe, too sandy
Newhan fine sand (10-35% slope)	93D	severe slope, too sandy	severe slope, too sandy	severe slope, too sandy	severe slope, too sandy
Sulfaquents	44	severe floods, wetness	severe floods, wetness	severe floods, wetness	severe floods, wetness

of 20 to 50 inches. In practically all areas of Corolla soils, there are dark colored minerals and fine shell fragments in varying proportions.

Corolla soils support a wide range of plant species. Woody and herbaceous species occur here. The relationship of plants, soils and island topography for all of the islands' soils are illustrated in figure 1 .

1. Corolla Fine Sand, 0 to 6 Percent Slopes (3B)

   This Corolla soil occupies a wide range of positions on various islands. It may occur behind the frontal dunes. Such areas are typically elongated in shape and range in size from 4 to 30 acres. In some locations, this soil occupies small insular positions surrounded by wetter soils. These small Corolla patches are typically elongated and range in size from 2 to 5 acres. It can be interpreted that these are eroded remnants of formerly higher, drier dunes.

   Included in this soil mapping unit are narrow strips or remnants of Newhan soils along the frontal dunes and small wetter inclusions of Duckston soils. These included soils comprise 15 to 25 percent of the unit.

   Surface infiltration of water and water movement through the soil is very rapid above the water table. Surface runoff is slow. The soil is mildly acidic to mildly alkaline throughout.

   This soil has severe limitations for most uses. Use restrictions for the soils of the Virginia Coast Reserve are illustrated in Table 3 . Disturbance of the surface vegetation creates a high potential for wind erosion as a result of the fine sand texture of the soil. Native plant species flourish here affording resistance to wind and water erosion. This wide range of plant adaptability also provides excellent wildlife habitat. Excessive traffic or disturbance of this soil will result in deterioration of the native grass species.

2. Corolla Fine Sand, 0 to 6 Percent Slopes, Overwash Phase (3BO)

   This nearly level to gently sloping soil consists essentially of beach material overwashing areas of Duckston soils. In some areas, it lies immediately adjacent to the beach, as on the southern ends of Shipshoal and Parramore Islands. In other areas, it occupies areas behind low frontal dunes where these have been breached. In some areas, the Corolla overwash extends from the beach to the tidal marshes.

   The soil is characterized by a pavement of shells and ocean borne debris. Areas of this soil are most prominent on Metomkin, Parramore, Hog, Cobb, Shipshoal, Myrtle, and Smith Islands.

   Included with this soil in mapping are narrow strips of Newhan soils along the beaches. These strips are 15 to 40 feet wide and in places are not continuous.

   Corolla, overwash soils uniformly have a water table at a depth of about 20 to 30 inches. Permeability is very rapid and available water

capacity is very low. Runoff is slow. Some plant species may periodically establish themselves between incidents of overwash. This soil has severe limitations for practically all uses as a result of periodic ocean overwash.

3. Corolla-Duckston Complex, 0 to 6 Percent Slopes (3B-4)

A soils complex mapping unit maps soils that are so intermingled that they cannot be feasibly separated at the scale used for mapping.

This soil complex consists of about 60 percent Corolla fine sand, 30 percent Duckston fine sand, and 10 percent of either Newhan soils or sulfaquents. The Corolla part of this complex is moderately well through poorly drained. The Duckston fine sand is poorly drained. The Duckston soils are more completely described below.

This Corolla-Duckston complex occurs on those islands having zones of well defined dunes. In some places, delineated areas consist of numerous low areas surrounded by the wetter Duckston soils. These areas are too small to delineate separately.

A very striking example of this complex occurs on the diagonal ridges of Smith Island. There, low Corolla ridges are interspersed with pockets of wetter Duckston soils.

The included drier Newhan soils occur on some of the higher areas of the Corolla part of this complex and small contained areas of dunes. These soils commonly are more sparsely vegetated than the Corolla or Duckston soils.

Both of the major soils in this complex are well suited to various kinds of vegetation. Both have an available dependable supply of moisture. The abundance of moisture supports woody vegetation such as marsh elder (Iva frutescens) and groundsel (Baccharis halmifolia). On some islands, the Corolla part of this complex supports loblolly pine (Pinus taeda), yaupon holly (Ilex vomitoria), sassafras (Sassafras albidum), and some American holly (Ilex opaca). The drier part of the Corolla soils also supports herbaceous species.

The prevailing winds pose an erosion hazard to slightly higher Corolla parts of this complex. Removal or destruction of the existing protective vegetation would result in the eventual disappearance of the Corolla areas. Wind erosion would cause them to flatten and merge with the adjacent wetter Duckston soils. Uses of this complex are limited by a high water table, sandy textures, and very rapid permeability.

C. DUCKSTON SERIES

The Duckston series consists of poorly drained sandy soils that are nearly level. These soils occur at low elevations in close proximity to the Atlantic Ocean.

Typically, the surface layer of a Duckston soil is gray fine sand about six inches deep. Subsurface layers to a depth of about 26 inches are

dark gray fine sand. Lower layers to a depth of 60 inches are commonly dark grayish through black fine sand. Dark colored sand sized minerals and shell fragments occur throughout the soil.

Duckston soils have a nearly permanent high water table. They occupy areas subject to seepage from higher lying adjacent sandy soils. Low areas of these soils are subject to tidal inundation, but not so frequently that they accumulate sulfides to any significant extent. Free water in the Duckston soils is only slightly brackish. Water movement through this soil is very rapid. Free water forms shallow lakes and ponds in many areas of Duckston soils. In some areas, these shallow ponds are persistent for long periods of time.

The Duckston soils support herbaceous plant species. Iva fautescens and Baccharis halimifolia commonly occur along the "edge" zone between Duckston and Corolla soils.

1. Duckston Fine Sand, 0 to 2 Percent Slopes (4)

   This nearly level poorly drained soil occupies areas between the frontal dunes and interior dunes on Parramore and Hog Islands. On most of the other islands, they are largely between the frontal dunes and the tidal marsh sulfaquent soils. The Duckston soils between the Corolla-Duckston ridges on Smith Island are unique in that these areas have an organic, mucky surface layer 4 to 14 inches thick. Areas of this soil are typically 3 to 50 acres in size.

   Included within this soil type are small areas of the Corolla soils and sulfaquents. These inclusions comprise about 10 to 20 percent of the mapping units. The Corolla inclusions occur as small islands that are slightly higher in elevation than surrounding soils. The sulfaquents occur at lower elevation along the high tide line. Also included are some areas that are low enough to be subject to some tidal inundation or seepage from higher lying areas. These areas accumulate sodium or chlorides. They appear to be salt flats. They are largely devoid of plant species except halophytes such as glasswort, (Salicornia virginica).

   As noted in the description of the Duckston series, this soil has a high water table for long periods of time. Surface runoff is slow. Water may be ponded. Duckston soil is intermediately acidic to mildly alkaline.

   This soil has severe limitations for practically all uses because of its high water table and susceptibility to tidal flooding. It provides most of the shallow ground water pond areas on the barrier islands.

2. Duckston-Corolla Complex, 0 to 6 Percent Slopes (4-3B)

   This complex consists of about 65 percent Duckston soils, 25 percent Corolla soils and 10 percent other soils. In most respects, this complex is very similar to Duckston fine sand, 0 to 6 percent slopes (4). It differs by having a higher proportion of Corolla inclusions that are drier than the surrounding Duckston areas.

The soils in this complex have slow runoff. They are mildly acidic through mildly alkaline. The major limitation to the use of the soils in this complex is due to a high water table and possible flooding during high tides.

D. NEWHAN SERIES

This series consists of excessively drained soils that are on either frontal or interior dunes. The soils vary in elevation as the dunes vary in size. The Newhan dunes are typically elongated areas situated roughly parallel to the Atlantic Ocean.

The surface layer of a typical Newhan soil is loose pale brown fine sand about 4 to 6 inches thick. Lower subhorizons are loose pale brown fine sand to a depth of six feet or more. Strata of dark colored minerals and fine shell fragments occur throughout the profile. Except on low elevations, there is no seasonal water table within a 60 inch depth in Newhan soils.

The Newhan soils constitute the highest parts of most of the barrier islands. Where they occupy the frontal dune, they are largely vegetated with herbaceous species. Interior dunes support more woody species.

The Newhan soils and associated dunes are generally widest and highest on the northern parts of the islands where they occur. They are low and narrow on the southern portions of the islands. The most extensive areas of Newhan soils observed occur on Parramore and Myrtle Islands. On islands such as Cobb and Hog, the Newhan soils are at low elevations and have been breached by tidal action. In some locations, the Newhan soils are on discontinuous low ridges parallel to the beaches.

1. Newhan Fine Sand, 2 to 10 Percent Slopes (93B)

This gently sloping to sloping soil occupies both frontal and interior dunes. Slopes are irregular, complex and less than 75 feet long. Areas of this soil are typically 20 to 75 acres in size. Included in mapping this soil are small areas of Corolla soils in low spots.

Permeability of this soil is very rapid and the available water capacity is very low. Surface runoff is slow. The soil is mostly intermediately acidic to neutral throughout.

In some areas, the Newhan soils on the frontal dunes are only slightly vegetated. On these areas, sand movement occurs during mildly windy periods. Small dune blowouts occur on exposed areas of this soil type.

This soil is droughty. It is highly vulnerable to wind erosion unless a dense vegetative cover is maintained. Traffic and recreational activities on this loose sandy soil will quickly cause deterioration of existing plant cover.

2. Newhan Fine Sand, 10 to 35 Percent Slopes (93D)

This moderately steep through steep, excessively drained soil is on the highest and steepest parts of the barrier island dunes, typically on the northern parts of those islands that have the

Newhan soils. The soils have irregular slopes that are less than 100 feet long. They occupy elongated areas parallel to the Atlantic coast line and are commonly 40 to 85 acres in size. This soil occupies both frontal and interior dunes on several islands, most notably Parramore Island. Included in mapping this soil are small wetter areas of Corolla fine sand and Duckston soils which comprise less than 10 percent of the area.

This loose sandy soil is highly subject to wind erosion unless it is well vegetated. Sand movement by wind is visible on areas that have sparse vegetation. Blowout areas 20 to 60 feet in diameter are evident in a few places. This soil has severe limitations for most uses because it is loose, has a very low available water capacity and is highly susceptible to wind erosion if disturbed.

3. Newhan-Corolla Complex, 2 to 10 Percent Slopes (93B-3)

This complex of excessively drained soils and moderately well drained soils occupies an interior position on Hog Island. The slopes on this landscape are highly irregular. The Corolla part of the complex occupies the lower areas. The complex consists of approximately 65 percent Newhan soils, 25 percent Corolla and small areas of Duckston soils in the lowest areas and along the fringes of the footslopes.

One depressed area of the Corolla soil type of this complex had been excavated to create a shallow pond. Such areas might similarly be utilized to creater other fresh water ponds.

This complex supports a wide range of plant species due to a wide range of moisture regimes that exist within the mapping unit. These soils have severe limitations for most uses because of their unconsolidated condition, and their susceptibility to wind erosion when disturbed.

E. SULFAQUENTS

The sulfaquents are an undifferentiated group of soils that have historically been referred to, and mapped, as "Tidal Marsh." Sulfaquent soils are mineral soils that have a high concentration of sulfides in the upper 20 inches as a result of daily inundation by tidal action. Different soil series within the sulfaquents can be recognized and mapped on the basis of soil texture. For the purposes of this survey, individual series were not recognized. The sulfaquents have similar kinds of vegetation; and in general, they have similar limitations to use.

For the most part, the sulfaquents occur on the western side of the barrier islands. There are extensive areas of sulfaquents along the entire chain. These soils constitute the largest single soil type in the Virginia Coast Reserve.

Sulfaquents are either basically sandy or silty to clayey. Dark areas of this soil that are noticeable on the aerial photograph field sheets were dominantly sandy. The lighter shaded areas are dominantly silty to clayey.

Typically, the sandy sulfaquents have a dark gray, fine sandy surface about 6 inches thick. This surface layer contains a mass of plant roots. Below the surface layer are 5 feet or more of gray fine sand. The silty to clayey sulfaquents have a dark gray silt loam surface layer with many plant roots. Below the surface layer is 5 feet or more of extremely viscous silt and clay and decomposing organic matter. Some of the areas which were more lightly shaded in the aerial photograph consisted of thin silty layers overlying sandy material. These areas result from recent depositions of silt over sandy sulfaquents.

The sulfaquents merge mostly with Duckston soils along the high tide fringe, although a clear demarcation line is not too apparent. Tidal drift mats offer a field clue to the separation of Duckston soils and sulfaquents, as do subtle changes in vegetation and the presence of a sulphidic odor in the sulfaquents. The sulfaquents normally have a neutral to moderately alkaline reaction while saturated. When they are exposed to drying, the soils become extremely acidic. When drained or dried out, they are poorly suited to plant production.

The sulfaquents, in their natural state, are important ecologically because of their potentially high primary productivity and the habitat they provide fish, shellfish, and diamondback terrapins (*Malaclemys terrapin*).

Any disturbance of the silty sulfaquents would have a much more detrimental effect than disturbance of the sandy sulfaquents. When disturbed, the silty sulfaquents tend to stay in suspension for long periods of time and would be subject to deposition by tidal action. This deposition could be hazardous to existing benthic communities.

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L E G E N D

SOIL MAP

Map Symbol	Soil Name
33	Beaches
3B	Corolla Fine Sand, 0 to 6 percent slopes
3BO	Corolla Fine Sand Overwash phase, 0 to 6 percent slopes
3B-4	Corolla-Duckston Complex, 0 to 6 percent slopes
4	Duckston Fine Sand, 0 to 2 percent slopes
4-3B	Duckston-Corolla Complex, 0 to 6 percent slopes
93B	Newhan Fine Sand, 2 to 10 percent slopes
93D	Newhan Fine Sand, 10 to 35 percent slopes
93B-3	Newhan-Corolla Complex, 0 to 10 percent slopes
44	Sulfaquents, 0 to 2 percent slopes
Special Symbols	
I	Intermittent Water

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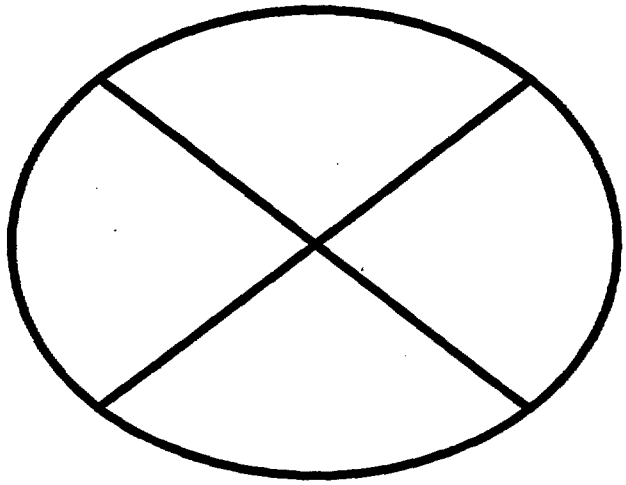

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Geology

THE COASTAL PROCESSES AND GEOLOGY

VIRGINIA BARRIER ISLANDS

By

Thomas E. Rice
Alan W. Niedoroda
Anthony P. Pratt

The Coastal Research Center
University of Massachusetts
Amherst, Massachusetts

(Metomkin Island to Fisherman's Island)

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Metomkin Island
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Ship Shoal, Godwin, Myrtle, Mink Islands
Smith Island

PREFACE

The following is the final report of a study conducted for The Nature Conservancy by the Coastal Research Center of the University of Massachusetts at Amherst. The study concerns the coastal processes and geology of the Virginia Barrier Island Group from Metomkin Island at the north to Fisherman's Island at the south. Wallops Island and Assawoman Island at the north end of the barrier island group were not included in this study. The study was carried out to provide an informational base that The Nature Conservancy could use in making management decisions concerning their holdings among these islands. The concerns of the study therefore include geographic parameters of the islands and the marsh and bay areas to the mainland, the history and analysis of documented changes in the shorelines of the islands, the coastal processes that have been at work on the islands and adjacent lagoons and tidal marshes, and the geologic history of the area as it can be interpreted from the geomorphology. The study began on July 22, 1975 and was completed on February 20, 1976.

This report has been deliberately written for the reader who has neither an extensive knowledge of coastal geology nor a familiarity with the literature. Technical language has been limited, and jargon has been eliminated. Sections on the general geology of the area and on coastal processes have been included to provide a basis for understanding the island descriptions, and for the purpose of defining terms, concepts, and processes. Persons familiar with coastal processes and the literature of the subject may wish to skim this introductory part of the report.

INTRODUCTION

During the summer and fall of 1975 a study was conducted on the geologic history and coastal processes of the Virginia Barrier Islands named Metomkin, Cedar, Parramore, Hog, Cobb, Wreck, Ship Shoal, Myrtle, Smith, and Fisherman's. Hereafter when the islands are referred to as a group, they shall be addressed as the Virginia Barrier Island Group. The first part of the following report discusses the general geology of the southern Delmarva area, the geologic processes which are known to act and shape all barrier islands, and the methods and procedures used during the course of this study.

The main body of the report consists of an island-by-island discussion of shoreline changes, coastal processes, geomorphology, and geologic history for each island. The final section of the report addresses overall characteristics and changes of the Virginia Barrier Island Group and provides management recommendations. An extensive bibliography is also included.

The intention of this report is to provide the reader with an in-depth appreciation of the physical processes and history of the individual islands so that rational decisions can be made concerning the future development or preservation of this island system.

The islands of the Virginia Barrier Island Group have been considered individually for the purposes of detailed study and description. The reader is advised not to allow this procedure to obscure the basic idea that the entire chain of islands operates as an interrelated system. Interrelationships between one island and other nearby islands are treated in the section dealing with that island. A section is provided toward the end of the report to discuss other aspects of this interrelationship. However, there are many areas of future study which should be conducted in order to more fully appreciate how the physical system acts in unison. Recommendations for such future study are made at the end of this report.

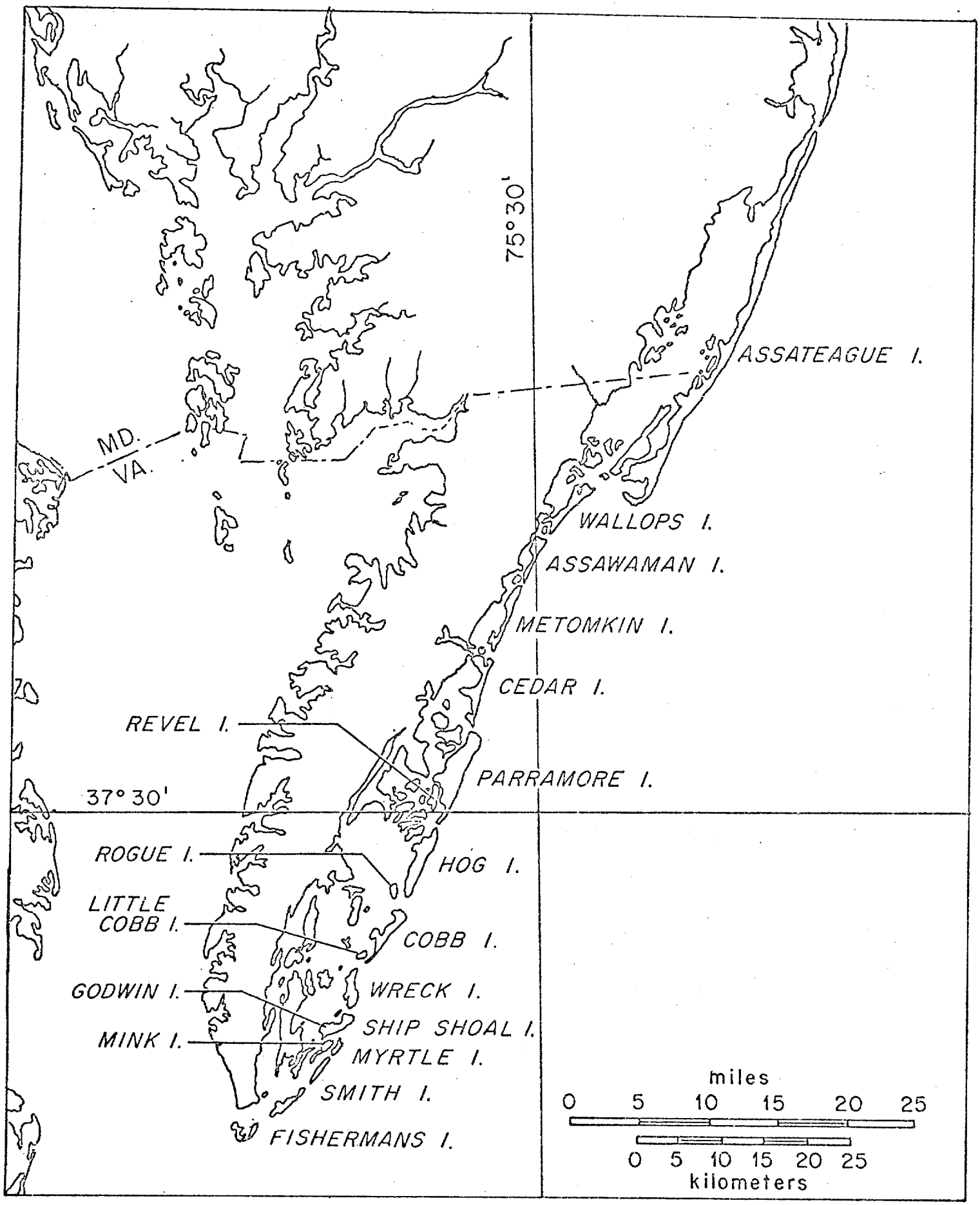


FIGURE 1. LOCATION MAP FOR THE VIRGINIA BARRIER ISLAND GROUP

GEOLOGY OF THE SOUTHERN DELMARVA PENINSULA

The overall geologic history of an area is usually determined through a careful analysis of the rock units which lie at the surface and below the surface in the area. However, the emphasis of this report is on very recent and modern geologic processes so that only a very brief treatment of the general geologic history is given in this report.

I. GENERAL GEOLOGY OF THE DELMARVA PENINSULA

The Southern Delmarva Peninsula and the adjacent Virginia Barrier Island Group are shown in Figure 1. In general this area is underlain by poorly consolidated to unconsolidated deposits ranging in age from very recent to more than 135 million years. The oldest rock material known in the area is encountered at depths varying from 7,500 ft. in northern portions of this region to 3,000 ft. in the southern part of the region. It is thought to be made up of crystalline metamorphic and igneous rocks. Overlying this crystalline basement complex there is a thick sequence of clays, sands, and minor gravel deposits which vary up to 1,500 ft. in thickness. These deposits are recognized as Cretaceous in age (63-135 million years ago). Above this unit there are formations of interbedded sands and clays of varying thickness. These deposits range up to 500 ft. in thickness and they are thought to be of Eocene Age (36-58 million years ago). A similar series of deposits including interbedded sands, clays, and marls of Miocene Age (13-25 million years ago) overlies the Eocene deposits. As with the other formations in this area the thicknesses of the Miocene deposits are quite variable. The apparent range of thicknesses is from 500 to 800 feet. Above the Miocene deposits there are deposits of clays, sands, and gravels of Pleistocene (approximately 2 million years to 15,000 years ago) and recent (Holocene) age. The distribution of the individual sand, clay, and gravel deposits is very discontinuous. These deposits often appear in the form of thin lenses which are continuous for only a few miles in any given directions. Overlying the entire section of sediment, which can be from 3,000 to 7,500 feet in thickness, there are sands, muds, and peats in the vicinity of the barrier islands which have resulted from present and recent marine processes. (See Figure 2 for geologic section.)

For a geologist, the sedimentary deposits overlying the crystalline basement record a fantastic story of great advances and retreats of the sea, changes in climate, and the evolution of life. However, this information is of little value for comprehending management schemes. The interested reader is directed to reports by Moody (1964) and Sinnot and Tibbits (1966) for much more detailed diagrams and descriptions of the subsurface geology in the general area of this study.

The important pieces of information from the limited data concerning the subsurface geology of this area are related to possible sediment sources which are presently incorporated in the barrier islands, lagoons, and marshes, and to the distribution of groundwater resources beneath these barrier islands. The general sequence of deposits beneath the Southern Delmarva Peninsula is thought to continue beneath the adjacent portions of the continental shelf.

If these sedimentary formations do extend eastward beneath the Virginia Barrier Islands, two possibilities exist: first, that offshore erosion of these formations may provide a source of sand for nourishment of the barrier islands, and second, that freshwater aquifers among these formations may extend eastward beneath the barrier islands. These possibilities will be considered later in this report.

II. CRYSTAL MOVEMENT IN THE SOUTHERN DELMARVA PENINSULA

A second major area of the geology of the Southern Delmarva Peninsula which is relevent to our study is an evaluation of the amount of crustal movement which may have occurred

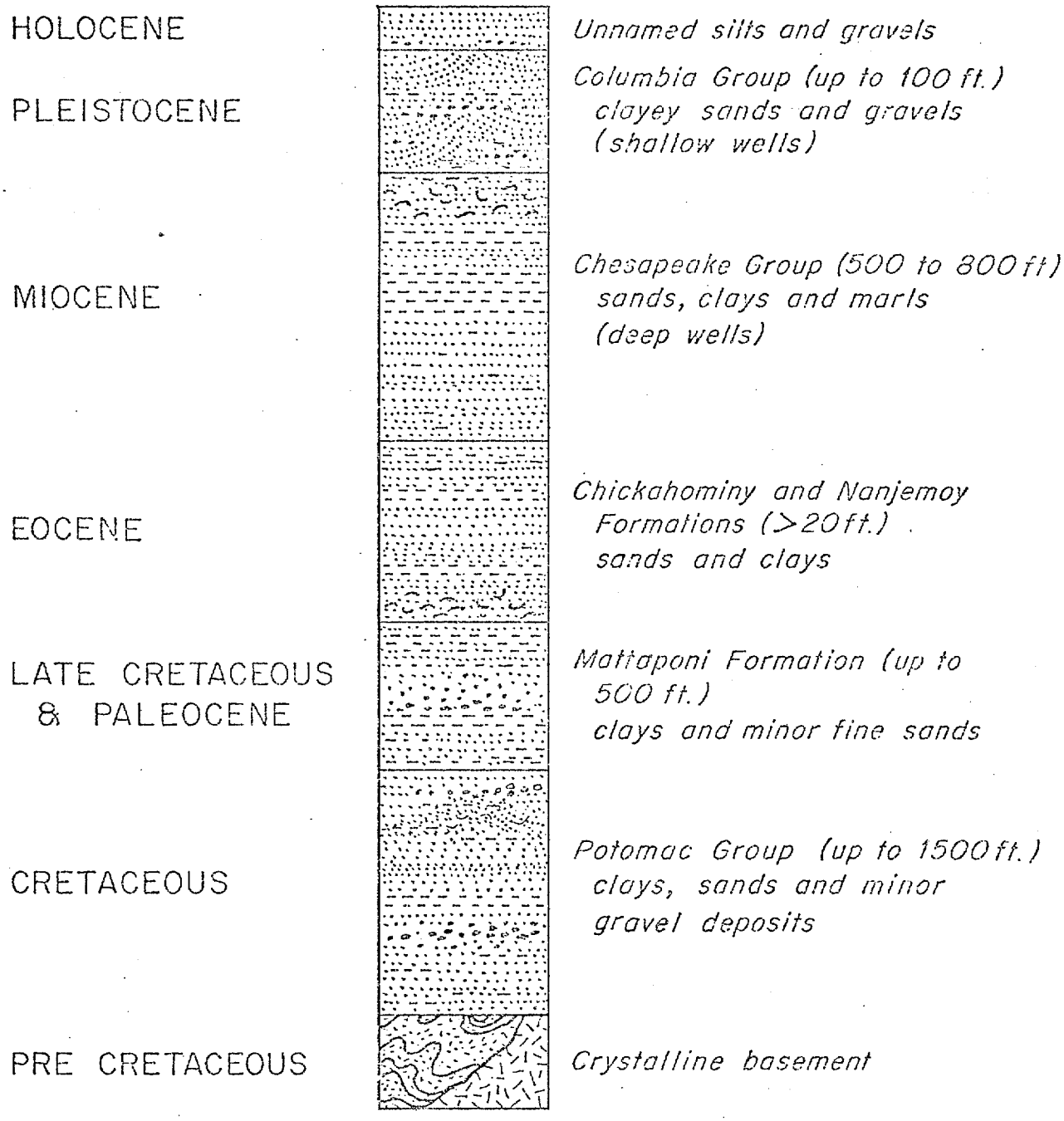


FIGURE 2.

GEOLOGIC COLUMN FOR THE EASTERN SHORE AREA, VIRGINIA

Modified from Sinnot and Tibbits, 1968

in this area during relatively recent times. Such crustal motions can either be rapid and associated with earthquakes or may be exceedingly slow, and, therefore, unnoticed. A fundamental point in considering geologic processes of any nature is the influence of very long periods of time and very slow processes. The relative rates of some very slow processes are very important in controlling the equilibrium, or lack of equilibrium of the barrier islands. In the case of crustal movements in the Southern Delmarva Peninsula, there are no indications of reported earthquakes. Maps and publications prepared by Brazee and Cloud (1956), Neumann (1958), Talley and Cloud (1960), and Hadley and Devine (1974) all indicate that the Delmarva Peninsula is located in one of the least earthquake prone areas in the United States. There are no indications of recorded earthquakes in this area since earthquake recording has been routinely carried out in this country. Therefore, if there are crustal deformations inthis area, they must be occurring without rupture of the crustal rocks. There is a general indication that crustal movements do occur along the eastern seaboard of the United States. Balaza (1975) indicates that the general region of the Delmarva Peninsula is uplifting at a rate of approximately 3.0 mm. per year relative to the areas located near Dover, Delaware, or south of Norfolk, Virginia. Actually, all of these areas appear to be undergoing slow submergence as a result of worldwide sea level rise. The area of the Delmarva Peninsula appears to be seeing a slower rate of submergence when compared to coastal areas far to the north and south. Harrison et al. (1965) has used evidence from buried and submerged channels in the Chesapeake Bay to obtain data which suggests an uplift of 175 feet which occurred sometime during the past 18,000 years. This magnitude of crustal uplift in the vicinity of the Delmarva Peninsula appears to have been greater than the rate of sea level rise during some portions of this period. As a result there may have been a period of slow emergence of the sea floor adjacent to the Delmarva Peninsula during the time 15,000 years to 6,000 years before present. Currently the information concerning these crustal movements in the Delmarva area is spotty and subject to dispute. We will show later in this report that there seems to be additional evidence to support Harrison's conclusions.

BACKGROUND ON BARRIER ISLAND PHYSICAL PROCESSES

Barrier islands are thin strips of sand deposits and inshore marsh which parallel the mainland coast at distances ranging from only a few tens of feet to several tens of miles. They are common features of the East Coast and Gulf Coast of the United States. Worldwide, they most commonly appear in areas where there is a wide continental shelf located immediately offshore. These islands are generally characterized by extremely low relief, and are frequently quite narrow. If regarded naively, they appear frail and easily subject to destruction by the sea. However, all lines of evidence indicate that the barrier islands are remarkably durable even in the face of extreme storms. This durability must be regarded in terms of the long-term and overall existence of the islands rather than the existence of the islands at any particular time or location, or for any finite short term period. That is, barrier islands tend to be extremely mobile and subject to migrations parallel and perpendicular to the coast.

I. ORIGIN OF BARRIER ISLANDS

The mode of origin of barrier islands has been debated by scientists for many years. At present there is no well substantiated theory to answer this question. However, several theories have been introduced and all are worthy of review. One of the first explanations for the origin of the barrier islands was given by de Beaumont (1945), and later given strong support in this country by Johnson (1919). Both of these individuals felt that barrier islands must have formed at a time when sea level was lower than its present elevation and the beach system was located further seaward than its present position. The theory, as modified by Johnson, involves the production of longshore sand bars far from the shore line on the gently sloping inner continental shelf. Johnson proposed that these sand bars could, on occasion, grow slightly above the mean sea level. Once

these islands became emergent, he proposed that wind transported sand would develop sand dunes upon the new islands thus giving them additional height and width. Johnson further indicated that this addition of windblown sand would allow the thin barrier island to migrate in a coastward direction in the presence of a slow rise of sea level. This model for barrier island development is shown schematically in Figure 3.

An alternate hypothesis for the development of barrier islands was first produced by Gilbert (1885) and more recently has been defended by Fisher (1962). In this model, barrier islands develop from the successive elongation of a coastal sand spit. They argue that the sand transport along beaches tends to be limited to the surf zone with little significant onshore or offshore exchange of sand. Thus, as the sand is moved along a narrow peninsula, such as a sand spit, it eventually encounters the end and is deposited, elongating the peninsula or sand spit. Eventually, the sand spit becomes so long that it can be torn open by wave attack during a severe storm. This then produces an inlet in the system and an isolated barrier island. Gilbert and Fisher envisioned these barrier islands and inlets as migrating in the general direction of longshore sand transport so that a new island is shed periodically from the original sand spit and all islands move like beads on a string. Fisher, recognizes that many other more complicated processes also act on these barrier islands during their development causing them to close old inlets and form new ones, as well as migrating landward in the presence of a sea level rise. However, the argument for the origin of these islands remains that they are shed from coastal sand spits. This model of the origin of barrier islands is shown schematically in Figure 4.

An additional hypothesis has been proposed by Hoyt (1967) and supported by Dolan et al. (1974) and Godfrey, (1974, 1975). This hypothesis holds that barrier islands originat from ordinary beach deposits during the lowest stand of sea level. The argument is that coastal dune ridges ordinarily develop behind beach systems. If such dune ridge systems existed during a time of lower sea level, then these systems would be subject to drowning as sea level began to rise. However, early rise of sea level would invade the land behind the coastal dune ridge (by seeping through the ridges or flowing across low points) and thus produce a lagoon between beach deposits and the coast. This theory argues that once the coastal dune ridge system has been partially inundated by the sea, it would begin to function as a barrier island. The processes of temporary inlet formation, and of sand from the beach washing over the islands during a storm would allow the island to migrate landward. Thus, the method of originating the barrier island in this theory is somewhat different from the other theories, but all agree that processes for the maintenance of the islands during sea level rise and landward migrations must exist in order to preserve these islands in their unique configuration. The development of barrier islands according to this theory is shown schematically in Figure 5.

The theories listed above stress that their particular scheme for the origin of barrier islands is most likely, but that alternate modes of origin may occur in restricted cases. Thus, some of these theories are exclusive of the others. This point is most emphasized by Otvos (1970). In his studies of Gulf Coast barrier islands, he has been convinced that these islands are capable of originating from any of the processes described above. Furthermore, he shows that the principal rate and direction of movement of Gulf Coast barrier islands is often landward, but in many cases may be longshore or seaward. Coring on several of these Gulf Coast islands has demonstrated that the sequence of deposits is somewhat unpredictable, owing to the fact that the direction of island migration determines the sequence of geologic strata encountered at shallow depths beneath the island.

Sediment sequences associated with different barrier island migration directions are shown in Figure 6. The sediment sequence of the compound barrier island could be formed by oscillatory onshore, offshore movement, of the barrier island, or by longshore migration of the island. Schwartz (1971) has expressed similar beliefs about the migration

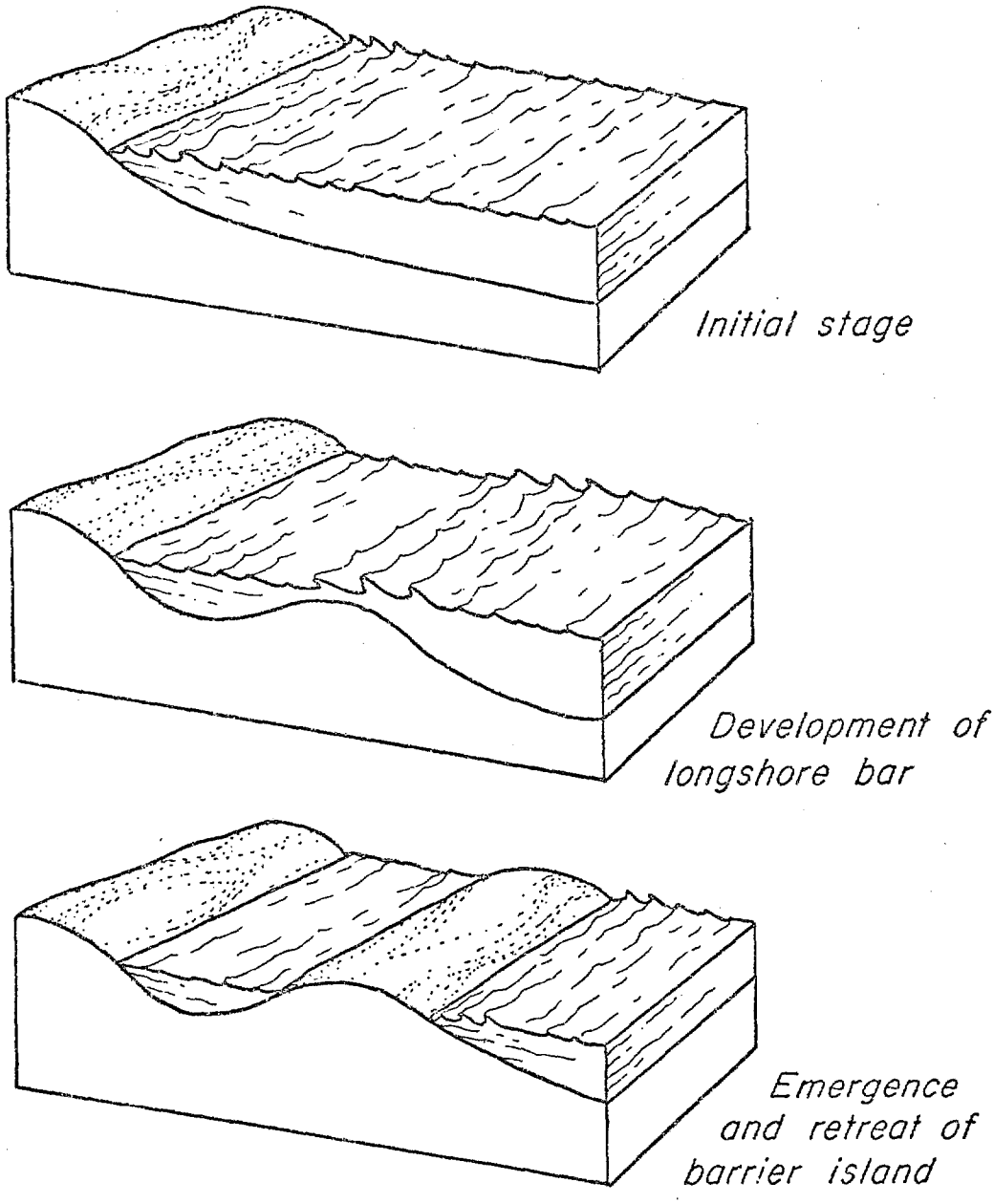


FIGURE 3. DeBEAUMONT-JOHNSON MODEL FOR BARRIER ISLAND FORMATION

deBeaumont (1845), supported by Johnson (1919)

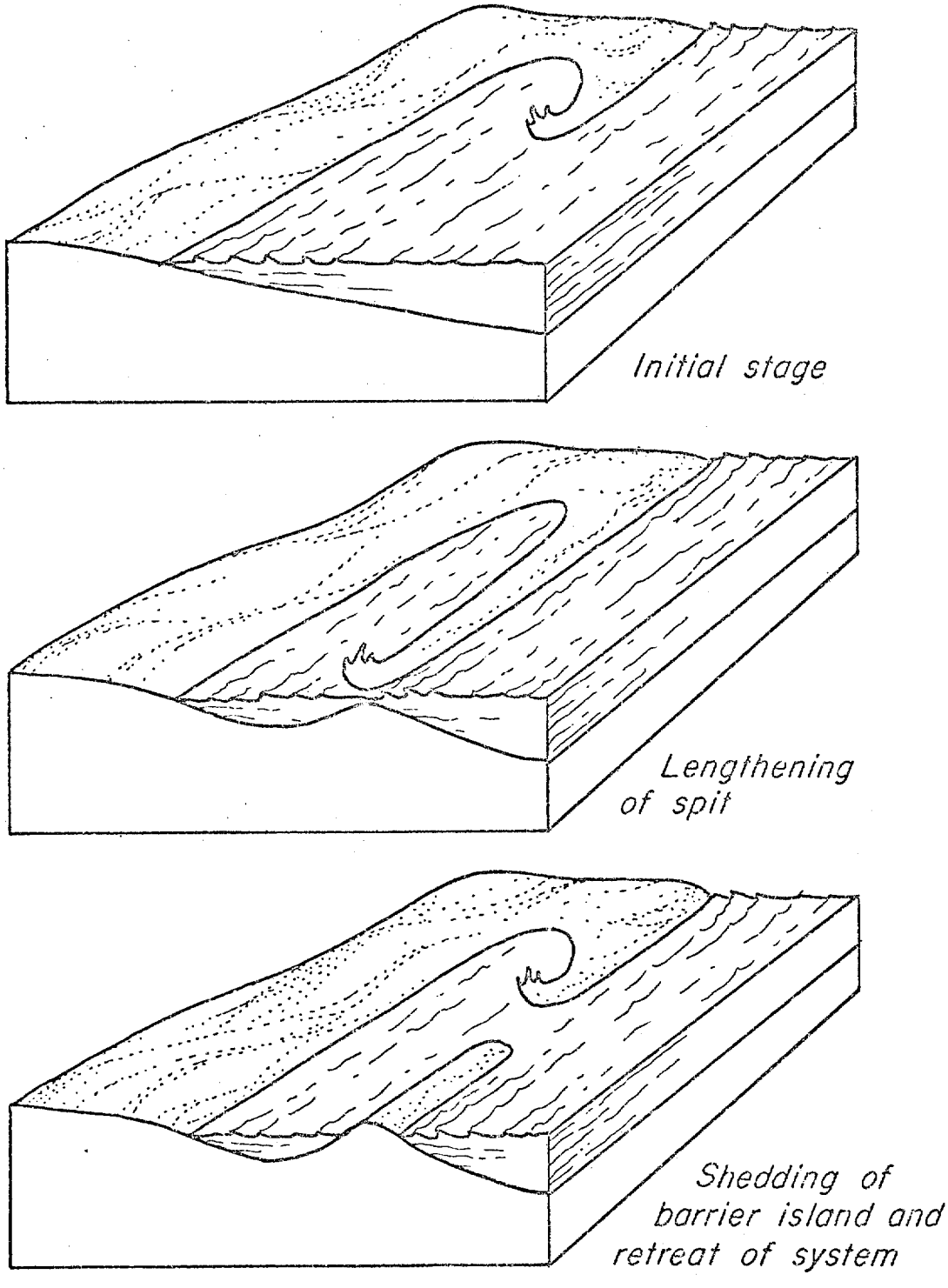


FIGURE 4. GILBERT-FISHER MODEL FOR BARRIER ISLAND FORMATION

Gilbert (1885), Fisher (1962)

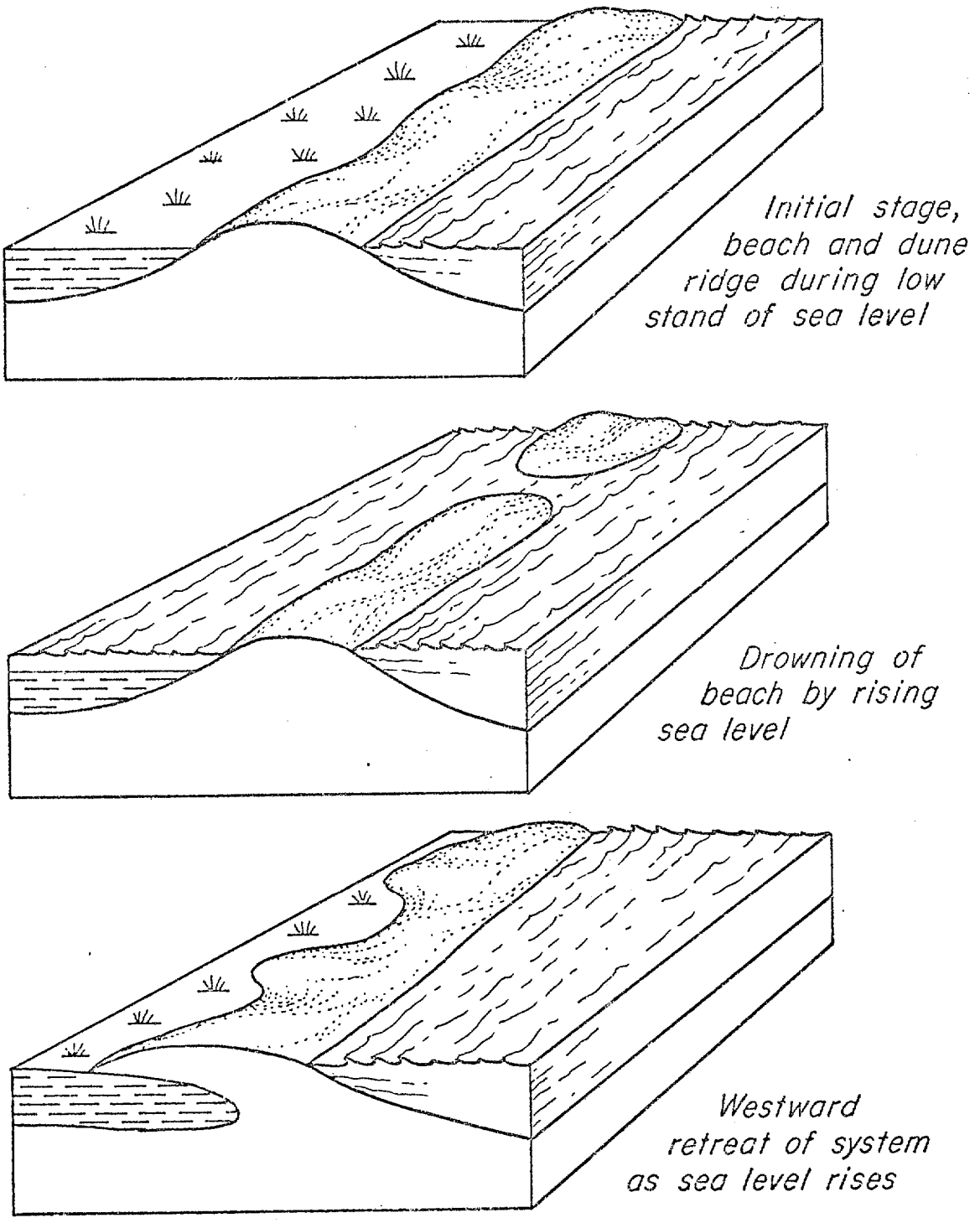


FIGURE 5. HOYT-GODFREY MODEL FOR BARRIER ISLAND FORMATION

Hoyt (1967), Godfrey (1972)

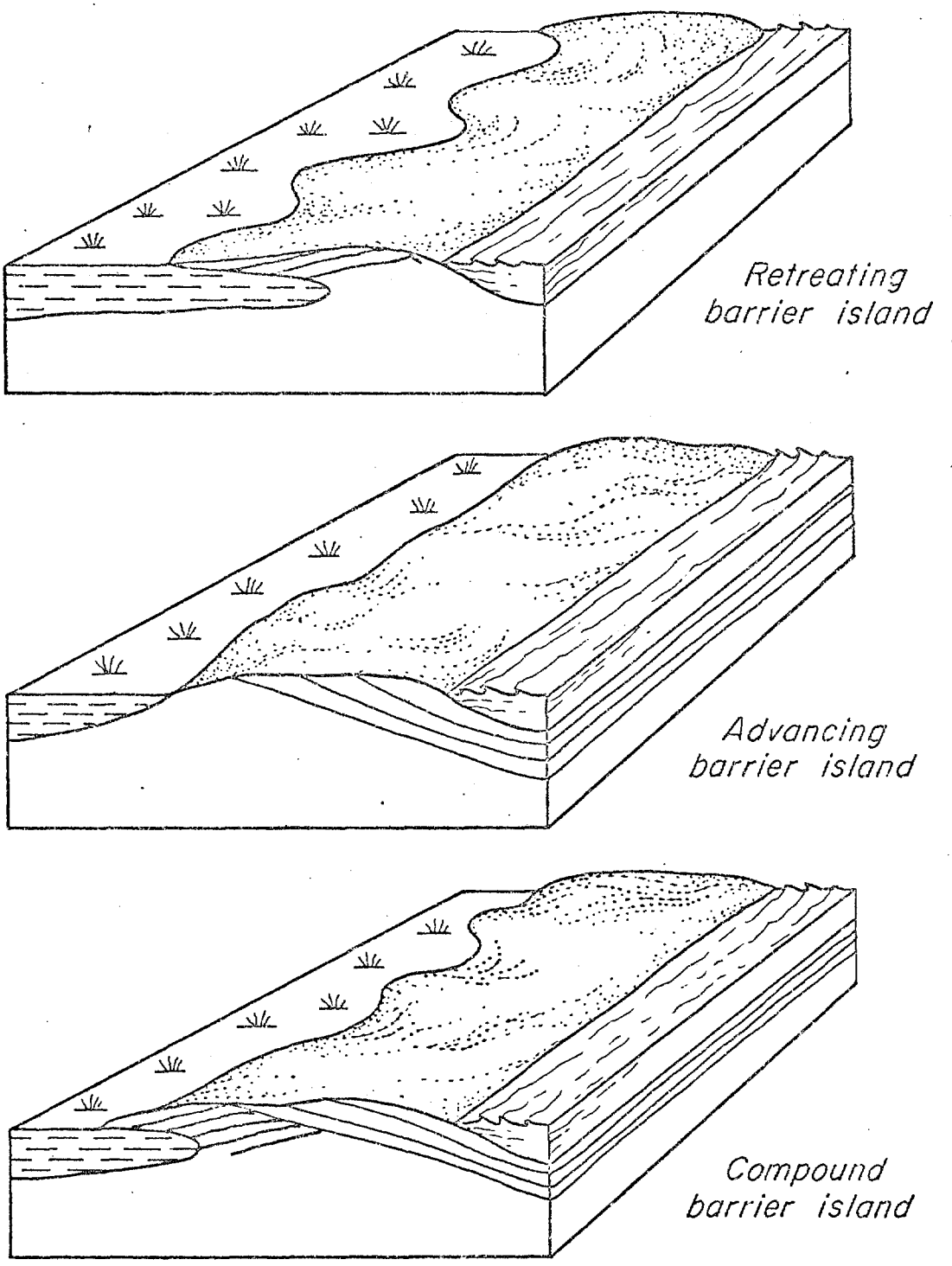
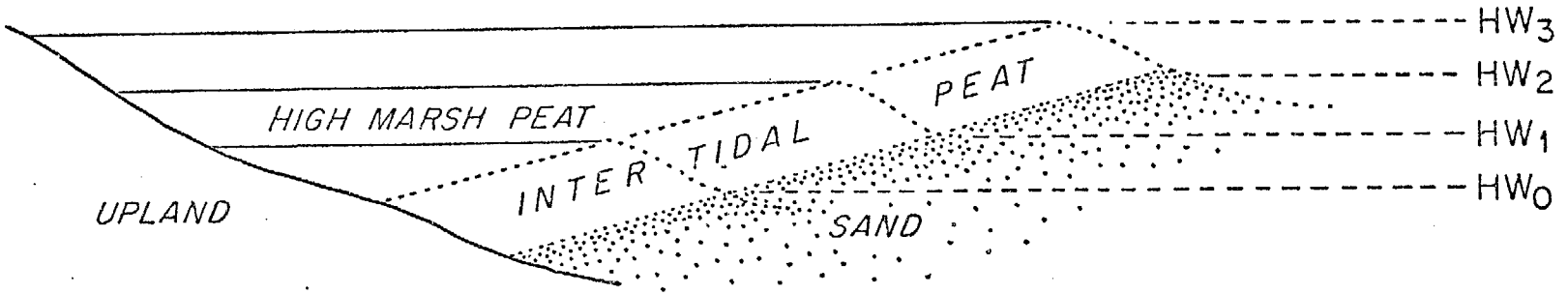


FIGURE 6. OTVÖS-SCHWARTZ MODEL
FOR BARRIER ISLAND MIGRATION

Otvös (1970), Schwartz (1971)



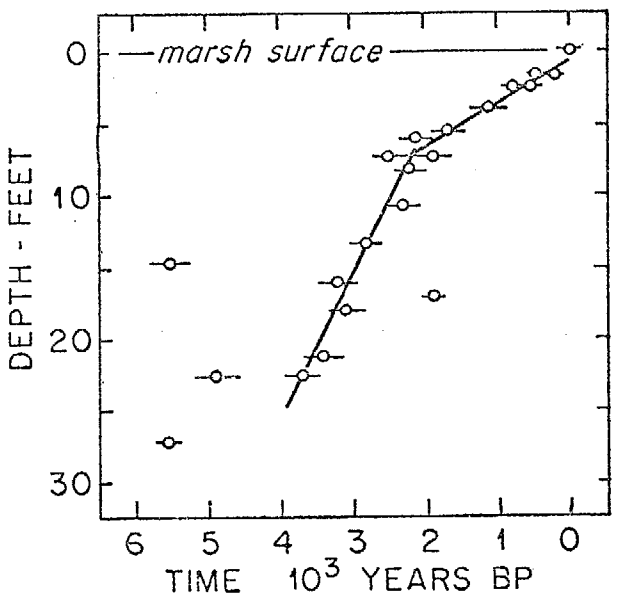


FIGURE 7. SEA LEVEL RISE CURVE FOR BARNSTABLE, MASSACHUSETTS

from Ruben & Redfield (1962)

and origins of barrier islands,

All theories for the formation of barrier islands are similar in that they attribute their ultimate origin to processes in existence at a time several thousand years ago, when sea level was lower and the shoreline was located many tens of miles seaward of its present location. The development of barrier islands is then seen to be the result of a series of processes which permit these islands to migrate up the continental slope at a rate which is in adjustment with local sea level stands. A recent study by Kumar (1973) has shown that there is evidence for drowned barrier islands off the eastern shore of Long Island. This indicates that it is possible for the combined processes to fail to maintain a proper rate of shoreward migration so that the island is totally submerged and thus destroyed. It is unknown how common such relics may be in other places on the continental shelf but surely the eastern Hog Island area must not be the only example.

It can be seen from the above discussion that the origin of barrier islands is a poorly understood subject. However, this question is fundamentally of philosophical interest and need not be considered as having large significance in determining the geologic processes in action on modern barrier islands or future trends of such islands. There is common agreement concerning an interrelationship between barrier islands and sea level stands. In addition, the processes responsible for the maintenance of barrier island systems in the presence of sea level rise must be understood. For these reasons, a brief discussion of the subject of sea level rise and barrier island processes has been included in this report.

II. SEA LEVEL CHANGES

It is well known that during the recent geologic past great continental glaciers covered most of northern North America, western Europe, areas inside Siberia, Greenland, and Antarctica. The time of the initiation of these great ice sheets is presently in dispute, but it appears to be in the order of at least two million years ago. During the period from the initiation of these great continental ice sheets to approximately fifteen thousand years ago, there were at least four major advances and retreats of the ice. There is, of course, an intimate relationship between the amount of ice residing on the continent and the volume of water in the sea. Seismic studies in Greenland and Antarctica indicate that thicknesses in the order of 10,000 feet are not uncommon for such continental glaciers. By taking a figure of this magnitude and multiplying it by the area of land covered by the glaciers during their maximum extent, it can be seen that a volume of water comparable to the upper 350 feet of the present ocean would have to be temporarily removed from the sea to produce this ice. Thus, sea level was substantially lower at times of maximum glaciation. As the continental glacier advanced and retreated during the ice age, sea level rose and fell. Many marine deposits on the mainland of the Delmarva Peninsula appear to have been deposited during high sea level associated with the interglacial (between glaciers) stages of the past ice age. It should be understood that these great advances and retreats of continental ice and concomitant changes in sea level occurred at very slow rates. Of the great advances and retreats of the ice, only the most recent retreat is of significance to the development of modern barrier island systems along the east coast of North America.

Several studies have been conducted to determine the rates of sea level rise. The first classic study was conducted by Redfield and Rubin (1962) on the rate of sea level rise at Barnstable marsh on Cape Cod, Massachusetts. They recognized that the salt marshes in this area must have grown vertically upward at the same rate at which sea level rose. In addition to growing vertically, the marshes extended themselves further inland and seaward over pre-existing sand deposits. By obtaining samples of the organic peats which are in contact with underlying sands at different depths within the marsh, Rubin and Redfield were able to assemble a rate of sea level rise using Carbon 14 dates obtained from those peats. This sea level rise curve is given in Figure 7. Their data

indicate that sea level has risen approximately 23 feet in the past 3,700 years. The rate of sea level rise is not constant but appears to have been in the order of 0.01 feet per year in the interval from 3,700 years before present to 2,100 years before present. Since the time 2,000 years before present, the rate of sea level rise appears to have decreased to 0.0033 feet per year. Since the time of the Rubin and Redfield study, the rate of sea level rise has been determined at many other locations in the world. In addition to determining these rates at different locations, the time span of these determinations has been increased. The full treatment of the information presently available on sea level changes would be extremely voluminous; therefore, only information relevant to the present study is included in this report. Additional information can be obtained from references cited in the bibliography of this report. Significant information concerning sea level history in the southern Delmarva Peninsula is data related to sea level change since the last major advance of continental glaciers. This last advance is thought to have terminated somewhere between 18,000 and 15,000 years ago. However, data are not always available for this entire period of time because the coastal deposits which represent the lowest stand of sea level are now either destroyed or located far out in the continental shelf. A significant study was conducted in the Wachapreague area by Newman and Numsart (1968). Their data wereobtained from basal peat samples from the lagoon east of Wachapreague, Virginia. These samples range back to a time 5,120 years before present. These data, as well as data from several other locations along the seaboard, are given in Figure 8. It is significant that the data for the Wachapreague area are incomplete during the period from 2,500 years ago to present. Furthermore, as the other sea level curves in this figure show a rather uniform rise of sea level over the past 7,000 years, the data from the Wachapreague area indicate a decrease in sea level during the period from 5,200 years ago to 4,400 years ago. This suggests that there has been crustal movement in the Virginia area relative to other locations on the Atlantic seaboard. Thus, the history of sea level rise in the area of the southern Delmarva Peninsula may not be as simple as it is elsewhere. Additional data from independent techniques also suggest that the rise of sea level relative to local land elevations in the southern Delmarva area has significant departures from the patterns established elsewhere on the east coast. A study by Harrison et al. (1965) suggests the possibility of a rise in the land level approximately equal to the rise in sea level (2.8 feet per century) during the period 15,000 to 8,000 before present. This information is obtained by comparing the gradients of various channels for the Elizabeth River, James River, York River, and Susquehanna River. The channel depths in the Susquehanna River are less than those expected and indicate the possibility of 170 feet of uplift some time during the last 18,000 years (see Figure 9). This uplift has not proceeded at a constant rate, and therefore the uplift of the southern Delmarva area, and the rise of sea level both influence the relative position of the shore line during post-glacial times. Further indications of even more recent uplift is given by Harrison et al. (1965) through their dating of peat deposits and shell beds located near the south end of Hog Island. These deposits are presently approximately three feet above mean high water and date at 1,170 years before present for the peat and 1,900 years before present for the shell bed. This suggests that after the subsidence documented by the study of Newman and Rusnak during the period from 4,500 years ago to 2,500 years ago, there may have been a period when the southern Delmarva area rose more rapidly than sea level. This event must have occurred since 1,900 years ago. If these events did take place, then the area has witnessed a recent retreat of the sea, which preceded the present condition of rising sea level.

In addition to the evidence given by Harrison et al. (1965) for a complicated sea level rise history in the southern Delmarva area, a study by Newman and Munsart (1968) gives evidence for a relative emergence of this area between 5,100 and 4,400 years before present. Further, they show evidence which may indicate a second, more minor regression, or at least a slowing of the rate of sea level rise in this area in the order of 1,000 years before present. A more complete description of their evidence for these changes of the sea level rise curve in the area, and other pieces of information from the report

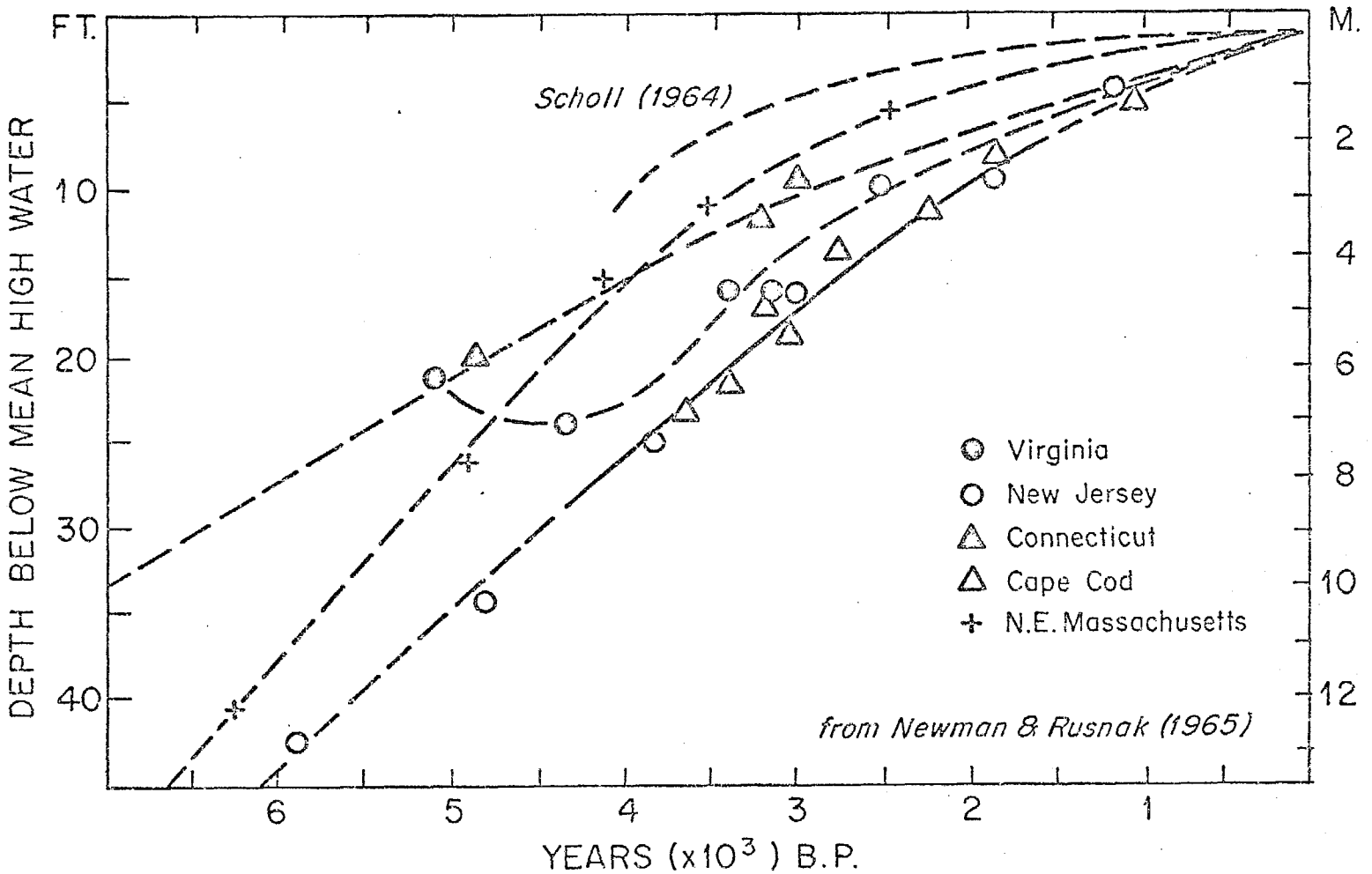


FIGURE 8. SEA LEVEL RISE CURVES FOR VARIOUS ATLANTIC SEABOARD LOCATIONS

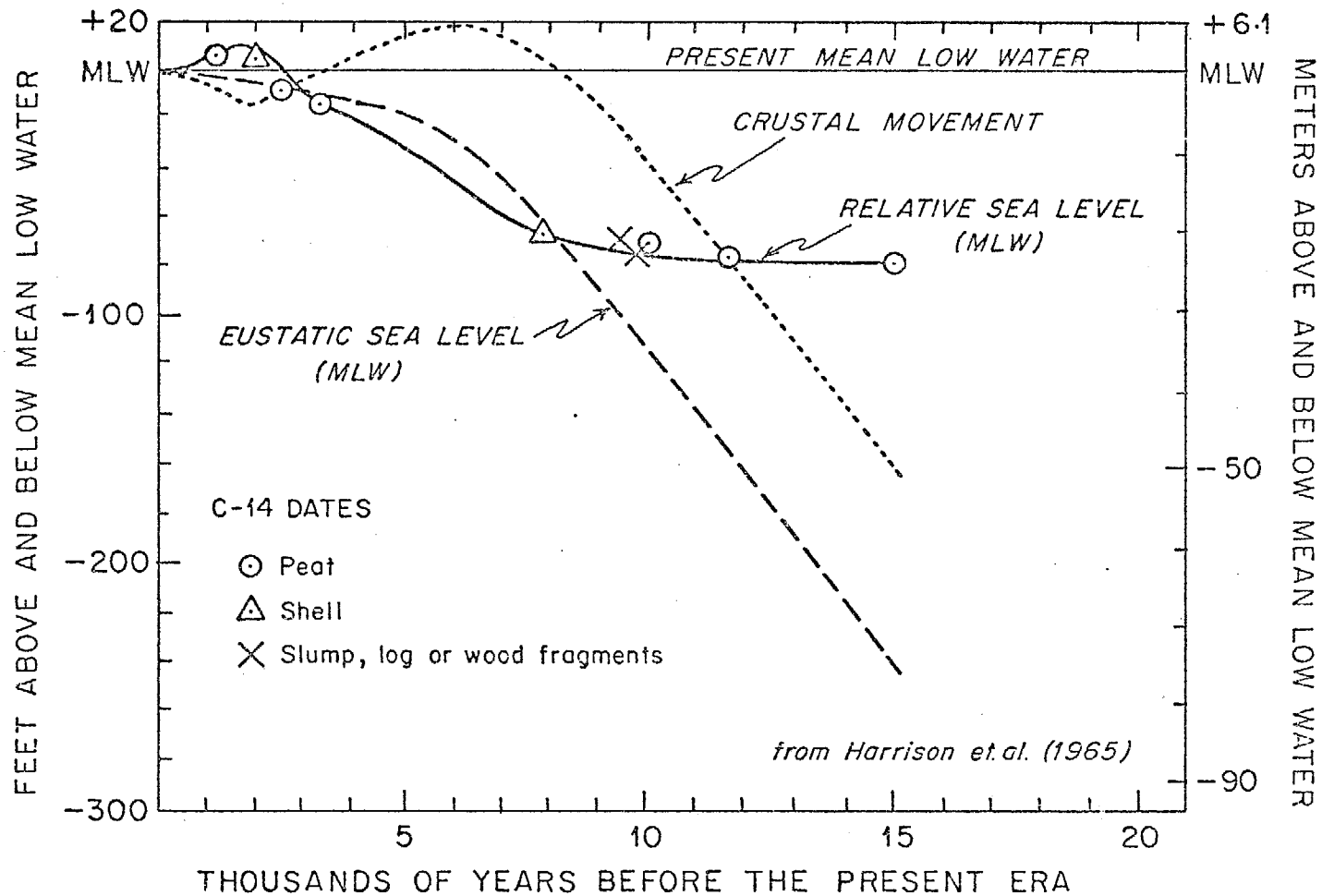


FIGURE 9. SEA LEVEL AND CRUSTAL MOVEMENT CURVES FOR THE AREA OF CHESAPEAKE BAY ENTRANCE

by Newman and Munsart are given later in this report, in the section concerning the geologic development of this barrier island system.

A very recent study of elevation changes in the area of the southern Delmarva Peninsula is provided by Holdahl and Morrison (1974). They used long-term tide gauge records and precision surveying techniques to determine the relative rates of absolute elevation changes going on during the past thirty years (see figure 10). This figure indicates that there are relative differences in the rate of sea level rise between the northern and southern end of the barrier island chain. Sea level appears to be advancing at an annual rate of two millimeters per year on Assateague Island and at an annual rate of 1.2 millimeters per year at Cape Charles. Therefore, it is clear that in most recent times sea level has been rising in this area. The possible significance of the differential rate of rise of sea level along the barrier chain is also covered in a later section of this report.

In summary, the sea level change curve for the southern Delmarva area over the past 8,000 years appears to have a more complicated characteristic than in most other east coast areas. There appears to be evidence for a rapid rise of sea level from 15,000 years to approximately 6,000 years ago which may have been coincident in average rate and time with a rise in the earth's crust. This may have been followed by a minor regression of the sea, beginning about 5,100 years before present, followed by a return to rising sea level conditions after approximately 4,400 years before present. The evidence from the shell beds and peats given by Harrison et al. (1965) suggests the possibility of a sea level stand above present sea level some time in the order of 2,500 to 1,900 years ago. It will be shown later in this report that there appears to be further independent evidence to suggest this occurrence, resulting from this study. At present, sea level is rising in the area of the southern Delmarva barrier islands as it is elsewhere throughout most of the world. The rate of sea level rise in the southern Delmarva area is not constant but varies in a north/south direction. The significance of all of these data is given later in our general interpretation of the geologic processes shaping these barrier islands.

III. BARRIER ISLAND PROCESSES

It is important to have a general understanding of the processes which are significant in shaping barrier islands. Therefore, a brief summary of these barrier island processes is provided. Work on understanding beach and barrier island processes has been under way for more than 200 years and our current level of understanding is the result of a large number of studies. Important studies related to barrier island processes are cited. Apologies are proffered in advance for pieces of information which are included without accurate reference. In most cases the cause of these oversights is that the information has become widely accepted and is generally utilized by most authors discussing beach processes and barrier islands.

There are many ways to organize a summary discussion of the barrier island processes. A system was selected wherein processes which are responsible for the longshore migration of sand are discussed first, and then processes resulting in on-shore/offshore movement of sand and general onshore/offshore translation of barrier island masses are described.

The fundamental point in discussing any coastal system is that beaches represent geologic deposits which are constantly in motion. It is well known that beaches can alter their profiles and shapes in a matter of a few hours. These changes in the geometry of beaches are often oscillatory in nature and cannot be used to form an appreciation of long-term and average changes which are occurring to the beach system.

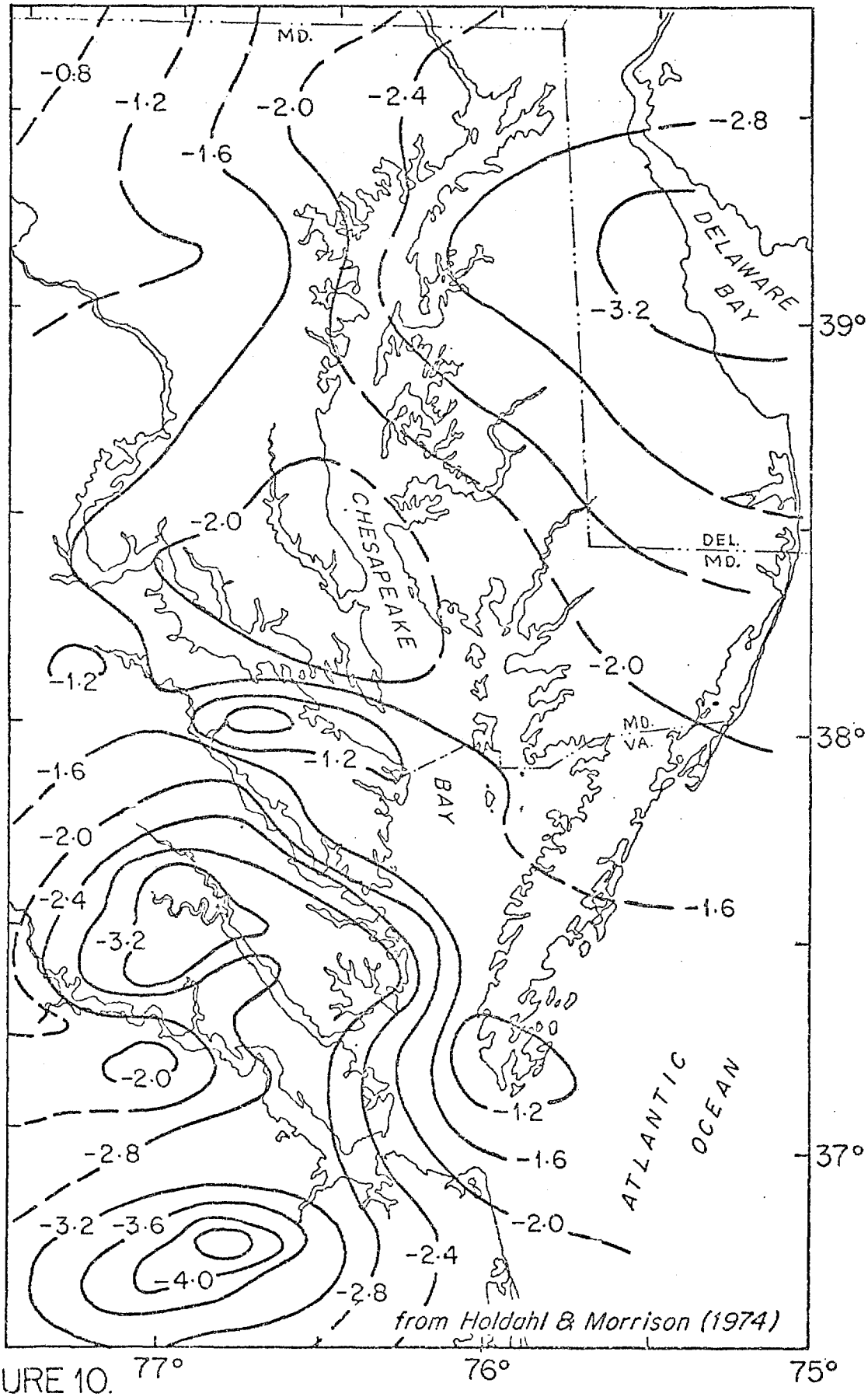


FIGURE 10.
ANNUAL RATES OF ELEVATION CHANGE (mm./yr.)
IN THE VICINITY OF CHESAPEAKE BAY

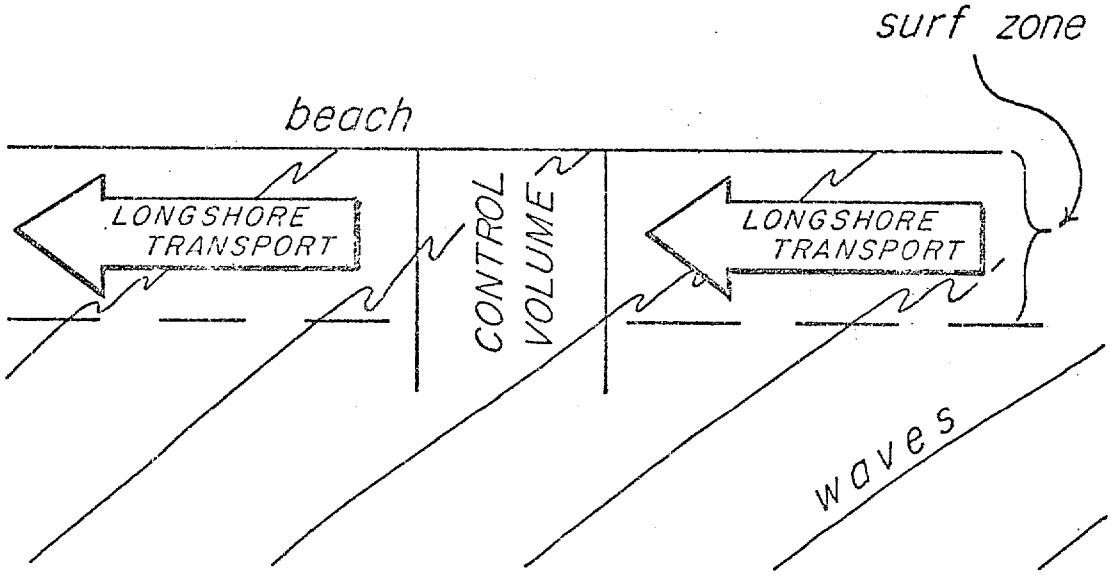
A. Beach Systems

Beaches can generally be viewed as consisting of two prismatic bodies; one located between the top of the active beach and the low tide line, and the other located between the low tide line and the seaward edge of the surf zone. The seaward limit of the offshore beach prism is ill-defined. Most of the movement of sand related to the beaches does take place within the surf zone. However, there is leakage between the surf zone and more distant portions of the inner continental shelf. The depth of approximately 10 to 15 meters is commonly assumed to represent the outer margin of the seaward beach prism. Considerable exchange of sediment develops between the offshore beach prism and the onshore beach prism as the wave conditions vary. These changes will be discussed in greater detail later in this section. In addition to the onshore/offshore exchange of sediment, there is a strong component of motion of the sand parallel to the shore. This sand motion develops both within the surf zone of the offshore beach prism, and along the active face of the onshore beach prism. The mechanics of this motion are related to momentum transferred from the motion of breaking and spilling waves (across the surf zone, and in the swash of the beach face) to the sand particles. Ultimately, the wave momentum is converted into sediment transport and surf zone currents. When the waves are breaking at an angle to the shore, the sediment is moved along the beach according to the longshore component of the wave propagation direction. Recent theoretical studies by Komar (1969), Komar and Inman (1970), Bowen (1969), Longuet-Higgins (1970 a & b), and others indicate that the rate of longshore sediment transport is proportional to the wave energy, or the square of the breaker height, the slope of the beach and surf zone, and the angle of wave attack. The transport is maximum when the waves are breaking at a 45° angle to the beach. Ultimization of these theoretical advances is limited in applied studies because the rate of sediment transport is dependent upon the instantaneous wave climate, and the wave climate is constantly changing. Therefore, the overall changes in beach systems are governed by the time-averaged rate of longshore transport. Thus, storm waves from one direction may more than overcome the sand transport of waves from another direction, even though those other waves may have operated throughout most of the year.

Unfortunately, it is extremely rare to have adequate information concerning the long-term average wave conditions so that quantitative models of average beach changes can be assembled. In the absence of these data, other forms of information must be used to understand the average longshore processes acting on a beach system.

B. Longshore Processes

For the purposes of a general discussion of wave processes, it is best to consider an ideal beach system where the time-averaged wave conditions are known. In such a system tremendous volumes of sand can be shifted along a beach during a year with no change in the position of the beach. This will occur when the average wave conditions and breaker angles remain constant all the way along the beach. For any given control volume located on such a beach, an equal amount of sand is moved into this volume from the updrift direction as is removed from it in the downdrift direction. It is not uncommon for ideal beaches facing the Atlantic Ocean to transport quantities of sand in the order of 300,000 to 500,000 cubic yards per year. Long-term erosion and deposition occurs in response to accelerations and decelerations of the rate of sand transport along a beach. If offshore topography substantially blocks or bends the waves so that the average wave height or average breaker angle at the beach are reduced, a situation develops where more sand is carried into a control volume than is removed. The difference is then deposited within this control volume, leading to accretion of the beach. The opposite effect occurs in areas where the average breaker height or wave approach angle is increased along the shore in the direction of the longshore current. In this condition more sand is removed from a given control volume than is brought in, and the difference is made up by erosion of the beach within the control volume. These three conditions are illustrated in Figure 11. It must always be stressed that the long term transport of sand along beaches is in response to time-averaged conditions. Therefore,



EQUILIBRIUM LONGSHORE SAND TRANSPORT

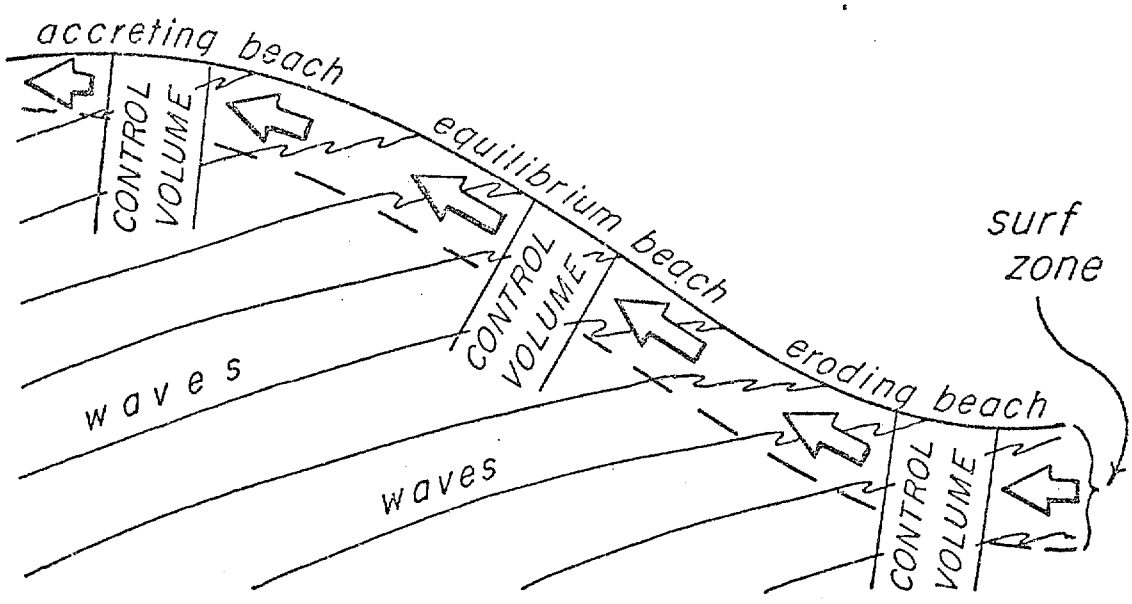


FIGURE 11. IDEALIZED LONGSHORE SAND TRANSPORT CONDITIONS

the preceding explanation represents an enormous over-simplification of actual longshore processes. Nevertheless it is sufficient to provide the basic understanding of longshore sediment transport along uncomplicated coasts. Finally, it must be pointed out that determinations of longshore sediment transport rates are difficult to make. Transport rates may be computed from estimates from the time-averaged wave conditions and theorectical relationships. However, such estimates are subject to wide error even when large amounts of information are available concerning the local wave climate. In other places, natural or man-made features may trap most or all of the sand being transported along a beach system. In these cases the rate of increase of the volume of sand trapped by a breakwater or a rocky point can be measured by successive mapping of these deposits. From this the rate of longshore transport can be determined easily. In areas free from man-made structures and natural sediment dams, determinations of longshore drift rates may be almost impossible.

C. Role of Tidal Inlet

Longshore transport of sand along barrier island chains is considerably more complex than it is on continuous beaches as described in the preceeding paragraphs. The basic patterns governing erosion, depositions, or stability (equilibrium) are the same. However, barrier island chains are broken by tidal inlets, which may be permanent or temporary. The overall functioning of tidal inlets and their interactions with the longshore drift system strongly affect the overall processes related to the stability and history of barrier island chains. Tidal inlets through barrier island chains are known to originate primarily as a result of storm activity. Inlets may be formed by storm waves from the ocean breaking over low and thin portions of the barrier island. It has been shown, however, by Fischer (1962), Dolan et al. (1973), and Godfrey (1973, 1974) that tidal inlets probably form most frequently as a result of lagoon water piled up against the back side of barrier islands by strong offshore winds. These winds frequently accompany storms. Such piling up of lagoon water ultimately results in its escape over the barrier island at a low point. The water rushing to the ocean rapidly erodes a channel, which may become permanent. The permanence of tidal inlets is primarily controlled by the relative ability of the longshore sand transport system to silt up and close the inlet, versus the power of the tidal flow through the inlet to clear it of sediment and keep it open. Thus, the average wave conditions and the volume of water exchanged through an inlet during each tidal cycle, ultimately determine whether the inlet will become a long-term feature of the barrier island, or quickly disappear.

The opening of a new inlet can affect older, adjacent inlets. If the tidal flow is preferentially re-directed through the new inlet then the older inlet often silts up and closes. Thus, position of inlets and the number of inlets along the barrier island chain is usually quite variable.

D. Inlet Processes

Tidal inlets obviously segment the longshore transport system into units related to each island. However, these long-shore transport systems are seldom totally isolated from each other. Sand and other sediment which is swept seaward by the ebbing flow through an inlet usually accumulates in the form of tremendous offshore sand bars, ringing the seaward mouth of the inlet. These sand bars are called ebb tide deltas. When an ebb tide delta begins to form outside of an inlet, sediment, at first, is removed from the longshore transport system and deposited to form the initial sand bars. Upon complete development of the ebb tide delta, it usually functions to permit the bypassing of substantial quantities of sand around the inlet. Sand enters the inlet area from the downdrift end of one island's longshore transport system, is carried around the ebb tide delta by inlet currents, and enters the updrift end of the next island's longshore drift system. However, this sediment bypassing is generally incomplete.

Some substantial portion of the sand deposited on the updrift side of the tidal inlet or moving onto the ebb tide delta is swept through the inlet and into the lagoon during the flood tide. A series of irregular, but grossly crescentic, sand bars and shoals develop within the lagoon surrounding the tidal inlet. The sand which makes up these deposits, called flood tide deltas, is lost from the longshore transport processes of the open beaches of the barrier islands. The degree to which the longshore transport of sand is bypassed around an inlet is thus highly variable and at the whim of wave and current activity at the inlet. Partial to complete trapping of sand from the longshore transport process can occur at an inlet. Separate and careful analysis of each individual inlet must be conducted to determine the degree to which sediment is lost from the longshore transport system due to these inlet processes. Secondary effects also develop about tidal inlets.

It has been shown by Boothroyd (1972) that wave bending or refraction about the ebb tide delta deposits on the downdrift side of tidal inlets often results in a reversal of the longshore sand transport direction on the beaches immediately adjacent to ebb tide deltas. This reversal in the drift direction can serve to stabilize the position of the downdrift beaches near the inlet. A generalized sketch of the interaction of tidal inlets with longshore transport systems is given in Figure 12.

A further complication in the transport of sand near tidal inlets results from asymmetries in the flood and ebb flow. The geometry of the inlet throat and adjacent sea floor often cause ebb flow to be concentrated along one bank of the inlet, and flood flow to be concentrated along the opposite bank. In extreme cases this alternate deflection of ebb and flood currents through the tidal inlet can produce a series of shoals and ephemeral islands in the center of the inlet throat. In addition to asymmetries in the ebb and flood flow through the inlet throat, asymmetries can develop in a vertical direction as well. If the lagoon waters are significantly warmer, or less saline than the ocean waters, a distinct density interface can develop in the inlet throat. The less dense warmer or brackish lagoon water tends to float above the more dense saline or cooler ocean water. This condition is referred to as density stratification. When it exists, the flood flow through the inlet throat may be concentrated against the bottom while the ebb flow is concentrated at the surface. As most sediment residing in or near such tidal inlets is of sand size, it is obvious that such an inlet would tend to move more sand to the flood tide deltas than it may bypass. All of these factors combine to make rapid analyses of the overall action of the tidal inlet difficult or impossible. Careful measurement of the tidal flow through the inlet over long periods of time, determinations of long-term changes in the inlet throat and nearby sand bar configuration, and knowledge of the longshore transport system are required before adequate assessment of tidal inlets can be made.

Finally, it must be pointed out that some tidal inlets tend to maintain their position for indefinitely long periods of time. These inlets may be stabilized as the result of deep pre-existing channels, by compacted or partially lithified sediments on one or both banks as shown by DeAlteris and Byrne (1973) or influenced by the offshore wave climate as indicated by Goldsmith (1973). In other cases, tidal inlets on barrier islands have been known to migrate rapidly. The direction of inlet migration is most frequently in the direction of longshore sand transport along the island chain, but not always. Updrift migration of tidal inlets is apparently controlled by the hydraulics of the tidal prism in the lagoon adjacent to such inlets.

E. Other Modes of Sediment Transport

The interactions of longshore sand transport systems and tidal inlets form only part of the story of the processes controlling the development and stability of barrier islands. Other processes lead to onshore and offshore motion of sand. These processes

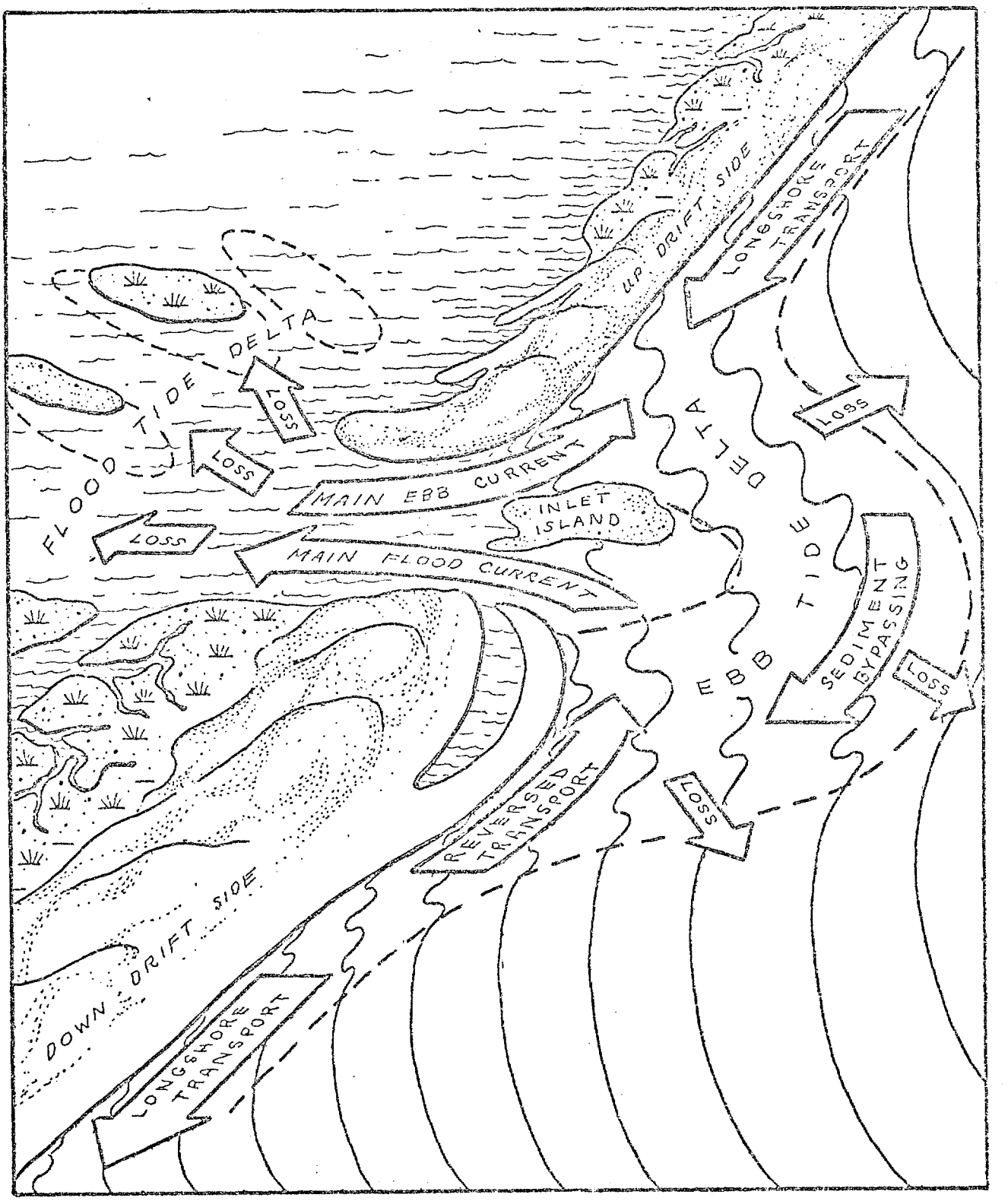


FIGURE 12. SEDIMENT PATHS AT INLETS IN A BARRIER ISLAND SYSTEM

include the transport of sand across the inner continental shelf, and to and from the beach tidal prism. This may occur in the form of migrating sand bars whose long axes are parallel to the beach, or through sediment transport along the crest of sand bars whose axes are at a high angle or perpendicular to the beach (Niedoroda and Tanner, 1970, Niedoroda 1973) Such exchange of sediment between the ocean floor and the beach face may be of an oscillatory nature and lead to no net change in the overall shape of an island, or it may have a preferred direction. Pierce (1969) has shown that the area of barrier islands between Cape Lookout and Cape Hatteras, North Carolina obtains 441,000 cubic yards of sand annually from the adjacent sea floor. However, losses of similar magnitude are quite likely on other coasts with barrier island chains. In addition to these transfers which occur beneath sea level, sand is transported perpendicular to barrier island beaches by wind and is stored inland in the form of sand dunes and sand dune ridges. These dunes may be vegetated or unvegetated. They frequently develop immediately behind the active beach prism and may extend great distances inland.

IV. BARRIER ISLAND MIGRATION

The processes previously described are strongly influenced by the slow world-wide rise in sea level resulting from the continued melting of Antarctic and Greenland continental glaciers. To understand the effect of vertical changes in sea level, it is appropriate to view barrier islands as small scale topographic features on the average slope of the coastal plain and adjacent continental shelf. The position of the barrier island beaches on this slope is adjusted relative to present sea level.

The slope of the inner continental shelf in the southern Delmarva area is on the order of 0.1 to 0.05 . For an average slope of 0.05 , a one-inch rise in sea level would result in a 95 foot advance of the sea in a horizontal direction. This is to say that a small rise in sea level causes an instability in the location of the beach and barrier island systems. A small change in sea level then can cause the barrier island beaches to tend to migrate large horizontal distances. This is illustrated in Figure 13.

In an earlier part of this report, it was shown that sea level may have alternately risen and fallen in this area with the net balance predominantly toward sea level rise. Also, at present, sea level is rising in the area of the Delmarva Peninsula. Thus, there is an overall tendancy for the Virginia Barrier Islands to retreat westward.

There are four major mechanisms which permit the landward migration (retreat) of barrier islands. First, the presence of calm water within lagoons behind barrier islands produces high rates of sedimentation. This is frequently accompanied by the development of salt marshes which add organic material to the sediment as well as forming efficient traps for fine inorganic sediment. The overall result is a gradual uplifting of the floor of the lagoon and the production of a sandy, silty, or peaty substrate behind the barrier islands. A second mechanism pointed to by Shiedeler (1973) among others, is the general movement of beach sand to sand dunes on the barrier islands. These dunes thus provide a reservoir of sand which can feed the longshore drift system during times of storms or can be redistributed along the barrier islands as they retreat.

A third mechanism has been discussed by Fisher (1962), Godfrey (1970), Pierce (1970), Godfrey & Godfrey (1972, 1974 a & b), and Dolan et al. (1973). These authors show that at times of storms, occasional wave surges carry over the beach and through low points in the dune ridge or discontinuous dune system. This wave surge is often charged with a high volume of suspended sand which is deposited in a channel and fan-like deposit. These deposits have been called overwash deposits. The ecologic studies carried out by Godfrey indicate that in many instances the influx of sand carried by the overwash across the barrier islands has a beneficial effect on the salt grasses of the adjacent salt marsh. In addition, the long-term effect of random overwash at various locations

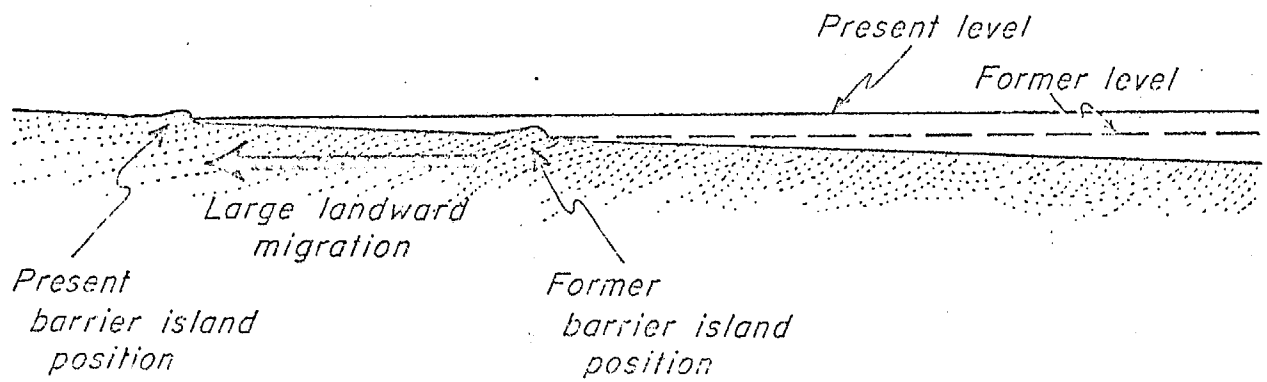


FIGURE 13. RELATION OF SEA LEVEL CHANGES TO BARRIER ISLAND MIGRATION

in all the barrier islands is to increase the overall height and width of the islands. Indeed, in some cases, particularly where salt marshes do not exist behind the barrier islands, the sediment from the overwash can be carried and deposited in the still waters of the lagoon. In such situations, overwash channels frequently become the sites of short-term ephemeral inlets. Sand swept through these inlets on the flood tide is added to the overwashed sand in the lagoon to produce a much larger deposit. In this report, deposits of this nature are called sand deltas. Such deposits can become sites of new marsh development. Thus, as the ocean side of a barrier island erodes in response to rising sea levels, the overwash processes continue their existence.

The final mechanism for the maintenance of barrier islands (in the presence of instabilities caused by rising sea level) is related to the flood tide deposits behind tidal inlets. Studies by El-Ashry and Wanless (1965), Pierce (1970), and Godfrey and Godfrey (1972, 1974 a & b), show that the flood tide deltas are abandoned when their adjacent tidal inlet is closed. In the resulting calm lagoon conditions, these shallow sand bars become the site of new marsh development. Organic peats and fine sediments trapped within these marshes are, thus, added to the mass of sand in the flood tide deltas.

The combined effects of sedimentation in the lagoons, dune building, overwash, and the development of flood tide deltas help to maintain the overall width of many barrier islands as sea level rises, and they are forced to retreat landward.

THE VIRGINIA BARRIER ISLAND STUDY

I. SETTING, PURPOSE, AND NATURE

The Virginia Barrier Island Group is part of a general coastal system which lies between the mouths of Delaware Bay and Chesapeake Bay. A significant physiographic division can be made between the northern portion of this system and the southern portion. The dividing point appears to be the southern tip of Assateague Island. North of this location the beaches are characterized by more continuous lengths, larger and more permanent inlets, and larger scale washover and sand dune deposits. The southern tip of Assateague Island is a massive, hooked sand spit adjacent to Chincoteague Inlet. From this point south, the style of the barrier islands changes. Permanent or semi-permanent inlets are more abundant, resulting in a shorter average island length. In addition, the scale of temporary inlets, washovers, and the overall width of the sand beach systems becomes markedly smaller than that of similar features to the north. The human development of the area parallels the natural patterns. The beaches north of Chincoteague Inlet are tied to the mainland by highways and have been developed primarily for recreational and vacation use. Wallops Island, located immediately south of Chincoteague Inlet, has been developed by N.A.S.A. as an airfield and missile test facility.

South of Wallops Island there is minimal human development along the islands because most are inaccessable by highway. However, there have been past attempts at developing the islands which have met with limited success. (See Graham, 1976. Land Use History--A Study of Man's Influence on the Virginia Barrier Islands: in this volume of the Virginia Coast Reserve Study.)

The present study is devoted to the Virginia Barrier Island Group. These include a total of twelve islands between Wallops and Fisherman's. At present, the interests of The Nature Conservancy do not include Wallops Island and Assawoman Island; therefore these islands have been excluded from the study.

The general aim of this study was to analyze the geologic history and natural processes acting on the ten islands along the southern portion of this barrier island chain. The study is concerned with the history of shoreline erosion and deposition, the processes which are significant in introducing those changes to the beach, the nature of all inlets in this barrier chain, and the development of lagoon and marsh systems behind these barrier islands. From the background material presented in earlier sections of this report, it should be clear that a comprehensive study of this nature would require years of conscientious and well planned research. Therefore, this report covers an overall reconnaisance study, which represents an attempt to gather together and analyze the most useful general data and information concerning this coastal system in the brief months allocated for the study. The report synthesizes and presents significant information produced by previous studies in this area.

II. ORIGINAL WORK

In addition, a program of mapping and original study has been conducted to determine the geologic history and geomorphology of each island, the nature of geologic processes acting on each island, and to quantitatively measure the changes in shoreline position and overall migration of each barrier island. Significant characteristics and changes in the marsh and bay areas have been reported also.

An additionally important objective of this study was to demonstrate the value, importance, and reliability of remote sensing techniques for the rapid analysis of large scale coastal systems. A secondary purpose was to highlight the value of short-term remote sensing imagery to such studies.

A primary source of information for this portion of the study has been extensive false color, thermal I.R. imagery provided by the Chesapeake Bay Ecologic Program Office at the N.A.S.A. Wallops Flight Center at Wallops Island, Virginia. The I.R. imagery was supplemented by vertical black and white aerial photographs, and black and white and color oblique photographs flown by the investigators in July and September, 1975. Additional information was obtained from U.S. Coast and Geodetic Survey hydrographic charts, and topographic maps of the U.S. Geological Survey and the U.S. Army Map Service.

III. BASE MAPS

The June 4, 1974 N.A.S.A. false color I.R. imagery is of excellent photographic quality It was, therefore, selected for use in preparing a planimetric base map for this study. A major difficulty in working with the N.A.S.A. imagery is that it is released for use as uncorrected aerial photography. It is, therefore, subject to scale changes due to variations in flight altidude, and distortions due to lense abberations, including vignetting, and flight vagaries such as pitch, roll, and yaw. The latter are not too significant because the altitude (10,000 feet) and the plane (C-54) worked to produce a relatively stable platform for the camera.

The base maps of the islands that were produced from this imagery resulted from careful, frame-by-frame tracing of features shown on the imagery. A Variscan Projector was used to produce the images that were traced. A magnification ratio of 3X was employed. The fine focus control of the Variscan Projector provided sufficient variation in magnification to permit adjustments of scale from frame to frame. Distortion problems were minimized by utilizing only the central portion of each frame, and by skipping individual frames that were badly distorted. The rotational effect due to vignetting was calculated by comparing positions of man-made landmarks and corrected manually for those distortions. These maps are proferred as the best result that could be produced, considering the imagery, equipment, economics, and time frame allowed for that portion of this study.

The base maps produced from the 1974 N.A.S.A. imagery (I.R.) have been used for the geomorphic and geologic mapping of the islands, as well as for a base for a second set of shoreline change maps. It must be made clear that no claim of geodetic accuracy is made for these maps. There are systematic variations in scale along the length of some of the islands due to changes in altitude of the aircraft along the flight line. These variations could not be corrected during the preparation of the maps. Therefore, adjacent scale bars were provided for different positions on a map according to the scale of that portion of the map. An average scale bar for the entire map is provided at the legend on the map. The scale differences are not great, but they exist, and are acknowledged. There are also slight residual rotational errors from the vignetting that could not be removed with the mapping technique employed. Because these maps were produced for the sole purpose of relative comparison and interpretation, these errors are not considered significant. The maps are intended only for the geologic purposes of this study.

IV. SHORELINE CHANGE MAPS: (1850's to 1960's)

The U.S. Coast and Geodetic Survey hydrographic charts used in the study were obtained from the U.S. National Archives. They are 2X1 Xerox reductions of the original charts. The information shown on those charts is based upon a series of hydrographic surveys begun in 1847. In later years the U.S.C. & G.S. hydrographic data was supplemented by topographic (and sometimes hydrographic) data provided by other U.S. Government agencies. Each succeeding edition of a hydrographic chart issued by the U.S.C. & G.S. is a composite of information available from all sources up to, or just prior to, the date of the edition. Successive hydrographic surveys of the U.S.C. & G.S. and the area covered

by them was also obtained from the National Archives. (See bibliography for a listing of the hydrographic charts and index sheets used in the study). These indices made it possible to indentify the updated portions of each of the charts utilized. Additional information on historical shoreline positions was obtained from Byrne's (1972) Historical Shoreline Positions maps which include hydrographic information not available from the National Archives. U.S. Geologic Survey and U.S. Army Map Service topographic quadrangle maps provided additional data that supplemented the hydrographic charts. These maps were obtained from the Map Library and Repository at the University of Massachusetts.

The data obtained from the preceeding sources was redrafted, island by island, to produce overlay maps to illustrate the nature of the shoreline changes that have occurred. Up to four successive shoreline positions were overlain for each illustration, depending upon the intricacies of the shoreline changes. Generally, two illustrations were prepared for each island to cover the time span from the 1850's to the early 1960's. Landmark features whose position remained stable through time were employed for indexing the shoreline overlays, and for making scale corrections where necessary. Scale changes were made on a Kail Plotter.

V. ANALYSIS OF ERROR

Errors are introduced at every step in the process of copying and redrafting maps and charts. Therefore, the steps in the redrafting process were kept to a minimum. A small, but unknown, error due to lense distortion is introduced in the Xerox reduction of the charts. The lense system in the Kail Plotter also introduces small errors, but these can be minimized by avoiding the peripheral areas of the lense field. It is difficult to evaluate the cumulative effect of compiling errors, but it is believed that the the maximum introduced error has been held to less than 100 feet, and most error probably lies within a range of several tens of feet of the correct position. At the scale of the hydrographic charts employed, the width of a very fine pencil line is approximately 120 feet. Because the final shoreline positions maps were produced on the Kail Plotter, the scale of a line varies from island to island, and the width of a line portraying the shoreline varies according to scale. The range of maximum possible error in tracing is thus between 80 feet and 120 feet. Measurements of historical shoreline changes were not made from the illustrations produced, but were made, in sequence, from the original (Xerox copies) charts, maps, and photographs available for the study.

VI. SECOND SET OF SHORELINE CHANGE MAPS

A second set of historical shoreline positions maps was created from imagery dated in 1949, 1966-67, 1974, and in some instances, 1955-56, and 1975. This set of maps was developed to illustrate in more detail the relatively short-term changes which have occurred in the study area. These data revealed that short-term changes occur at much higher rates than can be extrapolated from the first set of long-term historical shoreline changes maps. In fact, comparison of <u>all</u> variable data for the time period from 1949 to 1975 indicates that an even shorter interval of comparison (2-5 years) would yield a truer appreciation and understanding of shoreline oscillations and migration. The approximately ten-year interval used for this set of shoreline positions maps still resulted in time-averaging of many significant shoreline changes.

The shoreline positions for the other dates used in this second set of maps were carefully translated onto the 1974 base maps. Control for this translation was based upon both man-made landmarks on the islands and natural features located in the bay areas landward of the islands. Data for the 1949 shoreline positions was derived from a complete set of 1949 black and white aerial photographs furnished by The Nature Conservancy. Data for other dated shoreline positions was derived from U.S.G.S. topographic maps and from supplemental aerial photographs that were available for the study. In all cases, control points were plotted, and shoreline positions were carefully drawn between the known points. The spacing of control points varied from less than 100 feet

where the shoreline was changing shape rapidly, to more than half a mile where the beach was uniform. In spite of distortions that are residual from the N.A.S.A. imagery, the shoreline changes portrayed on these maps are considered to be quite accurate because of the care expended in translating the other shoreline positions to the base maps.

VII. GEOMORPHOLOGY AND GEOLOGY

The major effort in this study was directed toward the production of a highly detailed series of geologic maps. The purpose of those maps was to define the different types of deposits which comprised the islands and to infer from these the relative importance of the different geologic and coastal processes involved in shaping and modifying the islands. The maps were constructed by interpreting the June, 1974 series of false color I.R. imagery. The first operation in this study consisted of the construction of a detailed base map. This operation has been described above. The resulting base maps are included separately with this report. Upon the completion of the base map tracings from the 1974 imagery, individual acetate sheets were placed on the viewing screen of the Variscan Projector and the geology visible on each image was transferred to the acetate. Whenever doubt existed about an interpretation, other N.A.S.A. false color imagery from 1971 to 1975 was consulted to verify the nature of the geologic study. Without it, many of the interpretations of this study would not have been possible. To the authors' knowledge, few similar attempts have been conducted at precise and detailed geologic mapping of coastal systems from remote imagery. No other large scale, coastal system study has previously been completed using false color I.R. imagery. The authors are quite pleased and impressed at the level of detail and the amount information which can be obtained in this process.

VIII. FIELD WORK

Upon completion of the initial geological mapping, a field visit was conducted to selectively spot check various key groundtruth locations. Serious delays in receiving the N.A.S.A. imagery in the early part of the project, combined with the unpredictated high level of detail which the photo geology interpretation analysis require, caused this field visit to be conducted in September. As a result, the time spent in the field was more limited than originally intended. Thus, the procedure of spot checking critical areas which had previously been identified on the photographs was adopted. In addition, the entire area was overflown, maps in hand, to verify interpretations. During the five days spent in the field by the investigators in September, areas on Cedar, Parramore, Wreck, and Smith Islands were visited. The previous period of field work, during July, allowed Fisherman's, Wallops, and Assateague Islands to be visited. During both field visits, light aircraft reconnaisance and oblique aerial photography was carried out over the entire chain of islands. The results of the ground truth observations were <u>extremely</u> encouraging. Not only was it shown that <u>all</u> interpretations of the photographic data were read correctly, but it was also learned that much more information could be obtained from the photos than could be obtained from the field work, owing to the very subtle topographic expressions of most important geomorphic features.

VI. GEOLOGIC FEATURES MAPPED

A legend showing the meaning of all geologic units and symbols used in the Virginia Barrier Islands mapping program is provided with the geologic map series. In order to clearly define what is meant, and what can be inferred from each of these mapped deposits, the following definitions are provided.

A. Active Beach

This category generally includes all deposits forming between high and low tide. This

represents a conservative estimate of the June, 1974 location of the active beach which certainly extends well into the surf zone and can be considered to extend landward to the first scarped dune ridge or at least to the location of the highest recent storm berm.

B. Present Berm

Berm deposits generally appear as a low ridge immediately landward of the active beach face, or as breaks in the slope between the active beach face and the back beach areas. Where these features could be determined on the false color I.R. imagery, they were mapped as the location of the present berm.

C. Old Berms (Numbered)

In many locations, it was possible to distinguish a pattern of several old beach berms which usually represented accretion of the beach front. These appear as low ridges of variable length. These units have been given a distinct map symbol and further distinguished by sequential numbering from the youngest to the oldest whenever the development succession was apparent.

D. Back Beach Flats

In many areas, extensive sand flats developed landward of the modern beach. These generally consist of nearly horizontal surfaces with scattered remains of old berms and other hummocks which presumably represent early stages in dune formation. In some locations these deposits developed behind a large offshore bar which had migrated to the beach face and welded to it.

E. Ridge (bars welded to the beach front)

As described above, offshore bars appear to commonly migrate onshore and weld to the beach front. This results in a seaward advance of the island shoreline and a distinct ridge is formed in the beach terrain.

F. Runnel (trough behind a ridge, and within tidal range)

Areas of deposition of this type are similar to one form of back beach flats. They are created as low areas behind offshore bars which have migrated to the beach. In the mapping, only those portions of the area behind a ridge that are still within the tidal range were mapped as runnel. All of the areas mapped as runnels still have connections to the sea. Such areas are still receiving sediment brought in by the flood tide, overwash, and the wind. Most of these areas, if they survive, will become a type of back beach flat.

G. Vegetated Former Beach (on marsh areas behind inlets)

In many locations, distinct beach prisms can be recognized, surrounded by marsh. These appear to develop as the result of changes in the geometry of an inlet, which allows storm generated waves to drive sand over the marsh areas inside the inlet.

H. New Dunes (mostly unvegetated)

This symbol was used to represent areas where accreting beach deposits are being reworked by wind (and perhaps overwash). Small new dunes are abundant, and small overwash channels are evident. Younger areas included in this category often show multiple berms, and are not vegetated. Older areas show larger dunes, less overwash, no berms,

and scattered patches of vegetation,

I. Active, Established Dunes

This designation was given to areas where previously established dunes are not stabilized by vegetation, and are therefore subject to migration. Such dune areas tend to have more relief than new dune areas, typically in the range of 5 to 10 feet.

J. Old, Stablized Dunes

This designation was given to many areas on the barrier island where a continuous grass cover has developed on sand dune deposits. In general, these dunes are no longer visibly migrating. Although many such areas lie inshore of beaches that are retreating at appreciable rates, most areas included in this category are not being overwashed. The dunes in this classification are also backed up by marsh areas, in almost every instance.

K. Dune Area Cut by Multiple Overwashed Channels

In many areas, particularly those areas where the barrier island deposits are narrow (150 to 250 feet maximum), there are patterns of small vegetated sand dunes and narrow overwash channels, intimately interlaced. Where it was practical to separate such fine detail, the entire area was mapped with this symbol. Such areas are intermediate between normally retreating sections of beach, and stretches of beach that are experiencing rapid "rollback" by large scale overwash.

L. Dunes Developing on Overwash

In some areas of rather extensive overwash deposits, new dunes are evident. In order to preserve the information concerning the overwash origin of these deposits which are being modified by dune building processes, a separate symbol was used for these areas. In many parts of the barrier island system, this unit indicates areas that are beginning to stabilize after a period of "rapid rollback" of the beach.

M. Parramore Pimples

On many islands, particularly on Parramore Island, peculiar circular, or nearly circular features are readily distinguished. An explanation for this formation is given later in this report. All features throughout the Virginia Barrier Island Group that resemble the classic mounds on Parramore were mapped as Parramore Pimples.

N. Beach Ridge (no certain origin)

The subject of the formation of these ridges remains controversial in the geologic literature. Some argue that these deposits represent major berms of ancient beaches while others argue that all such ridges are dune ridges. The argument may be specious. Rather than assigning a positive description to areas of beach ridge which could have originated through either mode, this symbol was used.

O. Beach Ridge (strandline origin)

In areas where a definite strandline origin for the beach ridge was apparent on the photographs, this pattern was used to show the beach ridge deposits. In some instances units marked with this symbol may be recurved sand spits and old berm ridges.

P. Distinct Overwash Channels, Overwashed Deposits from Multiple Channels

In order to display the relative significance of overwash processes in different areas of these islands, it was important to distinguish overwash channels of small size. Below this size, the overall character of an area transected by multiple overwash channels was mapped with a separate symbol.

Q. Vegetated Overwash Deposits

In many locations, overwash origin of sand deposits which are now vegetated could readily be distinguished on the I.R. imagery. Such deposits were mapped with a unique symbol so that their mode of origin would stand out.

R. Distinct Overwash Fans Related to One Channel

At the landward margin of an overwashed channel, the sands are generally deposited in a radial, or fan-shaped pattern. These are readily distinguished on the I.R. imagery, and were so mapped.

S. Recent, Unvegetated Overwash (without dunes)

This symbol is used to portray areas of overwash of all sizes that were of sufficiently recent origin (2-3 years) to be easily identified on the I.R. imagery because they lacked vegetation.

T. Sand Flats (uncertain origin)

In many areas of a barrier island, extensive sand flats develop which have few, if any, distinguishing features to indicate their mode of origin. This symbol has been used for these cases. However, in many locations, sand flats develop as a result of extensive matts of marsh detritus being stranded on the lagoon side of the barrier islands. As the organic material decays, it appears to kill the vegetation of the area and results in the production of a wide and often long barren sand flat area. Care has been taken to relate such areas to the fundamental geology of the area and not to such ephemeral events. Mud flats are distinguished from sand flats in such cases.

U. Vegetated Sand Flats

These areas are identical to the above areas except that they are generally completely vegetated by grasses.

V. Salt Pans

In many locations on the marsh, the water from high tide does not completely drain during low tide. These puddles evaporate and produce salt encrustations. In a few areas these features were mapped. In most cases, little attention was paid to salt pans as they have questionable geologic significance.

W. Inlet Deposits

In many areas within the marsh and lagoon, it is possible to easily distinguish old flood tide delta deposits which have grown above sea level and are often vegetated. These deposits may lie in the vicinity of a presently active inlet or may be entirely surrounded by marsh and thus represent the position of an inlet which has closed.

X. Inferred Inlet Deposits in Marsh Areas

In many places within marshes, there are topographically higher areas which are sandy.

These deposits often are of the size and geometry which suggests an origin as flood tide inlet deltas.

Y. Established Marsh

All areas of well-established tidal salt marsh plants are mapped with a symbol. No attempt is made to distinguish between high marsh or low marsh vegetation, because these vegetative patterns have little relation to the local geology.

Z. Young Marsh and Vegetating Mud Flats

Areas within and adjacent to established marsh which appear to be sparsely vegetated or flooded daily are mapped with this symbol. These areas represent recent development of salt marsh.

AA. Mud Flats

Areas which appear to represent unvegetated mud flats, primarily within the lagoon, have been mapped with this symbol. Where possible, the existence of mud at these locations has been substantiated from published reports and field work. However, many submerged or inter-tidal sand flat deposits may easily have been mistakenly placed in this category.

BB. Dredged Spoil

Many areas of salt marsh have been buried with sediment from recent dredging operations. Where these areas could be recognized, they are distinguished with a pattern. A star-shaped symbol in the pattern indicates the location of the end of the outflow pipe used in pumping the spoil to that location. The outer contact line indicates the recognizable boundary of flow of the dredged spoil.

CC. Artificial Fill

Areas which have been artifically filled for the purposes of creating building or road sites are shown with this symbol.

DD. Ridge Lines on Beach Ridges

Very often the overall mode of growth of an island can be determined by noting the succession of beach ridges. In some areas, such as the southern tip of Smith Island, the beach ridges are extremely obvious. In other areas beach ridges may be very subtle. In each case where the linear trend of a beach ridge could be determined from the I.R. imagery, this symbol was used. In addition, the symbol was used for discontinuous beach ridge deposits that clearly exhibited a linear pattern. This includes many areas of Parramore Pimples within which linear patterns could be determined.

EE. Old Strand Lines

At many locations former shoreline positions can be distinguished by features such as old beach ridge systems or continuous long depressions. This information is highly significant in determining the processes leading to the growth of these islands. Therefore, features showing this information were mapped with this symbol.

FF. Old Inlet Openings

This symbol was used in areas where beach ridge and strand line patterns coupled with other information concerning the deposits definitely indicated the location of former

inlets. The lines were used to mark the maximum width of those inlets inferred from the geomorphic features and lineations. In many cases those inlets correspond to inlets shown on the historic shoreline maps. In other cases they show inlets which existed prior to the mid-1800's.

GG. Position of Former Marsh Channels

Linear features within the marshes often follow boundaries of old tidal canals. These boundaries may be obscured on the I.R. imagery by more recent deposition of sand, silt, and mud, and by the vegetation of the area. However, the geometry of these former marsh canals and their relative size is often very significant in determining long term history of these islands. Therefore, wherever former marsh channels could be inferred from linear features in the marsh, these symbols were used. In areas where several marsh canals existed, or in some cases intersected and even crossed, patterns involving one, two, three, or four dots between the dashed segments were used to distinguish different canals.

X. QUALIFYING STATEMENT

In concluding this section, several points should be clarified for the benefit of the reader who casually may use these maps in the future. First, the maps were prepared from false color I.R. imagery that was photographed in June of 1974. Therefore, the maps reflect the geology at that time. This is particularly true for the seaward side of the barrier islands where change occurs most rapidly. Secondly, geologic processes are on-going in time, and the future user must take into account the effect of time. For instance, an inshore area mapped as new dunes on overwash in June, 1974 could appear as stable vegetated dunes in 1984. Finally, an explanation of the use of the work "vegetated" as a qualifying criterion in setting the geologic symbols is offered. The presence, or absence, of vegetation is an important factor influencing geologic processes in the coastal environment. Its presence at one location can cause the trapping of sand that deprives another location of sand that it needs, to make up for erosional losses. The reader should be aware that on-going geologic processes can change the physical conditions for a plant community, and consequently lead to changes in that community, i.e., species changes. The interaction of the plant community and the geologic processes that affect the barrier islands may therefore result in features and conditions that differ from those recorded by researchers at the time of the 1974 Coast Reserve Study.

THE VIRGINIA BARRIER ISLANDS

The islands in the Virginia Barrier Island Group have been investigated one by one, beginning with Metomkin Island near the north end of the group. A series of maps was produced for each island. Shoreline comparison maps (2-4) are included in the text of this report, in the section treating the island to which they apply. Two large scale maps were also produced for each island at scales of approximately 1: 6900 (1 in. = 575 feet). These maps are planimetric. One shows the geography of the island and adjacent marsh area, and is intended primarily for locations reference and general use by The Nature Conservancy. The second shows the geology of the island, superimposed upon the first, and is intended as a specific scientific reference map for the section of each island description dealing with the geology of the island. These maps have been delivered to The Nature Conservancy in roll-form, separate from the text of this report. The reader may wish to have both maps available when reading the island descriptions. These large scale maps are accurate as of June 4, 1974 when the I.R. imagery from which they were prepared was flown. A few of them have been corrected for significant changes through April, 1975, and these can be identified from the shoreline positions maps, where a 1975 section of shoreline is noted. Finally, the Virginia part of Chincoteague Island, Wallops Island, and Assawoman Island are not included in the following descriptions because the interests of The Nature Conservancy did not encompass them.

METOMKIN ISLAND

I. GEOGRAPHY

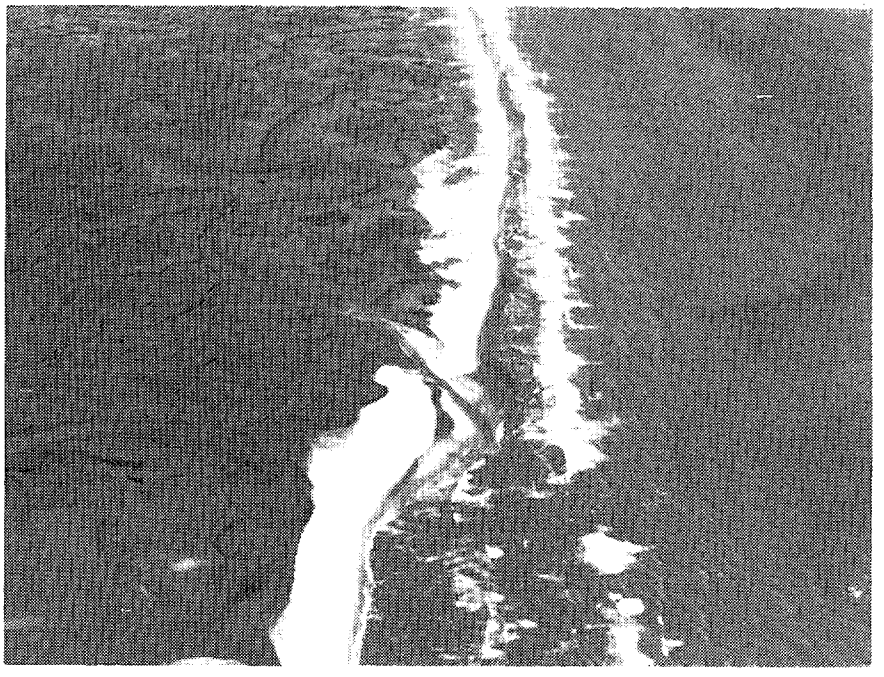
Metomkin Island is the northernmost island in the study area and is the third island from the north in the Virginia Barrier Island Group. Adjacent communities on the mainland are Metomkin and Daugherty, and further inland are the towns of Accomack, Onancock, Onley, and Tasley. The island is separated from Assawoman Island on the north by Gargathy Inlet, and from Cedar Island to the south by Metomkin Inlet. The June, 1974 imagery, upon which the mapping is based, shows that Metomkin Island is made up of three parts separated by lesser inlets. The parts are designated North, Middle, and South Metomkin Islands, respectively. The seaward beach face at the north end lies approximately 1.5 miles from the mainland and this distance increases down the island to 1.9 miles at the south end.

II. PHYSIOGRAPHIC DESCRIPTION

North Metomkin Island may be described as a narrow linear barrier island backed by extensive marsh except at its southern end where perhaps 15% of the island's length is backed by Metomkin Bay with little or no marsh present. The roughly circular and smaller Gargathy Bay is contained in the marsh behind the northern portion of the island. Except for the portion of the island backed by Metomkin Bay, most of the length of this island exhibits dune fields and scattered beach ridges. The maximum relief of this part of the island is 8 feet (U.S.G.S. Topographic map, 1968). The southern portion exhibits an array of old berms and new, mostly unvegetated, dunes with a relief of several feet. There are numerous reaches of active overwash consisting of small scale overwash channels and small fans or narrow aprons. During a storm on April 1, 1975, the southern end of this island was cut off when a new inlet opened at the south edge of the marsh. This inlet had not sealed when the area was visited on September 27, 1975. The new inlet, Gargathy Inlet, and most of North Metomkin Island, are shown in the photographs which are reproduced in Figure 14.

Middle Metomkin Island is an accreting and mobile barrier island with little marsh behind it. The present length is 0.9 mile. The beach face is 0.3 mile closer to the mainland than that of North Metomkin. The inlet that separates it from the southern tip of North Metomkin is clogged with flood tide deposits, many of which are emergent as beaches or low islands with new dunes beginning to form on them. However, well defined channels connect into the bay, and a deep inlet channel turns toward the northeast behind an inlet island on the seaward side of the inlet. This seaward island is built upon marsh peat that had been overridden by the retreating barrier island. Other outcroppings of marsh peat are found seaward of the beach all along Metomkin Bay.

The inlet at the south end of Middle Metomkin is protected on the seaward side by a large outcropping of marsh peat and has a well defined channel directed northeasterly and outward from the inlet. The flood tide deposits on the bay side of this inlet clearly show ebb and flood current influences with established new channels connecting into Metomkin Bay. There is also some accretion of sand around and upon the peat on the seaward side, but no visible evidence of an ebb tide delta. Portions of earlier inlet deposits lie along the bay side of this island, and new marsh is forming on and around them. On the island, itself, new low dunes are forming and some are beginning to vegetate. The relief of the entire island is very low, reaching a maximum relief of 3 to 4 feet above the most recent storm berm. This island has moved, grown, and closed a major shallow opening into Metomkin Bay that is shown on the 1968 topographic map of the area.



a. View is northward. 1975 ephemeral inlet at south end of North Metomkin Island.

b. View is northward. Gargathy Inlet, center, and North Metomkin Island, bottom, in July 1975.

FIGURE 14: North Metomkin Island and Gargathy Inlet

South Metomkin Island has a longer and straighter beach than Middle Metomkin Island. This island is backed by some marsh areas which contain large tidal canals. These channels are remnants of an older and more extensive marsh and tidal canal system. The island is separated from Middle Metomkin by the inlet described above, and from Cedar Island by Metomkin Inlet. In the 1974 and 1975 imagery, a major inlet island is shown to be moving into Metomkin Inlet. Numerous flood tide deposits are forming in the bay inside of the inlet. These deposits have been formed in former channel areas, restricting those channels and enlarging mud flats and other inlet deposits. This suggests that the tidal circulation in Metomkin Bay may be shifting in the direction of establishing one of the new inlets as the major inlet, with the shifting or closing of Metomkin Inlet being fostered by the northward growth of the north end of Cedar Island. This will be discussed further in the part of this section dealing with tidal circulation. Figure 15 shows the beach and recurved sand spits at the north end of this island and the southern end of the older marsh behind the island. The photograph of the marsh area shows an old dredge spoil dump in the marsh.

III. SHORELINE CHANGES

Historical charts (U.S.C. & G.S. charts) have been used to prepare the Historical Shoreline Positions Maps of Metomkin Island (Figures 16 and 17) included with this report. (Dr. Robert Byrne of V.I.M.S. has prepared a similar set of Historical Shoreline Position Maps for his studies in the area.) These maps indicate that Metomkin Island was a single barrier island in 1852 and that the shoreline retreated quite uniformly until 1955. Shoreline retreat during this period varied from 0.25 to 0.35 mile at various locations along the island's length for an average rate of retreat of 15.4 ft./yr. between 1852 and 1955. By 1955, the southern portion of the island, east of Metomkin Bay, had been reduced to a thin barrier island with little marsh behind it except at the southern end. Figure 18 shows recent shoreline positions for Metomkin Island, and Figure 19 portrays the changes to Metomkin Island along Metomkin Bay since 1955.

Between the 1955 mapping of the area and the 1957 plane table survey of the island, an inlet was opened through this thin portion of the island to create South Metomkin Island. Hurricanes Connie and Diane (Truitt, 1968) in August, 1955 hit this area two weeks apart, and it is reasonable to attribute the inlet opening to them. (However, Kenmerer (1972) cites a damage producing storm in January, 1956 that could also have caused the island to breach, or could have enlarged a previous breach.) In the interval between 1957 and 1966, the barrier island north of this new inlet retreated rapidly northward until this inlet opening approached 6000 feet in width. Hurricane Donna in September, 1960 and the Great March Storm of 1962 (Truitt, 1968) undoubtedly accelerated this process. Byrne (1975, unpublished communication) notes that the rapid widening of this shallow inlet was accelerated when the 1962 storm broke through the thin remaining barrier beach in several places.

In the interval from 1955 to 1961, the rate of erosion of the shoreline of North Metomkin Island increased from an average of 15.4 ft./yr. to an average of 17.6 ft./yr. with the rate being somewhat higher along the beach at both the north and south ends. In the interval from 1961 to 1963, the shoreline retreated an average of more than 300 feet. How much of this is attributable to the March, 1962 storm and how much is due to the changing regime of sediment transport is uncertain.

During the period 1955 to 1961, the beach on the southern half of newly formed South Metomkin Island was eroding back at an average rate of 47 ft./yr. with the rate higher at the southern end and falling to zero at a point about two-thirds of the way up the island where the shoreline position remained essentially unchanged. The shoreline

a. North end of South Metomkin Island. Photo shows a pattern of advancing recurved sand spits, bypassed inlet deposits, and peat outcrops seaward of the beach.

b. Established marsh area behind south end of South Metomkin Island. Old dredged spoil dump is at center.

FIGURE 15: South Metomkin Island

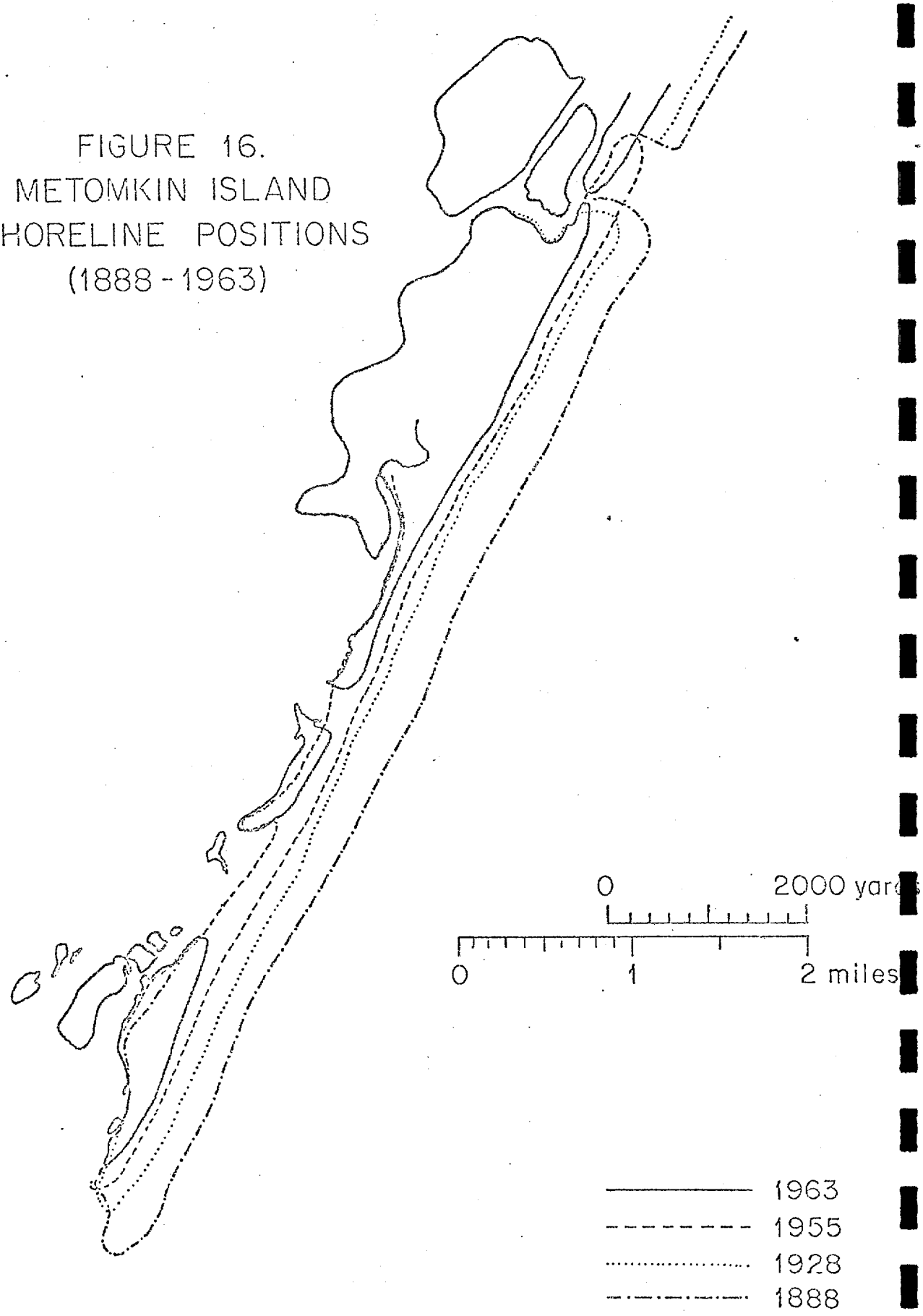
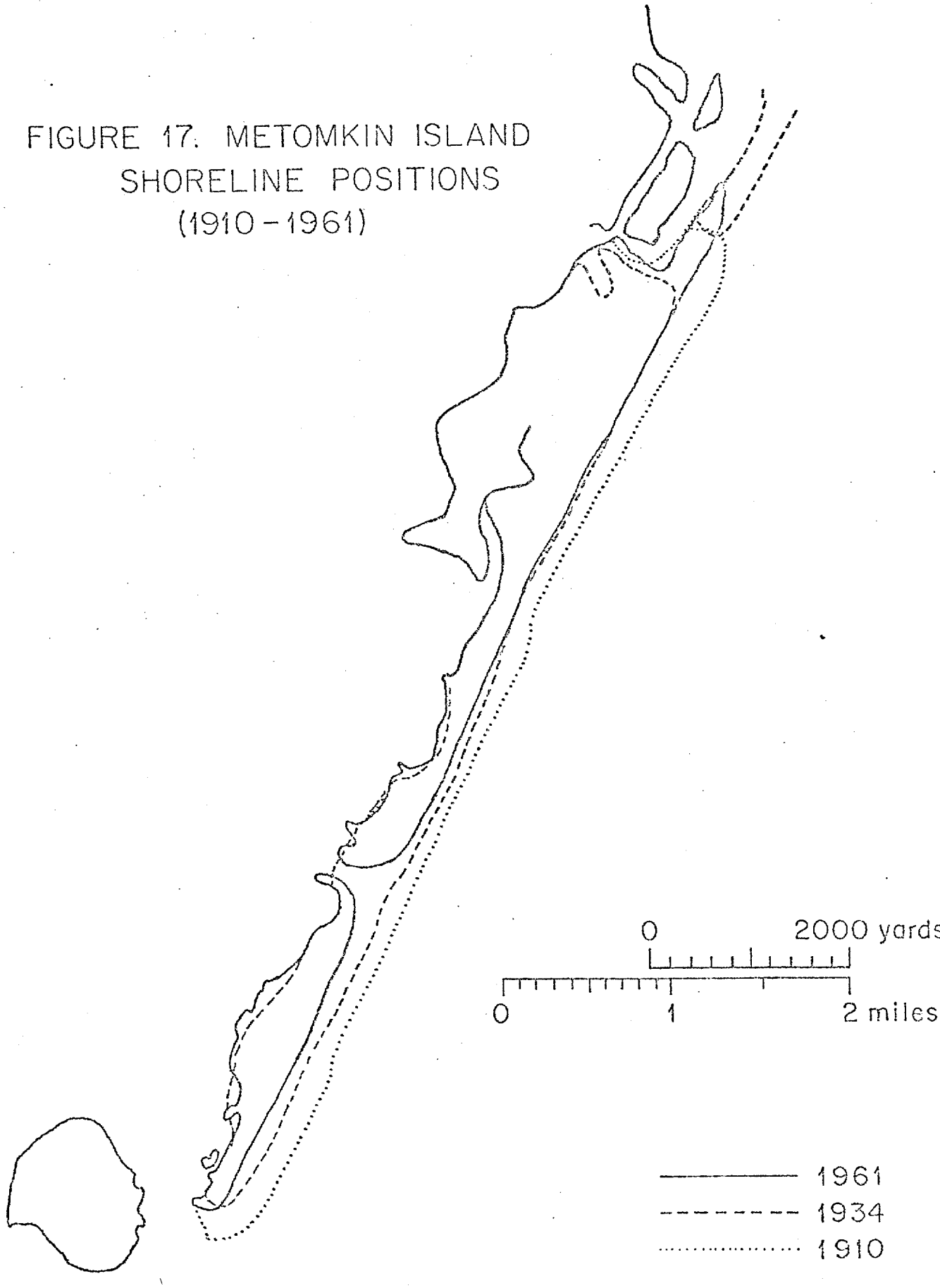


FIGURE 16.
METOMKIN ISLAND
SHORELINE POSITIONS
(1888 - 1963)

FIGURE 17. METOMKIN ISLAND SHORELINE POSITIONS (1910 - 1961)



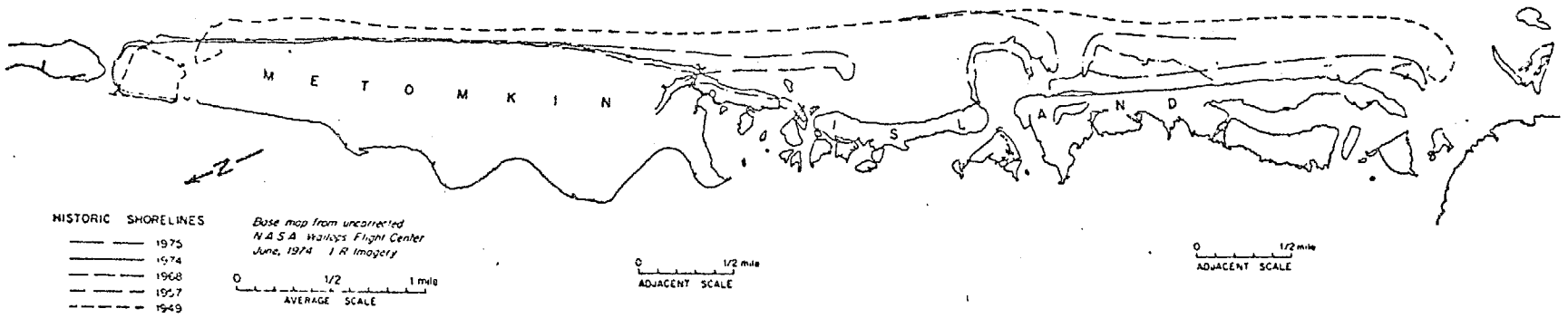


FIGURE 18. RECENT SHORELINE POSITIONS ON METOMKIN ISLAND (1949 – 1975)

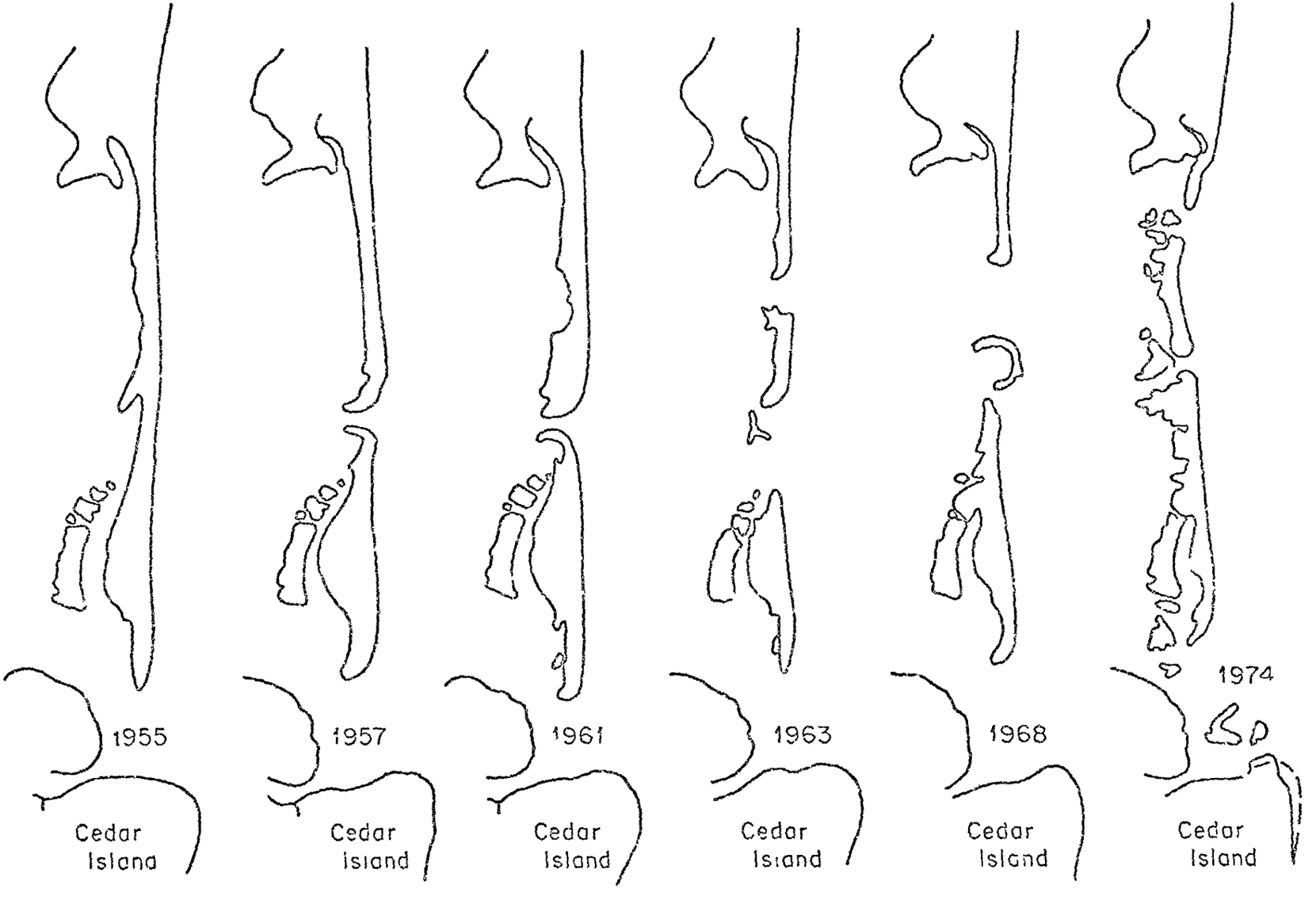


FIGURE 19 SEQUENTIAL CHANGES IN BARRIER ISLANDS EAST OF METOMKIN BAY

along the northern quarter of this island retreated more rapidly as the end of the island recurved toward the bay and the new inlet opening.

In the two years from 1961 to 1963, South Metomkin Island was reduced about one-third in area, presumably during the March, 1962 storm. By 1963 the north end of the island had been shortened by more than 2,500 feet and the south end by about 840 feet. The beach on the southern third of the reduced island had remained in place. From just south of the midpoint on the island to the north end, the beach had retreated about 425 feet. The gap between the north end of South Metomkin Island and the south end of the barrier beach on North Metomkin Island had widened to more than 8,500 feet. An unstable island occupied about 3,900 feet of this gap so as to form a narrow northern inlet and a broad southern inlet.

Rapid changes in the section of Metomkin Island bordering Metomkin Bay continued (Figure 19) and presumably will continue until the tidal circulation in Metomkin Bay becomes established in a more stable pattern. By 1974, South Metomkin Island had grown in length from 7,600 feet to 10,850 feet, a gain of 3,250 feet. The unstable island that lay in the gap had stabilized to an elongated barrier beach 4,850 feet in length, and had moved northward as a barrier beach at the south end of North Metomkin Island was shortened by about 1,950 feet. The broad, shallow, ephemeral southern inlet of 1963 narrowed from 3,500 feet to 750 feet as it shifted northward and developed a channel system. The northern 1963 inlet, while shifting northward and becoming established, had diminished only slightly in width, from 1,270 feet to 1,000 feet.

Shoreline positions for the part of Metomkin Island east of Metomkin Bay during this period of break-up of the island are shown in Figure 19. The maps of this figure indicate that South Metomkin Island, after a period of very rapid washback, had slowed its rate of retreat to an average of 71.4 feet/year, and is now extending its length northward. The path of inlet migration is clearly shown in this figure. Because Middle Metomkin Island has been forming and stablizing during this period, changes in shoreline position are of little meaning. However, it is worth noting that this island is reforming 2,800 feet west of the 1957 shoreline position, a measure of the magnitude of change for this portion of the island. The creation of yet another new inlet at the beginning of April, 1975 near the south edge of the marsh behind North Metomkin Island suggests that the processes of adjustment of the north end of Metomkin Bay are continuing.

This analysis of shoreline changes, and a consideration of the map of shoreline changes over the past quarter century (Figure 18) leads one to certain inferences in regard to these changes. First, it is apparent that as long as Metomkin Island presented a uniform beach face to the sea, the rate of retreat remained quite uniform for the whole island. This implies an undisturbed longshore drift pattern, whatever it may have been. Second, it is apparent that once the barrier island was breached and a new inlet connected to Metomkin Bay, the pattern and rate of beach erosion changed abruptly. This implies both a change in the pattern of longshore drift and a change in tidal circulation in Metomkin Bay.

Figure 18 shows that since 1955 the shoreline of Metomkin Island has been literally sucked into Metomkin Bay. DeAlteris (1976) has suggested that following breaching of a barrier island, flood tide currents produce rapid beach erosion and bay filling, which would result in the effect of "sucking-in" the shoreline. The effects of this change extend to the north nearly half way up the length of North Metomkin Island. However, this change does not appear to have affected appreciably the north end of Cedar Island, or the northern half of North Metomkin Island where shoreline changes more closely follow the previous pattern. The implication of this is that the component

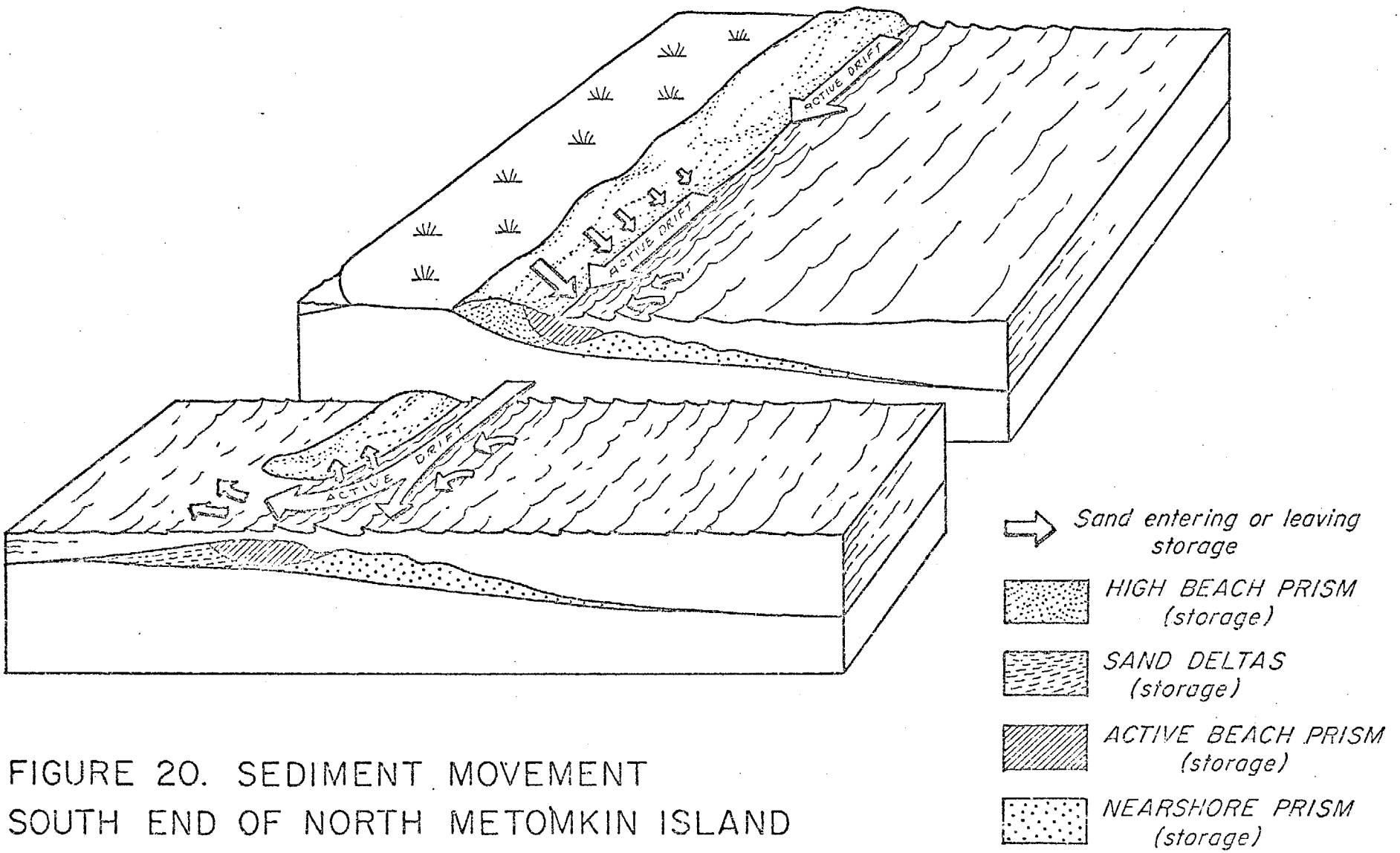


FIGURE 20. SEDIMENT MOVEMENT
SOUTH END OF NORTH METOMKIN ISLAND

associated with the nearshore sediment prism has not changed appreciably.

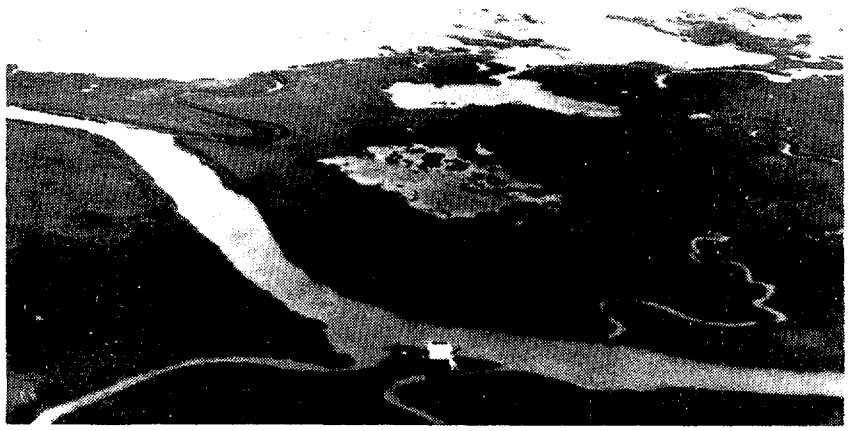
Figure 20 illustrates what appears to be happening to the sediment drift along the southern shore of North Metomkin Island. In cross-section, the diagram shows the sediment mass of the barrier island and the nearshore sediment associated with it. It does not portray the substrate, or marsh and bay deposits. Along the barrier island, this sediment mass can be treated in three parts; the high beach prism, the active beach prism, and the nearshore prism. This is not the usual manner of addressing these sediments, but in this instance it is useful, and seems to fit with observed evidence.

The high beach prism represents sand in storage above the high tide line and behind the storm berm. Sand in this prism is under the influence of wind, and storm events. It comprises what is commonly recognized as the upland barrier island, but within the longshore drift system, it is stored sand. The active beach prism represents that mass of sand which is frequently set in motion by wave activity along the beach. This prism is most directly responsive to diurnal events; tides, wind and wave direction, storms. The prism responds quickly to immediate forces, and over the longer period to averaged forces such as seasonal changes in wind and wave direction and changes in the local tidal circulation. Most active drift of sediment along a shore is through this prism. The nearshore prism represents a mass of sediment that lies outside the normal surf zone. It is influenced by at least two factors, longshore currents and storm activity. The nearshore side of this prism is more susceptible to disturbance than the portion which lies in deeper water. Although sediment in this prism experiences both slow drift and abrupt movement due to storms, it otherwise can be considered to be in storage. Along the east side of Metomkin Bay, sand deltas may be the storage analogue of the high beach prism of a retreating barrier island.

Along the seaward face of a barrier island, interchanges of sediment between these prisms is noticed only as a result of time-averaged changes in the appearance of the barrier island; i.e., evidence of gradual accretion or erosion of the high beach prism. In a situation where the active beach prism is being rapidly depleted of sand, this loss can only be made up by removal of sand from storage and that will be reflected in an accelerated and noticeable rate of erosion. Sand will be rapidly brought back into circulation from storage in the high beach prism by daily wave activity, and more slowly from the nearshore prism as offshore slope adjustments occur. This appears to be the process that is operating along the southern half of North Metomkin Island, and at the northern end of Metomkin Bay.

The separate geographic and geologic maps of Metomkin Island that accompany this report show that large volumes of sand have been deposited in Metomkin Bay as flood tide and inlet island deposits. Cherry (1968) noted that large amounts of sand had been washed back over the marshes and remarked that little beach remained on Metomkin Island at that time. Byrne (1975, unpublished personal communication) has indicated that large sand deltas were spread into Metomkin Bay at the onset of this shoreline change in the mid-1950's. This was before the migration of the new inlets began. These earlier sand deltas have been partially reworked as the beach has continued to roll back, and their sand is contributing to the growing active beach prisms of South and Middle Metomkin Islands (See Figure 21).

As the inlets have migrated north, additional sand has been carried into the bay and deposited as flood tide deltas. The increased rate of washback of the south end of North Metomkin Island indicates that active beach prism is being sapped as sand is being shunted into Metomkin Bay through the inlet between North and Middle Metomkin Islands. There is some indication that this disruption of longshore transport associated with the active beach prism is increasingly being restricted to the shoreline section associated with the south end of North Metomkin Island and the inlet located there.



a. Multiple overwash channels and overwash fans in marsh, south end of North Metomkin Island.

b. Offshore peat outcrops, multiple sand spits, and overrun flood tide deposits at north end of South Metomkin Island show nature of island's migration.

FIGURE 21: Beach Migration on Metomkin Islands

In recent years, the shoreline of South Metomkin has been following a parallel mode of retreat, and the rate of retreat is less.

That longshore transport associated with the nearshore sediment prism has been less affected by these shoreline changes may be seen at Metomkin Inlet. The north end of Cedar Island (Figure 19), while retreating landward since 1852, has retained its position remarkably well. Byrne's Historical Shorelines Position Maps (1972) show that from 1852 to 1962 the dimensions of the inlet opening have increased steadily, and that the inlet has become progressively offset as the south end of Metomkin Island moved into Metomkin Bay.

Kemmerer (1972) reports migration of Metomkin Inlet, but neither Byrne's maps nor the work of this study show any evidence to support a thesis that Metomkin Inlet has migrated within the past one and one-quarter centuries. Since 1966, approximately 350 feet have been lost from the beach of Cedar Island along the half-mile south of Metomkin Inlet. In the same time period, the north end of Cedar Island has grown to the north approximately 350 feet, and the beach a mile south of the inlet has grown seaward by up to 150 feet for a distance of over a mile. During this same time interval, large volumes of sand have been carried into Metomkin Bay and deposited as flood tide deltas and inlet islands. All of this evidence tends to indicate that longshore drift associated with the near shore sediment prism has continued to operate at nearly the same rate as it did prior to the breaching of Metomkin Inlet in the mid-1950's. It is worth pointing out at this point that the growing offset of Metomkin Inlet appears to be related more to the retreat of the Metomkin beach and the disruption of longshore transport in the active beach prism than to wave activity (Goldsmith, 1975) or to bar building on the down drift side of the inlet (Boothroyd, 1972).

IV. TIDAL CIRCULATION

The rapid changes along the eastern edge of Metomkin Bay that began in the mid-1950's clearly disrupted the former pattern of tidal circulation within the bay that had maintained Metomkin Inlet. This study has shown that during the preceding period of rapid change that led to the formation of the present South and Middle Metomkin Islands, the two new tidal inlets have shifted north. This northerly shift has been accompanied by a shift in tidal circulation in the southern part of Metomkin Bay toward increased ebb flow through the new inlets. There is clear evidence of ebb flow through both of the new inlets. The 1975 inlet appears to be kept clear by ebb flow from the marsh behind North Metomkin Island. The pattern of inlet deposits at these inlets indicates that ebb flow leaves the inlets along their northern sides, and discharges toward the northeast. Flood flow through these inlets appears to be directed toward the west and southwest. In the imagery from which the 1974 planimetric and geologic maps were made there is evidence in the pattern of tidal canals, marsh filling, and bars that tidal flow in the marsh behind North Metomkin has a net north to south component directed into Metomkin Bay.

These observations would suggest that prior to the mid-1950's, discharge through Metomkin Inlet had a net ebb flow component due to north to south tidal flow in the marsh behind North Metomkin. The circulation pattern that now appears to be developing allows that net ebb flow to discharge through the new inlets with the result that Metomkin Inlet is shifting toward a flood dominant inlet. The evidence of this study indicates that Metomkin Inlet will close, allowing Cedar Island to grow rapidly northward, annexing South Metomkin Island. Eventually one of the new inlets will stabilize. Present evidence would indicate that the inlet between North and Middle Metomkin Islands will migrate further north and then stabilize, allowing the inlet between Middle and South Metomkin Islands to close and join Middle Metomkin Island to Cedar Island.

V. GEOLOGY

Because of the recent rapid changes in the shoreline of Metomkin Island, the modern beach deposits, as shown on the accompanying geologic map, are both young and simple in form, consisting mostly of low dunes, berms, and overwash areas. These forms appear to have developed since the beach was devastated in the early 1960's (Cherry, 1968).

There is a line of vegetated dunes behind the beach along the middle reaches of North Metomkin Island that is built upon older overwash. The relief of these dunes is about 8 feet above high tide level. This line of dunes has been breached by overwash in several places, notably at the north end. Seaward of this line of dunes there is a strip, up to 400 feet in width, that consists of very low and partially vegetated dunes and abundant small overwash channels. This strip ends at the upper edge of the active beach, and is attributable to the process of rollback of the beach. About a mile south of the north end of this island, there is a recent overwash area approximately 3,000 feet in length. Sand from this overwash spread over the adjacent marsh. There is another smaller area of recent overwash just south of the north end of the island. At the very north end of this island there is a pattern of recently added berms that indicate some northward growth of the island. All of these forms indicate that rollback of the beach on North Metomkin Island is continuing, but that earlier damage has healed.

Middle Metomkin Island has developed a sufficient width (200 to 300 feet) to allow new dunes to begin to build along its length. Sand for these new dunes would appear to be derived from a pattern of berms that are being added along the beach face. This island is accreting at the present time.

South Metomkin Island has reached a width of 300 to 500 feet over most of its length, and a field of low dunes has been established. Vegetation has colonized these dunes which will facilitate their continued growth and stabilization. On the southern half of the island the dune field has been cut by overwash channels in several places. One or more berms have been built along the beach side, and these extend into spits at both ends of the island. This island, too, is presently accreting.

Both Middle and South Metomkin Islands are now backed by extensive sand deposits, many of which occur as tidal sand flats. There is some older marsh behind the southern half of South Metomkin Island. Marsh vegetation has been established on the new deposits behind these islands, which should facilitate further development of new marsh.

In the marsh behind North Metomkin Island there are a number of older landforms that stand out in the marsh. In the southwest corner of the marsh, and at its north end, there are a series of deposits which have been interpreted as submerged former beach deposits.

Throughout the marsh there are numerous former inlet islands, which are indicated on the geologic map of Metomkin Island with two symbols. Those which could readily be associated with former inlets have been marked with the inlet island pattern. Others, of uncertain association, are simply indicated by a marsh symbol.

In the southern portion of the marsh behind the modern beach deposits of North Metomkin Island, there is a pattern of recurved ridges, berms, and inlet deposits. These and the inlet islands north and west of them (up to the line on the geologic map indicating a former inlet opening) record the northward migration of a former inlet and the concommitant northward growth of the island south of it.

In the middle portion of the marsh behind North Metomkin Island there is evidence of

a former very wide inlet opening and of a later and smaller inlet opening. The shape and size of the inlet islands in this area attest to the magnitude of the inlet opening. Beach retreat in the last century or more has obliterated evidence to the east which might have yielded more information about this inlet and the islands associated with it. The younger, and smaller, inlet at the northern edge connects through the marsh to vestigal canals which are visible on the false color I.R. imagery. Only the major canals which are readily discernible were portrayed on the geologic map.

Near the north end of the island another inlet opening is shown on the geologic map with several associated inlet islands behind it. It is known that this inlet was closed between 1955 and 1957. This inlet was formerly a branch canal leading from Gargathy Inlet to Gargathy Bay. The 1949 black and white aerial photograph shows that retreat of the beach has progressed to the point where the inlet opening coincided with the merging of drainage canals from Gargathy Bay and Kegotank Bay, with the inland waterway joining the two through the intervening marsh. Between 1949 and 1955, the north end of Metomkin Island grew rapidly until it coincided with the southern margin of drainage from Kegotank Bay. Between 1955 (U.S.C. & G.S. charts) and 1957 (U.S.G.S. Plane Table Survey), this inlet closed, and the beach merged with the segment of marsh cut off by the inland waterway. Since that time, the inland waterway has functioned as the inlet opening to Gargathy Bay. Gargathy Inlet is now much narrower than it was in 1949, and appears to be dominated by ebb flow from Kegotank Bay.

Except for a small portion of marsh (containing former major tidal canals) which still exists behind South Metomkin Island, all other geomorphic evidence of the earlier history of this island has been destroyed by beach retreat. Interpretation of the limited older geomorphology yields a sketchy geologic history of the island. The previously mentioned strand lines in the north and southwest portions of the marsh appear to be the oldest features in this island's history. Those in the southwest portion of the marsh indicate the absence of a barrier island system with the beach against the mainland. Other marsh features near the mainland tend to support this. The northern set of strand lines indicates a beach migrating southeast from the mainland, although the nature of this occurrence is less clear. Both of these features indicate the onset of a decrease in sea level at some ancient time.

The pattern of ridges, berms and inlet deposits of the southern portions of the marsh behind North Metomkin Island indicate a continuing drop in sea level with the subsequent formation of a barrier island that migrated northward until inlet processes arrested its further migration. At this stage of development, it appears that Gargathy Bay, Kegotank Bay, and Metomkin Bay were connected and bay circulation was through this major inlet at the mid-point of the present North Metomkin Island. There is little other geomorphic evidence of the earlier history of Metomkin Island. Presumably another island was present north of this inlet, but its position must have been offset to the east of the modern beach deposits because there is no recognizable evidence of that island in the marsh north of the old inlet. The smaller inlet opening marked at the northern margin of this inlet area was probably a large tidal canal that connected to the bay when the island and marsh extended further to the east.

The present changes in the island east of Metomkin Bay are a normal part of the barrier island processes. The barrier island migration mentioned in the preceding paragraph was a similar event that occurred in a more ancient time. The processes and results remain essentially the same, and when the present adjustments along Metomkin Bay are complete, the new island will display similar ridges, berms, and inlet deposits as a partial record of its growth.

CEDAR ISLAND

I. GEOGRAPHY

Cedar Island is the fourth island from the north end of the Virginia Barrier Island Group. It is located between Metomkin and Parramore Islands, and is bounded on the north by Metomkin Inlet and on the south by Wachapreague Inlet. This island, like Metomkin, has an extensive marsh area behind it at the north end, and a long thin spit at the south end. The marsh area at the north end extends to the mainland and contains the nearby circular Cedar Island Bay which is approximately a mile in diameter. The much larger Burton's Bay extends from the southern sand spit on Cedar Island to the mainland and reaches up into the marsh behind the mid-portion of Cedar Island. The island is about 6.5 miles long on its seaward side, and lies at a slight angle to the mainland coast. At the north end, the island is nearly two miles off the mainland while at the south end, it is almost four miles from the mainland.

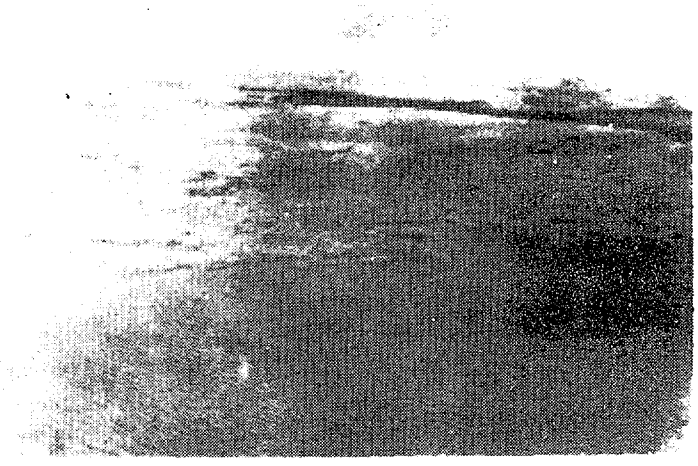
The barrier island itself varies in width along its length. At the north end where the beach ridge area is most developed, the barrier island reaches a width of 2,500 feet. Kemmerer (1972) reports a width here of 900 yards, which indicates a 200-foot disagreement with this figure. It is unclear whether one or both of the measurements are in error. It is likely that there is an error factor in the measurements introduced by the reduced scale Xerox copies of charts obtained from the G.S.A., Archives Division. However, it seems unlikely that the Xerox reproduction system could introduce an 8% error, and other possible sources of error have been rechecked. South of the widened north end of the island, the upland portion of Cedar Island rapidly narrows to a width of about 200 feet in the section east of the extensive marsh area. At Burton's Bay, the island narrows again to an average total width, including marsh, of 600 feet. This width is maintained along Burton's Bay until the island widens again at the site of an ephemeral inlet north of Trout Channel. Here the island widens again to between 800 and 1,200 feet before it narrows again at its southern sand spit. There is a small area of older marsh behind the island in the vicinity of Trout Channel. However, much of the marsh behind this part of the island has been colonized recently on inlet deposits and overwash associated with the closing of the ephemeral inlet north of Trout Channel. This part of the island is shown in Figure 22, a & b.

Daugherty and Locustville are the nearest mainland communities. The town of Onley, which is on the main highway (US-13) lies west of the north end of Cedar Island. Folly Creek Landing, Burton's Shore, and Wachapreague have landings from which the island may be reached by boat. The reader who wishes to visit Cedar Island is cautioned that the waters of Burton's Bay are very shallow, and the guidance of a local waterman should be sought before attempting to reach the island.

II. PHYSIOGRAPHIC DESCRIPTION

Physiographically, Cedar Island may be described as a long, thin barrier island composed throughout of beach and low dune fields with scattered, isolated areas of beach ridges. The relief of the low dune fields behind the beach is in the range of 6 to 10 feet. The relief of the beach ridges at the northern end of the island reaches 15 to 20 feet (see Figure 23), while those at the southern end of the island (Figure 22) are slightly lower. There are isolated remnants of beach ridges in the marsh behind the barrier island. Sneads Beach is one such isolated and partially submerged beach ridge found in the marsh.

There are two bays behind Cedar Island. Cedar Island Bay is situated near the mainland, in the marsh behind the northern third of the island. This bay is connected to Metomkin



a. Aerial view of sand delta formed in Burtons Bay during the lifetime of the 1950's - 60's ephemeral inlet on the southern sand spit.

b. Wachapreague Inlet, showing north end of Parramore Island, Dawson Shoals, and the southern part of Cedar Island.

FIGURE 22: South End of Cedar Island

Inlet through Longboat Creek, and to Burton's Bay by Teagle's Ditch. Cedar Island Bay has filled with sediment in the past century, to the extent that much of it is now tidal flats. Teagle's Ditch, which began as a narrow 4-5 foot, man-made canal is now approximately 400 feet wide (Hennessey, 1975, personal communication). The Inland Waterway follows a course through Longboat Creek, Cedar Island Bay, and Teagle's Ditch as it connects Metomkin Inlet to Burton's Bay. Dredging of the Inland Waterway on its course to the Town of Wachapreague by the U.S. Army Corp of Engineers has kept the passage open through Cedar Island Bay, and has undoubtedly helped to widen Teagle's Ditch. However, there is strong evidence in the I.R. imagery used for this study to indicate that tidal circulation in the marsh behind Cedar Island is now from north to south, and one cannot but wonder about the role of Teagle's Ditch in this circulation pattern.

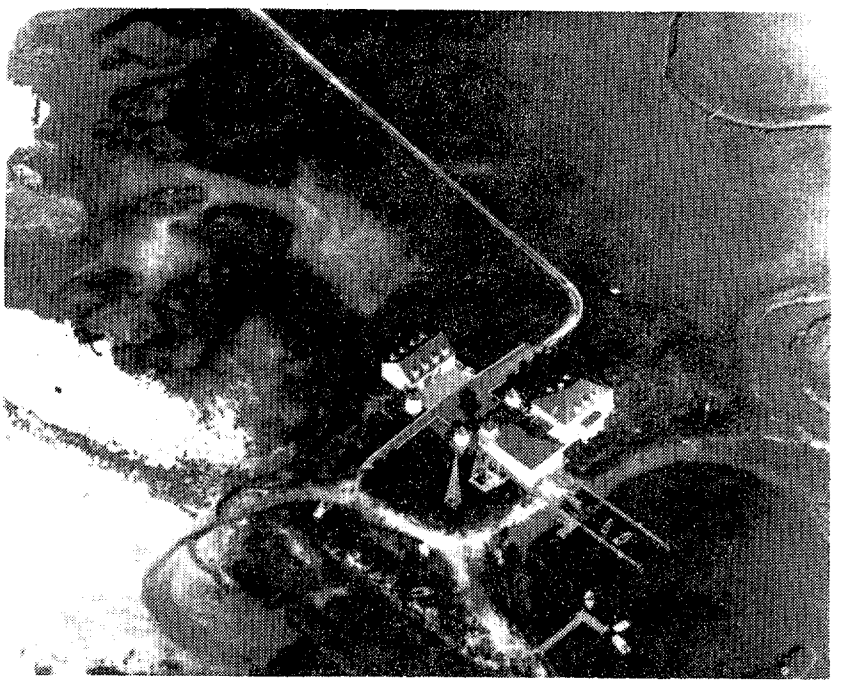
Burton's Bay, the larger of the two bays, extends along the mainland behind Cedar Island for 3-5 miles. The southern portion extends an equal distance east from the mainland to the southern sand spit of Cedar Island, but the northern part of the bay is narrower and ends against the marsh behind the mid-portion of Cedar Island. Throughout most of the area, Burton's Bay is shallow, and large parts of it are navigable only at high tide. In addition to the through-going Inland Waterway Channel there are well-developed tidal channels that conduct tidal circulation through this bay. The marsh areas, the bays, the tidal channels, and the sedimentation of this area have all been extensively considered by other authors, Callahan(1972); Kemmerer (1972); Knowlton (1971); Newman and Rusnak (1965); and Newman and Munsart (1968).

III. TIDAL INLETS

The tidal inlets bordering Cedar Island are Metomkin Inlet on the north and Wachapreague Inlet on the south. All evidence on Metomkin Inlet indicates that it began to develop extensive flood tide deposits as the southern spit of Metomkin Island narrowed in the quarter century prior to the breaching of the island in the mid-1950's. In the past two decades, the influence of flood tides on this inlet has increased rapidly. It is a conclusion of this study that at present time, Metomkin Inlet is flood-tide dominated, and is in the process of closing. On the other hand, Wachapreague Inlet appears to be dominated by ebb flow. There is a remarkable scarcity of flood tide deposits inside this inlet and there is an extensive, and well studied ebb tide delta on the outside (seaward side) of this inlet. The ephemeral Dawson Shoals, which appear and disappear at frequent intervals, are a visible portion of the ebb tide delta on the updrift side of Wachapreague Inlet. The ebb tide dominance in this inlet has been extensively studied by Byrne et al. (1974), and the nature of Dawson Shoals has been related to sediment circulation within the inlet. Byrne has also indicated that inlet forces and processes are such that the southern flank of this inlet is kept at a steep slope and subject to some erosion, while the northern flank slopes more gently into the inlet and comes under the influence of drift of sediment from the north. He also indicated an asymmetry of tidal flow at this inlet, suggesting that ebb flow is directed to the northeast along the north flank of the inlet, whereas flood flow follows a more southerly path through the inlet.

IV. SHORELINE CHANGES

Shoreline changes for Cedar Island are best described in relation to each portion of the island. The reader is referred to the Geographic Map of Cedar Island included with this report. It can be said that between 1852 and 1968 there was a general retreat of the seaward face of the island of about 1,950 feet. This averaged amount of retreat yields an annual retreat rate of 16.8 ft./yr. Kemmerer (1972, Thesis) has cited a retreat of 16.7 ft./yr. It is worth noting that these retreat rates do not differ significantly from the average retreat rate for Metomkin Island which was 15.4 ft./yr. in the century prior to 1955, and 17.6 ft./yr. in the following decade. However, there



a. Abandoned Coast Guard Station: north end of Cedar Island at Metomkin Inlet.

b. Accreting beach near north end of island. Note bars comming ashore, an older, forested, beach ridge, ORV trails, and cottages.

FIGURE 23: North End of Cedar Island

are differences between the two islands that are apparently related to sediment supply. The barrier island east of Metomkin Bay breached again and again between 1955 and 1967, with resulting drastic changes in tidal circulation in Metomkin Bay. The barrier island east of Burton's Bay was breached between 1955 and 1957 and remained open through 1961, but had healed by 1963. Tidal circulation in Burton's Bay and through Wachapreague Inlet was not permanently disrupted as was the case at Metomkin Bay. This would suggest that the ephemeral inlet did not receive enough ebb flow through Burton's Bay to keep it open long enough to develop a network of tidal channels. Indeed, the size of the sand delta that grew in Burton's Bay at the site of the inlet indicates that sand trapping on the flood tide was the dominant event during the short lifetime of this inlet. The enormous volume of sand moved through the inlet also indicates that there was an abundant supply of sand from the longshore transport system.

Examination of the shoreline changes on Cedar Island for different periods of time is useful (see Figures 24, 25, and 26). In 1911, the shoreline for about a mile at the north end of Cedar Island occupied almost the same position as it did in 1852. Between 1911 and 1928 the beach at this location retreated, but thereafter remained at about the 1928 shoreline position until sometime after 1955, whereupon it began to retreat again. It should be recalled here that Metomkin Inlet was breached sometime between 1955 and 1957.

During the same time interval, the beach south of that northern section retreated. Over the next 3,000 feet south, retreat increased from zero at the north end to 1,200 feet. From that point south, to near Trout Channel, retreat varied between 1,150 feet and 1,290 feet, reaching 1,325 feet in a few places. The 1955 beach lay parallel to, but west of, the 1852 beach. The average rate of retreat in this time period was 11.8 ft./yr.

Between 1955 and 1963 the seaward beach retreated all along the island's length south to Trout Channel. Just south of Metomkin Inlet, retreat varied from 130 to 325 feet, being greater toward the inlet. For this 8-year period, the average rate of retreat for this reach of beach was 35.8 ft./yr. From this northern reach south, to Trout Channel, the retreat varied from 265 feet to 530 feet. This yields retreat rates between 33 ft./yr. and 66 ft./yr. An average retreat for this main length of beach would be on the order of 53 ft./yr.

In this time interval, Metomkin Inlet was trapping large volumes of sand which undoubtedly reduced the volume of sand moving in the longshore drift system. The ephemeral inlet at Burton's Bay was open, and also was trapping sand from the longshore drift system. There is an obvious relationship between the accelerated rate of beach erosion along Cedar Island, and the volume of sand removed from the longshore drift system at the ephemeral inlet into Burton's Bay.

From 1963 to 1968, beach retreat slowed abruptly, and measurements indicate it to have been on the order of 10 ft./yr. This was after the ephemeral inlet at Burton's Bay had closed and during the period that the southern tip of the spit was growing southward. Between 1968 and 1974, shoreline changes along this beach were minimal. The northern reach of shore just south of Metomkin Inlet retreated (see descriptions of Metomkin Inlet), while the beach southward to just north of Wachapreague Inlet either accreted slightly or remained unchanged.

The sand spit at the southern tip of Cedar Island has been very active during the time period since 1852, first growing south, then retreating to the north, then shifting west, and finally growing to the south again. These movements are portrayed in the Historical Shorelines Maps of Figures 24, 25, and 26. It is interesting to note that in 1852 the sand spit extended as far south as it did in 1963, but lay to the east of

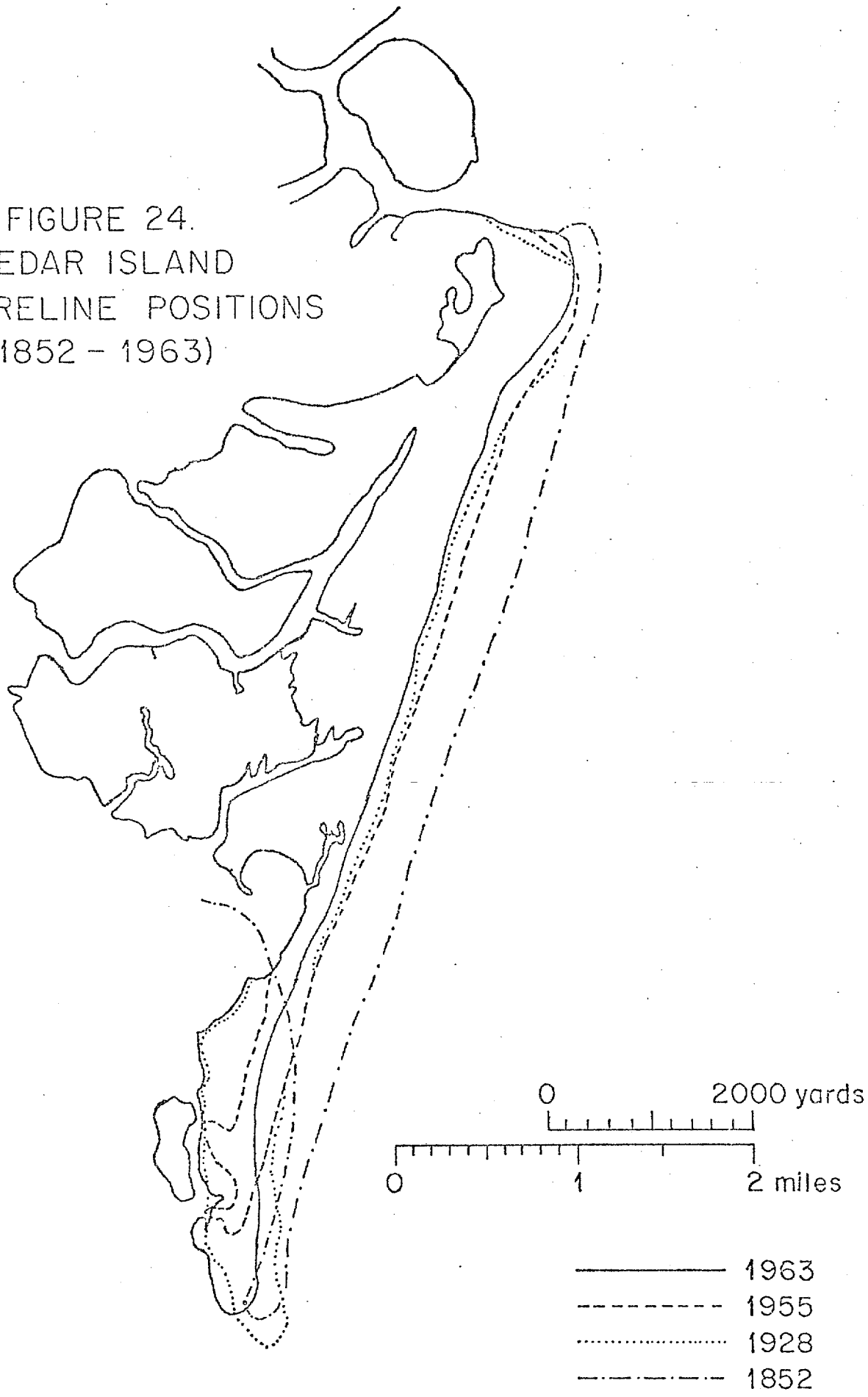


FIGURE 24.
CEDAR ISLAND
SHORELINE POSITIONS
(1852 - 1963)

FIGURE 25.
CEDAR ISLAND
SHORELINE POSITIONS
(1911-1961)

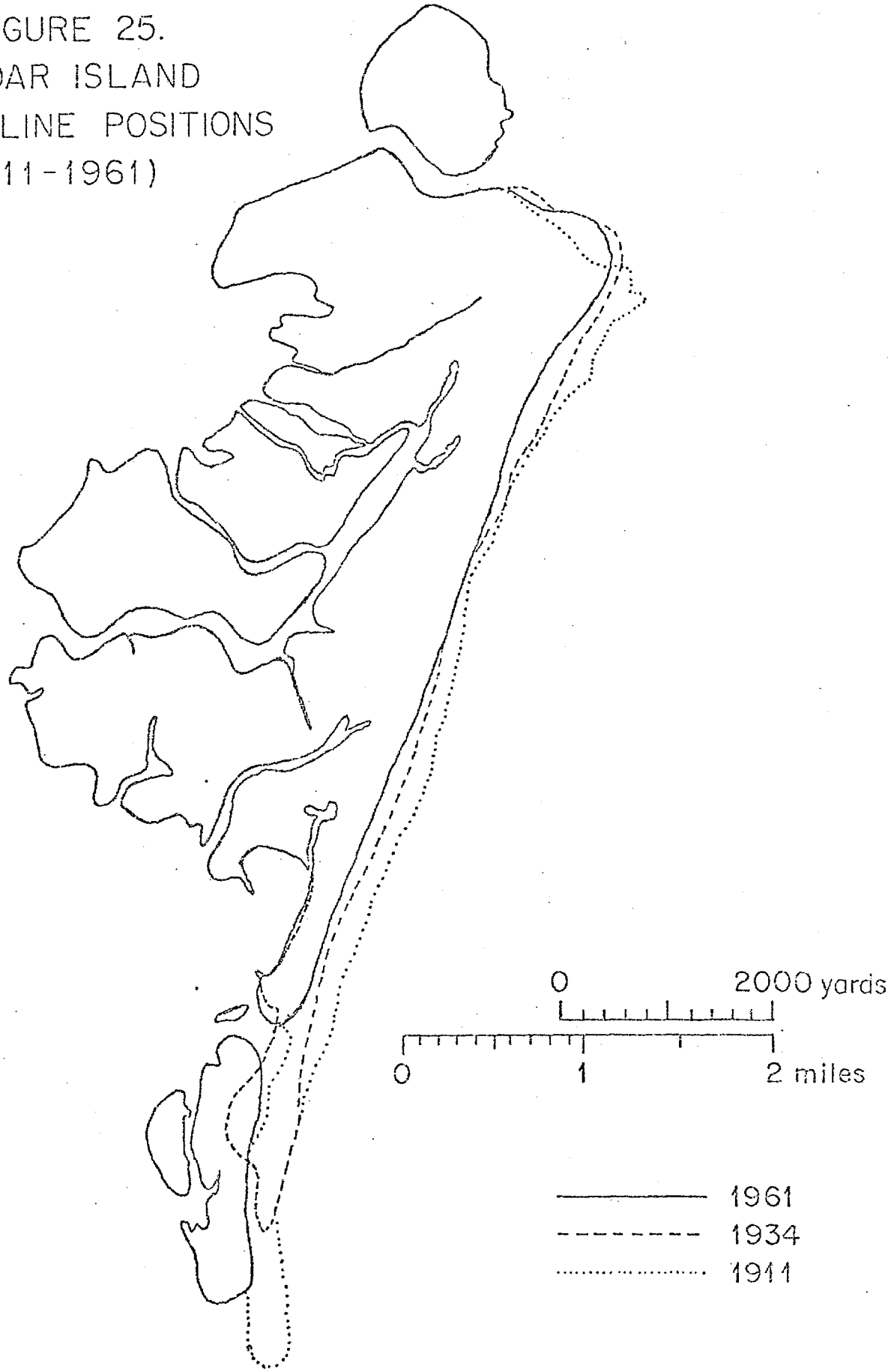
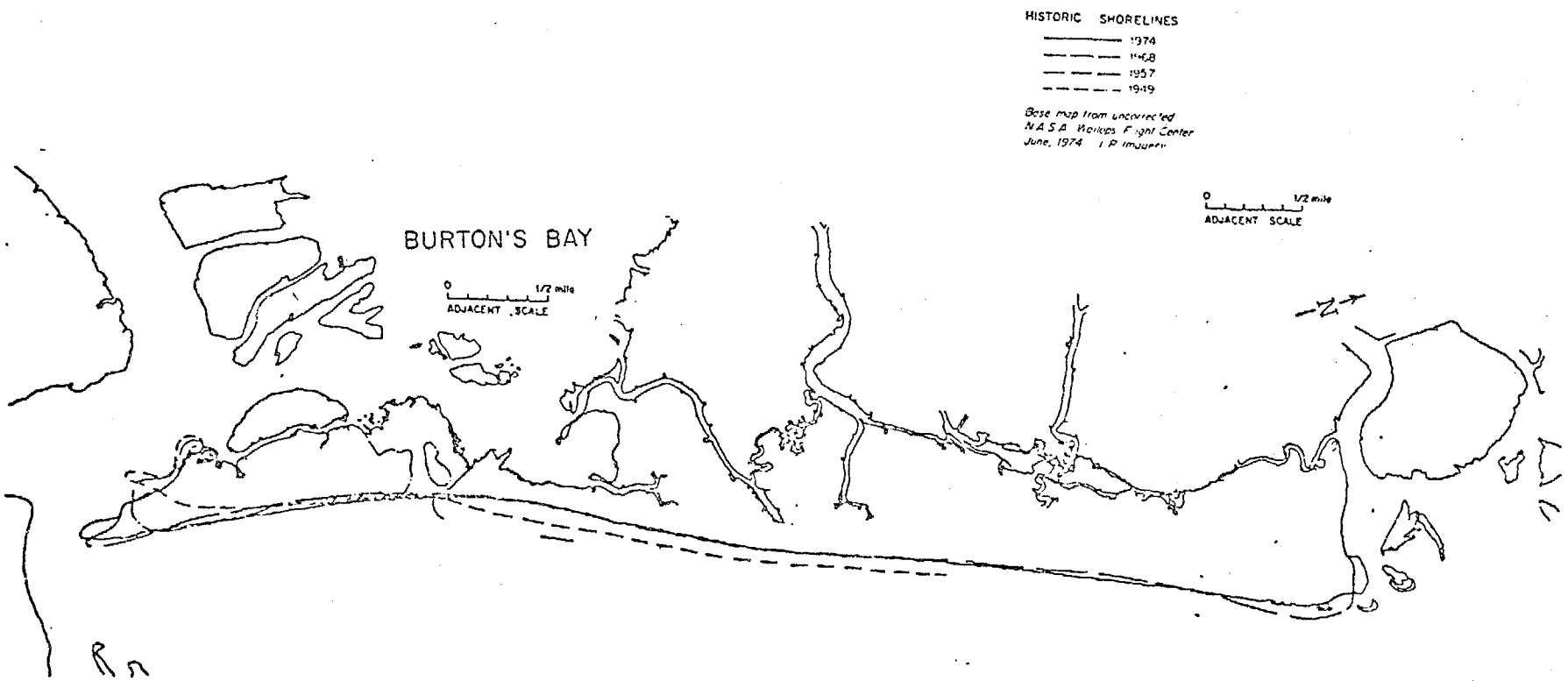


FIGURE 26. RECENT SHORELINE POSITIONS ON CEDAR ISLAND (1949-1974)



its 1963 position. Between 1852 and 1911, the sand spit built 1,550 feet to the south, which was about equal to its present southern extent (1975). However, between 1911 and 1928, the sand spit retreated 700 feet and by 1934 had retreated an additional 3,500 feet, to a point near the south end of Trout Channel. A series of storms beginning in February, 1920 and culminating with the devastating storm of 1933, probably contributed to this rapid retreat of the sand spit. Between 1934 and 1955, the sand spit had shifted 1,125 feet to the west, without any significant change in length. A period of rapid growth began after 1955. By late 1955, the sand spit was recurved sharply to the west and had developed dune ridges. The 1957 U.S.G.S. Plane Table Survey showed that it had grown 1,500 feet to the south and almost as far to the east, having become a broad, blunt sand spit on which dune ridges had begun to form. By 1963, the sand spit had extended another 825 feet and still retained its broad, blunt character. By 1968 another 750 feet had been added as a thinner sand spit that by 1974 had begun to recurve and migrate to the west. When visited in September, 1975, this most recent extension of the sand spit already had 6 to 8 foot dunes and showed evidence of continuing to grow and recurve to the west. The Cedar Island sand spit as it appeared in July, 1975 is shown in Figure 27. It is also shown in other figures included in the section on Parramore Island. The present extension of the southern tip very closely matches the 1911 extension, but lies slightly west of that position. The island is presently about 1,080 feet longer than it was in 1852.

V. TIDAL INLETS

Shoreline changes at Metomkin Inlet have been described in the section on Metomkin Island. U.S.C. & G.S. charts show that between 1852 and 1955 the inlet widened from about 1,330 feet to 3,640 feet, but that the centerline of the inlet opening remained unchanged. Shoreline changes at Wachapreague Inlet have been similar to those at Metomkin Inlet. From 1852 to 1955, this inlet changed from a width of 2,130 feet to a width of 3,733 feet, but in 1934 it was 4,670 feet wide, and may have been wider at the maximum extent of the retreat of the Cedar Island sand spit.

Throughout this period and up to the present, the north shore of Parramore Island has remained at about the same position shifting slightly north and south. Most of the change in width is attributable to the changing length of the Cedar Island sand spit. The deep inlet channel has also been quite stable in its position through this long period, showing only a slight shift to the south on the U.S.C. & G.S. charts. Between the 1955 and 1963 charts, the south shore of Wachapreague Inlet shifted about 270 feet to the south, having previously shown little net change in position since 1852. This period is coincident with the time when the ephemeral inlet was open into Burton's Bay. Several change-producing storms also occurred during this interval. Combined, these may have worked to increase ebb discharge through Wachapreague Inlet and cause erosion along its southern flank. Byrne (1974) cites a southerly shift of 1 m./yr. during the previous century. Byrne also notes the continued presence of a well developed ebb tide delta (including the ephemeral Dawson Shoals) on the seaward side of the inlet that has maintained itself over the past century and a quarter.

Across Burton's Bay on the north side of the inlet there are five inlet islands that have remained essentially unchanged since 1852. These inlet islands are shown in Figure 26, and they lie west of Trout Channel at the north end of the southern sand spit. However, Clubhouse Marsh which lies directly athwart the inlet and about .8 mile west of the south end of Cedar Island has shown an average westerly retreat of 800 feet during this time period. There are beach ridges and extensive overwash deposits along the edge of this marsh that faces the inlet, obviously built by waves breaking against the marsh. Because these deposits are now covered with vegetation, it is apparent that such wave attack is no longer occurring. It can be concluded that wave attack on this marsh was concurrent with the retreat of the Cedar Island sand spit

New portion of Cedar Island Sand Spit. The grass covered beach ridges, dune ridges, and new sand dunes have all formed along this part of the sand spit since it began growing rapidly in 1955. Dawson Shoals at Wachapreague Inlet are in the background.

FIGURE 27: Cedar Island Sand Spit

and the maximum surface opening of Wachapreague Inlet. This study would place that time interval between 1920 and 1968.

The ephemeral inlet that opened about 2,000 feet north of Trout Channel was first established in the time period after the November 14, 1955 U.S.C. & G.S. chart was drawn, and before the 1957 U.S.G.S. Plane Table Survey of the island. The damage-producing storm of January, 1956 was probably the storm that opened this inlet. The inlet remained open and is shown on the June 12, 1961 chart. It closed sometime after that and is not shown on the March 11, 1963 chart, which shows instead an inlet deposit stretching 2,225 feet from the beach to the bay side. Kemmerer (1972) reports that the inlet was opened by the May 7-8, 1962 storm, but closed shortly thereafter. The data of this study suggests that overwash from the March, 1962 storm probably initiated the closing, if it did not, in fact, close it.

VI. SUMMARY CHANGES

In concluding these sections on shoreline and inlet changes, several points should be noted. Shoreline retreat from 1852 to 1955 closely paralleled that on Metomkin Island. In the decade from the mid-1950's to the mid-1960's, shoreline retreat was accelerated along Cedar Island beach. Two events coincide with this decade: the disruption of Metomkin Bay and the opening of the ephemeral inlet on Cedar Island. Because both of these events caused sand to be diverted from longshore drift to storage in the bays, either or both could be the cause of an increased rate of beach retreat on Cedar Island. However, there is evidence from other islands to the south that shows that there was an increase in the rate of beach retreat on those islands that began in the mid-1950's; and those islands are far removed from Cedar Island. This would suggest that the full explanation of the temporarily accelerated retreat of Cedar Island may not be simple. From the late 1960's, the rate of retreat has dropped to a rate comparable to, but lower than, that of the century prior to the mid-1950's.

Another notable observation is that during the twenty years since 1955, two large volumes of sand have been placed in storage by the longshore transport system along Cedar Island. The first of these is the huge inlet deposit (sand delta) formed behind the ephemeral inlet to Burton's Bay. The second of these is the enormous volume of sand deposited as the southern sand spit of Cedar Island grew southward about 3,100 feet at a width of nearly 1,500 feet; and dune ridges grew upon it. No attempt was made in this study to compute sand volumes, but the data of the study creates the impression that more than simple longshore redistribution of sand was involved in forming these deposits. One possibility is that some of this sand was removed from the nearshore prism or the north side of the ebb tide delta at Wachapreague Inlet.

VII. GEOMORPHOLOGY

On the Geologic Map of Cedar Island, there are a number of older landforms shown in the marsh behind the island. These will be considered from oldest to youngest. However, between the mainland and the east side of Cedar Island Bay, there are numerous areas of topographically higher marsh which have been interpreted as former bay and inlet islands. These areas are marked with a marsh symbol, rather than with an inlet island symbol because they could not easily be associated with any former inlet or tidal channel. A number of vestigial marsh channels, one of major proportions, are also found in this part of the marsh, but more to the east and north of Cedar Island Bay.

In the marsh between Cedar Island and Cedar Island Bay, there are a number of inlet islands, some topographically high areas that show ridge patterns, and vestigial tidal channels and inlet scars. The inlet islands that could be associated with a former inlet opening have been shown with the inlet island pattern, and others are marked with

a marsh symbol. Consult the accompanying legend sheet for other geologic symbols. These vestigial channels and inlet deposits are cited here to explain the way in which they were mapped. They are not the oldest features on the island, and are, in fact, of various relative ages. Patterns of one age will be discussed with other features of the same age.

About 0.3 mile southwest of Sneads Beach, which is located due east of Cedar Island Bay, there is a group of three inlet islands that show ridge lines. These three inlet islands suggest a flood tide delta by their arrangement. However, the ridge patterns on the larger of these islands does not fit that interpretation, nor does it fit with the pattern of old marsh canals bordering it. It is, therefore, interpreted as a partially drowned remnant of a former beach ridge. About a mile northeast of this feature, in the pond at the north end of the island, there is a group of five topographic units marked with the beach ridge symbol, and connected with a ridge-line symbol. These also have been interpreted as the remaining evidence of a former, partially drowned, beach ridge. Together, these two remnants lay along a NE-SW line and represent an ancient shoreline position which is believed to be the oldest geomorphic feature on Cedar Island.

At the south end of the large pond near the north end of Cedar Island there is a small island marked with the beach ridge symbol. It is connected by a ridge-line to another beach ridge unit south of it. These two units are the drowned remnants of another (younger) ancient beach ridge that paralleled the shoreline trend described above.

Sneads Beach is an obvious ancient beach ridge with numerous sand spits and berms associated with it. One quarter of a mile northeast of Sneads Beach at the south end of the pond there is a complex ancient beach ridge unit with an array of sand spits and berms. Some of the separate beach ridges sections in this unit are believed to be of different relative ages. The small section of beach ridge at the western edge of the unit, as shown on the false color I.R. imagery, relates best to the island in the pond to the north of it, and is therefore older than other sections. The sections of beach ridge in the middle relate best to Sneads Beach, and those on the east side relate to other, younger features. Between the portions of this unit that relates to Sneads Beach, and Sneads Beach, there is an ancient inlet opening. Some of the inlet island deposits and vestigial tidal channels that can be seen on the I.R. imagery in the marsh area west of this ancient inlet, appear to be related to the inlet but others do not.

About 0.7 mile south-southwest of Sneads Beach, and again about 1.3 miles in the same direction, there are inlet islands with ridge lines on them that recurve in westerly directions. West of these inlet islands there is a dense distribution of other inlet deposits extending toward the mainland between Cedar Island Bay and Burton's Bay. Together, these features apparently outline the northern and western embankment of a large former tidal channel which migrated (extended) to the south. Great Channel, which was formerly very much larger than at present, is aligned with the position of the ancient channel. This evidence suggests that Cedar Island Bay was initially separated from Burton's Bay by deposits from this ancient tidal channel. These deposits fostered the development of a marsh area that gradually enlarged to the south and west, increasing the isolation of Cedar Island Bay. Growth of the marsh area to the south would have caused the southward extension of that former tidal channel. Tidal circulation for the isolated northern end of the former bay was through tidal channels at the north and south ends of Sneads Beach. Large vestigial tidal channels have been mapped parallel to the present tidal chanals called Straight Creek and Sneads Beach Channel.

East of Great Channel and the other features previously described in this section, and landward of the modern barrier island deposits, there are a number of ancient geomorphic features. Beginning at the north end of Sloop Channel, where the modern barrier island deposits are encroaching upon it, and extending westerly to Great Channel, there are at least two intersecting vestigial tidal channels. North of those features, for the next 0.75 mile, the marsh between Great Channel and the beach is studded with inlet island deposits. Along the east side of this marsh area there are several areas mapped as beach ridge in which the ridge lines recurve into the marsh from the south.

At the north end of this marsh area there is a large area of beach ridges and berms that extend westward to Great Channel. The northern edge of this beach ridge area is mapped as the south embankment of an ancient inlet opening. The northern embankment of this inlet is mapped about 0.4 mile northward. All of these features record the northward migration of an ancient inlet and the north end of a barrier island. The ancestral Great Channel described in the previous paragraph was connected to this ancient inlet, and became more defined as the inlet migrated north. Other vestigial channels show that this inlet was also connected to Cedar Island Bay and to the marsh west of Metomkin Inlet.

The pattern of ancient beach ridges and sand flats that lie northward of the inlet described in the preceding paragraph is difficult to interpret. Immediately north of the inlet, and south of the large pond, there is a broad sand flat. There are nearly parallel lines of small mounds (Parramore Pimples) strung out across the sand flat with an orientation close to that of the modern beach. Along the east side of this sand flat there is an area of ancient beach ridges that reach elevations of five to eight feet. The ridge line pattern in this beach ridge area is confusing. This beach ridge unit is being encroached upon by modern active sand dunes and by shoreline retreat. At its northward side the sand flat is truncated at what has been interpreted as an ancient, shallow inlet opening because of the pattern of ancient berm ridges associated with it.

On Assateague Island, Parramore Island, and elsewhere on the Virginia Barrier Islands, sand flat and beach ridge patterns similar to those in this area have been produced during periods of rapid accretion of a barrier island.

At the south end of the large pond and north end of the sand flat just described, there is a compound beach ridge unit that was previously referred to in the paragraph on Sneads Beach. The east end of this unit is partially encircled by a pattern of curved berm ridges. These berm ridges, and the berm ridges associated with the inlet opening that is shown there, appear to relate to two different periods of time; an earlier time period before the sand flat to the south was formed and a somewhat later time after the inlet had shifted south and partially eroded the sand flat. The northern embankment of this inlet is found near the north end of the pond where it is associated with a pattern of curving beach ridges and berms. This inlet does not appear to have been either a major or deep inlet. There are no significant vestigial tidal channels associated with it. It is interpreted as a breach in (or washover of) a former narrow barrier island.

Within this shallow inlet and east of the pond, there is an area of sand flat and east of that an area of current beach ridges, berms, and back beach sand flats. These features record the closing of this ancient inlet opening by the northward migration of the north end of a barrier island. East of the middle of the pond a section of the curved beach ridges is enclosed with an inlet opening line in such a way as to define a narrower northern inlet and a broad tidal channel south of that. The tidal channel disappears under modern barrier island deposits, but it formerly connected to a bay

or marsh area southeast, or south, from its present remnant. The reduced northern inlet was closed by island encroachment from both sides of the inlet but dominantly from the south side. The sand flat extends beneath the pond to the marsh, where an area that is mapped as vegetated beach seems to mark its western limit. This sand flat is interpreted as a sand delta similar in magnitude to the one formed at the recent ephemeral inlet near the south end of Cedar Island.

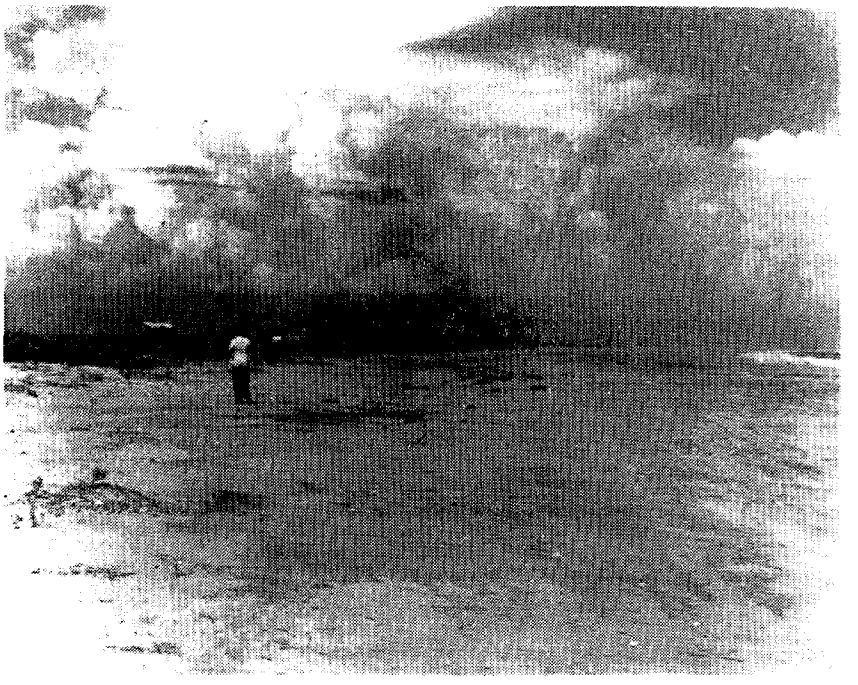
The only other older geomorphic features are the ancient channels and marsh area behind the southern sand spit of Cedar Island. Most of the marsh seen in this area is new marsh growing upon sand deposited in the past two decades. However, there are two ancient tidal channels, Trout Channel and Brandywine Channel, which still survive although their function has been lost. The marsh areas west of each of these channels are built upon flood tide islands. These older marsh islands are at the eastern end of an east-west group of five islands. Cedar Island has retreated westward against this group of islands, and now incorporates the easternmost two of them. These islands are shown in their present form on the oldest charts available for this study, and are therefore older in origin. However, their relative age and origin is unknown, particularly with reference to other ancient features described on Cedar Island.

VIII. MODERN GEOMORPHIC FEATURES

The geomorphology of the modern, retreating barrier island is straightforward. At the northern end of the island there is a prominent nub protruding toward Metomkin Inlet. This nub exhibits a pattern of accreting beach ridges and berms which are known to have formed in the past decade. Along the third mile of beach immediately south of the north end of the island, erosion has been dominant in the past decade. Here the beach and berm are narrow, and there is a field of young, active, partially vegetated sand dunes which are covering older geomorphic units as they migrate toward the marsh. At the south end of this section, the active beach and berm lay against an older beach ridge that has been partially eroded away.

From this point south to the tip of the southern sand spit, the beach (see Figure 28) has been stable or has accreted in the past decade, after an earlier decade of rapid change. This section of the barrier island has a broader active beach and berm with a strip of older berms and back beach flats. Low, frequently breached, foredune ridges have formed in the vicinity of the ephemeral inlet (see Figure 29) and along the beach seaward of the marsh behind the northern part of the island. Landward of this berm strip, sections of new sand dunes alternate with sections of overwash channels along the northern half of the marsh, but overwash of various recent ages (Figure 29) is all one finds along the southern half of the marsh and down the length of the southern spit to the north side of the ephemeral inlet. The new sand dunes and overwash have been encroaching on the marsh and older geomorphic features of the northern half of the island. At Great Gut Cove, at the east end of Burton's Bay, overwash is carrying through into the cove.

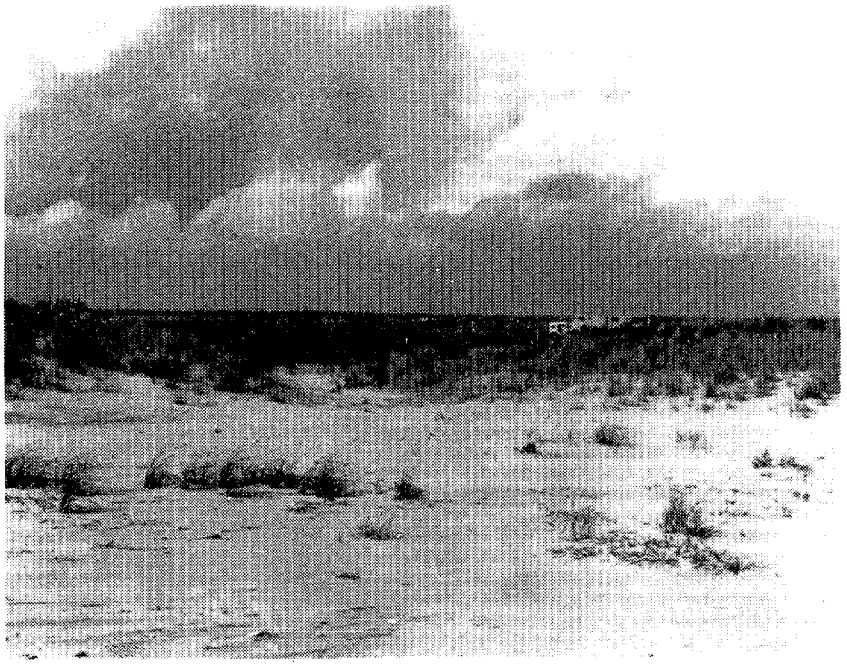
From just north of the ephemeral inlet (shown in Figure 26) to the southern tip of the sand spit, the beach has accreted rapidly since the mid-1950's. All evidence of the inlet opening has been erased by overwash, and beach and new sand dune accretion. Behind the position of the inlet there is now a huge sand delta which has been added to by continuing overwash since the inlet closed. The bay side of this sand delta has been colonized by Spartina a. but the central portion is still open and occupied by a salt pond that is floored with an algal mat. The eastern margin of this sand delta is sparsely vegetated and wind-blown sand from tongues of overwash is forming low sand dune mounds. A field of low (3-5 feet) sand dunes, still cut by overwash channels, is beginning to form. When visited in September, 1975, evidence of fresh overwash was seen in these channels. The area is pictured in Figure 30.



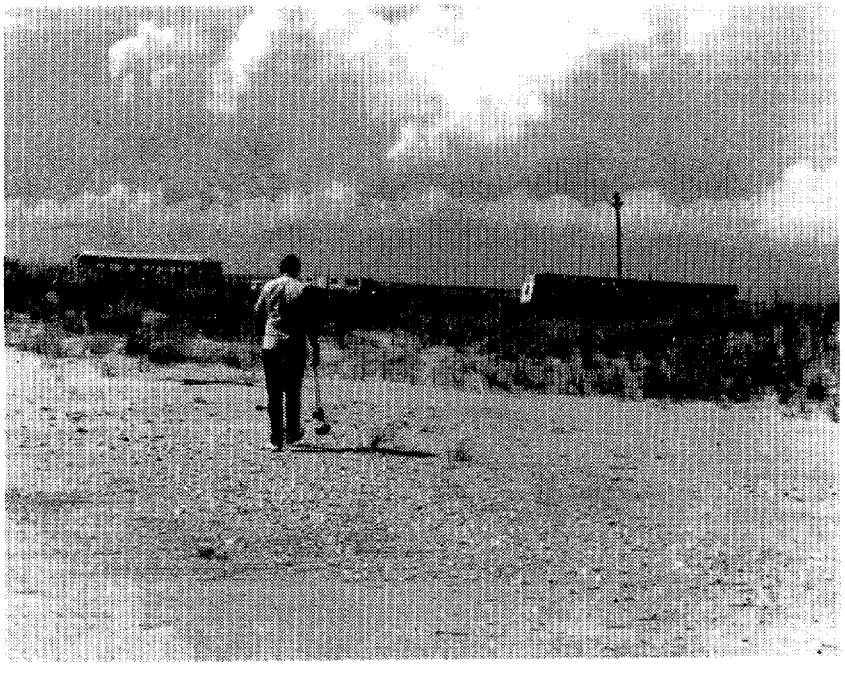
a. Accreting beach east of the 1950's - 60's ephemeral inlet. Dr. Niedoroda is photographing a small overwash channel opening.

b. Cheryl McCaffrey, Botanist in the Virginia Coast Reserve Study, poses in mired ORV on accreting beach east of Trout Channel.

FIGURE 28: Cedar Island Beach



a. Seaward end of a medium sized overwash channel east of north end of Trout Channel. Jeep trail follows bottom of overwash channel.



b. Location of a former medium sized overwash channel now closed by a low dune. Shell pavement denotes floor of channel, and jeep trail marks the low point in the dune.

FIGURE 29: Overwash Channels on Cedar Island

From the north end of Trout Channel southward, there is an area of beach ridges and active sand dunes, all of which are partially vegetated. Several overwash channels cut these ridges. The ridges on the west side recurve sharply toward Burton's Bay and record the 1955 position of the southern tip of the Cedar Island sand spit. The other ridges are all younger and have grown mostly in the period 1955-1968, and near the south end of the spit the youngest have already been truncated by beach retreat since 1968. The area is pictured in Figure 31.

IX. GEOLOGIC INTERPRETATION AND HISTORY

The geomorphic features found on Cedar Island are sufficient to allow some interpretation of geologic history to be made. The oldest features found are sections of a drowned beach ridge that still rise above the general level of the marsh, and mark the position of an ancient shoreline. The orientation of that ancient shoreline is N40°E. Southeast of that ancient shoreline there are remnants of two more drowned beach ridges that parallel the first. These record parallel, but younger, shoreline positions. The youngest of these three shorelines includes Sneads Beach.

The age of these shorelines is not known, beyond the fact that they are ancient. They also record an ancient regression of sea level. No published radiometric age dates were found that could be related to these shorelines. An appropriate subject for further study would be the determination of their age.

From the data base available for this study, a reasonable case can be made for suggesting that these shorelines may record the early Wisconsin regression of sea level in this area. The geomorphic evidence on Cedar Island indicates a long period of time after the formation of those shorelines, during which the shoreline advanced seaward, and then retreated with a different orientation. The orientation of those ancient shorelines is N40°E, while the orientation of the next younger features is about N28°E The orientation of the shoreline trend along this type of coast usually reflects the general trend of the coastline. Therefore, this large change in orientation of the two shoreline trends represents a significant change in coastline orientation. Such changes occur only over long periods of time.

In the bay and marsh areas west of the islands south of Hog Island, there are ancient beach ridges that can be related to the early Wisconsin regression of sea level by radiometric dating. All of those beach ridges show a progressive clockwise rotation with increasing distance from the mainland. The ancient shorelines of Cedar Island are also rotated in a clockwise direction from the mainland. In both cases the angle of rotation, approximately two miles off the mainland, is about 12° even though the bearings of the ridges are different at the two locations. A last point of interest to be made in respect to this argument is that the bearing of those ancient Cedar Island beach ridges is the same as the bearing of a number of undersea ridges that are found at depths of about 60 feet, on the continental shelf, east of Chincoteague Inlet. The projection of the ancient shoreline on Cedar Island is coincident with the position of those undersea ridges.

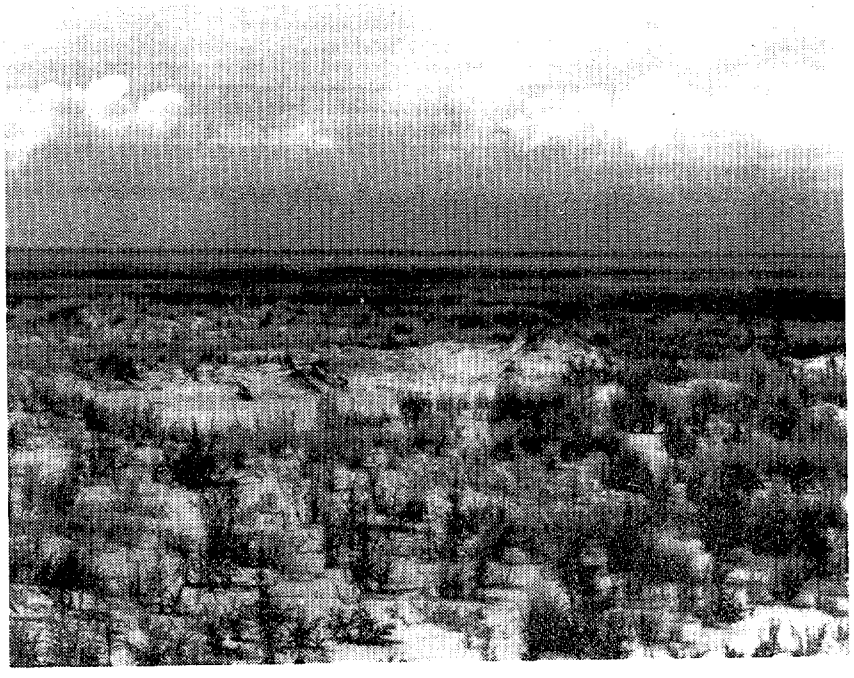
Whatever the age of the ancient shorelines, there followed a long period of time during which the shoreline advanced and then retreated. The retreat of the shoreline appears to have been against an area that was largely bay, without large marsh areas. At the time that the retreating shoreline began to approach the ancient shorelines, there was an inlet to an ancestral Burton's Bay that was located east of the modern Sloop Channel. The barrier island north of that inlet was offset to the west of the barrier island south of the inlet just as the modern Cedar Island is offset to the west of Parramore Island.

a. Salt pond and jeep trails on sand delta at ephemeral inlet location. White spots are shells.

b. View toward beach from sand delta. Low spot in dune ridge is an overwash channel opening.

FIGURE 30: Sand Delta - Cedar Island Sand Spit

a. Foredune ridge along new part of sand spit. Cheryl McCaffrey examines dune face that is overriding vegetation. Note wind fluting on dune surface.



b. Western half of new part of sand spit. Note overwash channel leading back into dunes.

FIGURE 31: New Part of Cedar Island Sand Spit

The geomorphology in the area north of Sloop Channel and east of Great Channel was formed as those ancient barrier islands continued to retreat to the west, and the inle migrated northward to a location just southward from Sneads Beach. By that time, the northern of the two barrier islands had migrated west to a position against the ancient shorelines in the area northward of Sneads Beach. It had also breached at the location of the large pond at the north end of Cedar Island and sand was being carried through the breach into the bay area west of the ancient shorelines. Sneads Beach was partially reworked by waves and inlet currents during this period of time, and may have been enlarged by new sediment deposited around the ancient beach ridge. The patte of low berms surrounding it would suggest that this had occurred.

The southern barrier island had migrated to a position that was nearly coincident with the modern Cedar Island, so close that only parts of it are still preserved in the marsh of Cedar Island. Sediment carried through the migrating inlet had been deposited across the ancestral bay in a sufficient degree to begin the isolation of Cedar Island Bay from the ancestral Burton's Bay. Great Channel was established as the main tidal channel between the inlet and the north end of Burton's Bay.

Following this period of time, the islands began to accrete rapidly, and the shoreline began to prograde to the southeast. The onset of this rapid progradation is recorded in the ridged sand flat and ancient beach ridge area found east of Sneads Beach. As progradation continued, the breach in the northern barrier island closed as beach ridge built seaward of the breach. A broad sand flat was left where the breach had been. The inlet to Burton's Bay through Great Channel was also closed and Great Channel began to fill in.

It is not known how far the island prograded to the southeast before retreat began again. Certainly the distance was great because retreat since 1852 has approached 2000 feet, and retreat was in progress long before 1852. The ancient geomorphology of Cedar Island clearly records a regression-transgression of the sea. However, none of the data available for this study gives any indication of the dates for those events.

PARRAMORE ISLAND - REVEL ISLAND

I. GEOGRAPHY

Parramore Island is the fifth island from the north end of the Virginia Barrier Island Group. It is located between Cedar Island and Hog Island, and is bounded on the north by Wachapreague Inlet and on the south by Little Machipongo Inlet, which is also called Quinby Inlet. Another barrier island, Revel Island, lies close beside the southern third of Parramore Island on the landward side. Parramore Island, at present, protects Revel Island from attack by ocean waves. A broad tidal channel called The Swash separates the two islands. The south end of Revel Island is bounded by Sandy Island Channel, which merges with The Swash at Quinby Inlet.

Parramore and Revel Islands differ in geographic description from the previously described islands. Parramore Island has a large land area above high tide level with much of the interior of the island protected from the sea by beach ridges. The beach ridges on this island are forested, with many large mature trees. The northern two-thirds of the island's land mass averages about a mile in width but the southern third narrows rapidly to a width of 0.3 to 0.4 mile, and ends in a sand spit less than a mile in length. Overall, Parramore Island is 7.9 miles long. The interior of the middle third of the island is a broad low swale between eastern and western beach ridge units. Midway in the length of this swale there are two large shallow salt ponds which appear on the 1968 U.S.G.S. Topographic Map (Wachapreague Quadrangle) as a single large intermittently flooded area. There also are numerous smaller ponds in the swale.

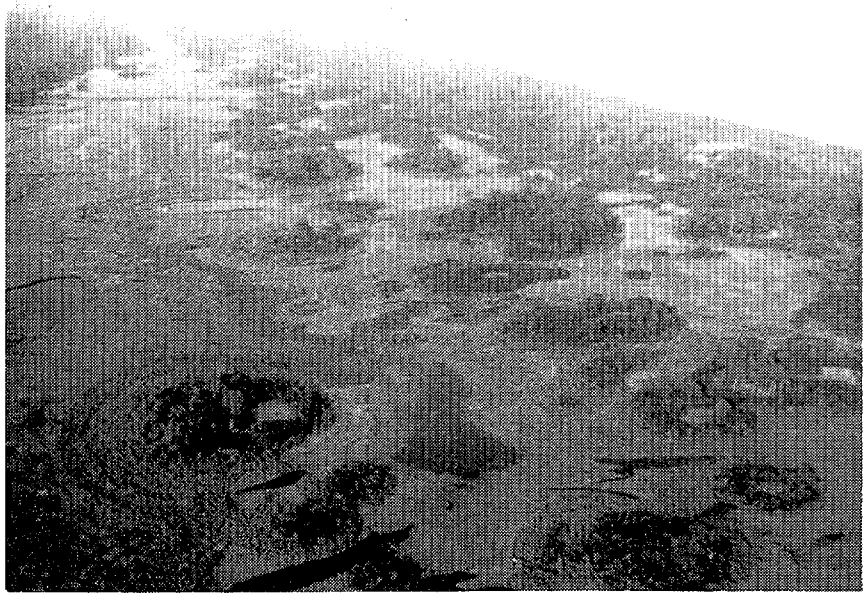
Figure 32a shows Little Beach which is part of the western beach ridge unit. One of the large salt ponds on the interior swale can be seen behind Little Beach. Figure 32b is a view to the north along a southern portion of the interior swale. The eastern beach ridge unit may be seen at the right of the picture. Small ponds and nearly circular topographic features known as Parramore Pimples are scattered along the length of the swale.

Parramore Island has a contiguous strip of marsh on the mainland side that is continuous from the Coast Guard Station at the north end of the island to the sand spit at the south end of the island. The marsh varies in width from 0.1 mile to 1.25 miles. Thi marsh area terminates against Swash Bay, or against broad tidal channels that connect to this bay from both ends of the island. Revel Island, lying protected from the sea by Parramore, is surrounded by marsh. Figure 33 depicts portions of Revel Island and The Swash. Figure 33a shows a western portion of the marsh area of Revel Island, while Figure 33b shows The Swash and some of the beach ridges of the eastern part of the island

The beach ridges on Revel Island rise out of the marsh, and like those on Parramore Island, they are forested. The overall length of Revel Island from the north end of the ridge area to the southern end is 2.3 miles. The seaward face of the island is curved and the ends of the island are approximately a half mile closer to the mainland than the mid-portion of the island. The upland of Revel Island forms an irregular vee, opening to the south, and the marsh and tidal canals reach back into the open vee. Each arm of the vee has a beach ridge along its length. The western arm of the vee varies in width from 500 to 1500 feet and is about 1.3 miles long. The eastern arm varies in width from 750 feet to 1,750 feet and is about 1.8 miles long.

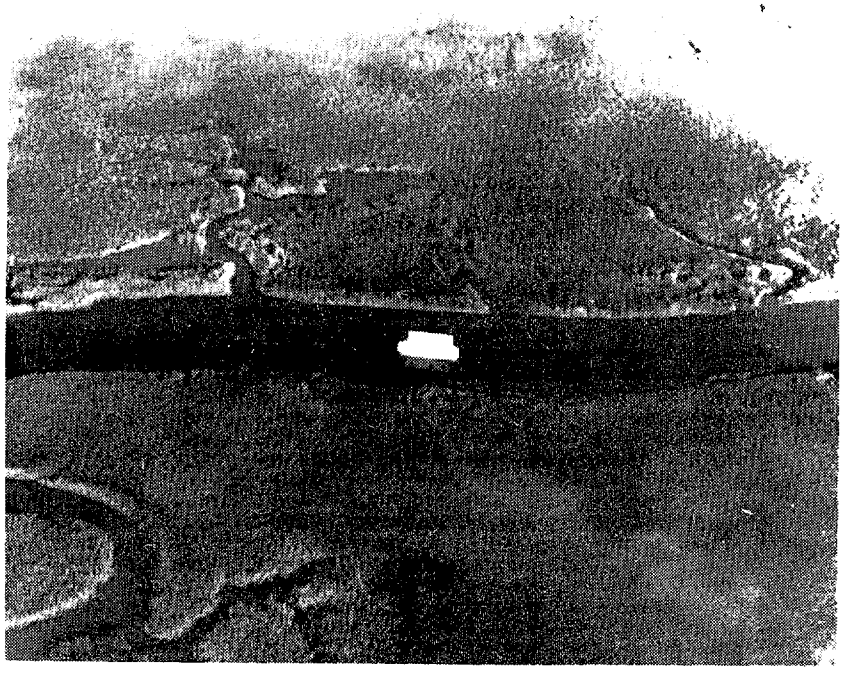
The beach face at the north end of Parramore Island lies 5.4 miles off the mainland coast. At the midpoint of the island, the beach is 5.5 miles off the mainland coast, and at its southern end, the beach is 5.8 miles from the mainland coast. The bearing of the straight mainland coast behind Parramore Island is N31.5^{o}E, while the bearing of

a. Little Beach, an ancient beach ridge, with small Parramore Pimples in foreground. Interior swale is at top of picture. Note dendritic drainage at bottom right.

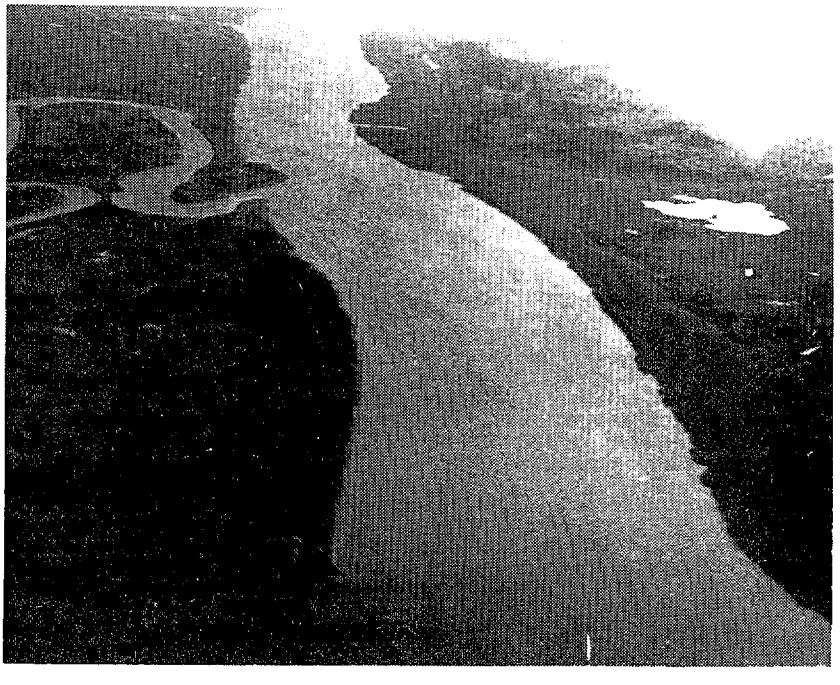


b. Parramore Pimples on the interior swale south of Little Beach.

FIGURE 32: Physiographic Features of Parramore Island



a. Houseboat in marsh canal on Revel Island.



b. The Swash. View is toward Quinby Inlet with Revel Island on the right and Parramore Island on the left. Note ancient inlet opening midway along Revel Island.

FIGURE 33. The Swash and Revel Island

the seaward beach of the island averages about N28.5°E This places the beach of Parramore Island essentially parallel to the mainland coast; a condition not seen on Metomkin and Cedar Islands. The central part of Revel Island lies about 1.2 miles landward of the Parramore Island beach, and about 4.5 miles from the mainland coast.

Between these islands and the mainland, there is a wide area of bays and tidal marsh, with slightly more marsh than bay area (Figure 34a). Knowlton (1971) has studied the ratio of bay to marsh area in some detail. The four major bays are Bradford Bay, Revel Island Bay, Swash Bay, and Upshur Bay. Various names have been applied to other smaller bay areas. Boat access to the marsh and islands can be made from the towns of Quinby and Wachapreague on the mainland.

Figure 38a portrays the type of conditions found along the marsh side of most of the Virginia Barrier Islands, and illustrates what one encounters in trying to land on the islands by boat. The tidal range along the islands is slightly more than a meter, and it is only near the high phase of the tide that most boats can be brought near to the upland portions of the islands. In Figure 38a, Dave Tyler and Tony Pratt are shown poling The Nature Conservancy's boat through the marsh area with the boat's engine raised. The larger towns along Interstate 13 on the mainland are Painter from which Quinby can be reached via highway 182, and Keller from which Wachapreague can be reached via highway 180.

II. PHYSIOGRAPHIC DESCRIPTION

Physiographically there is little of interest to this study in the surface morphology of the marsh between these islands and the mainland. The available 10,000 feet I.R. imagery did not include much of this marsh area but the U-2 coverage from 60,000 feet included the entire marsh area, and that imagery showed no significant morphology in the marsh except levees and flood deposits related to tidal channels. Other imagery (U.S.G.S. Topographic maps, 1949 and 1973 B & W aerial photographs) did not reveal any distinctive features in this marsh and bay area. It should be noted here, that the Inland Waterway wends its way southward past Wachapreague, through the bays and channels of this area. Associated dredging has produced spoil dumps in both bays and marsh, and has doubtlessly influenced tidal circulation in this large area.

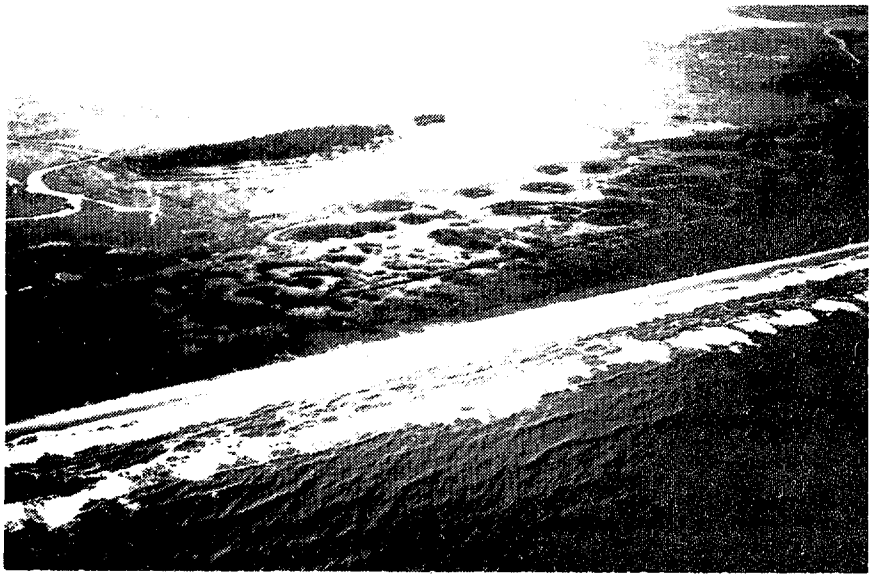
The physiography of Parramore Island is more involved than that of the other islands. The island can be described as a broad, relatively stable barrier island. The breadth of the island is somewhat atypical when compared to the other barrier islands in the Virginia Barrier Island Group. The breadth compares to that of some of the longer barrier islands found along the Atlantic Coast. The northern two-thirds of the island is composed almost entirely of old beach ridges and intervening swales (Figure 34b). Much of the swale area is only slightly above sea level, and there are numerous areas of marsh and open water. The larger swale areas are drained by streams leading to the marsh on the landward side of the island. The relief of the beach ridges varies from a few feet to more than 20 feet. Surprisingly, only two prominent ridges bear names: Italian Ridge and Little Beach. Other equally prominent ridges remain nameless in the literature. The most prominent beach ridge (Figure 34b) curves across the north end of the island for 3.8 miles before it ends east of Little Beach. Elevations on the northern part of this ridge often exceed 20 feet, but the southern end is only about half as high.

In the middle third of the island, south of the main beach ridge area (see Figure 35), the physiography differs. Here a broad swale bordered on the east and west by prominent beach ridges is the dominant feature. Down the length of the swale there are numerous low, nearly circular, mounds varying in height from a few inches to more than five feet, and ranging in diameter from less than 10 feet to as much as 500 feet. The more

a. Wachapreague Inlet. Parramore Island is at the left, Cedar Island Sand Spit at the right, and Dawson Shoals in foreground. Marsh bays, clockwise from upper left, are Revel Island Bay, Upshur Bay, Bradford Bay, and Swash Bay.

b. North end Parramore Island. Short, east facing beach is at the bottom of the picture. Dark bands are forested ridges, white bands are bare sand areas along the ridges. Grey areas are swale.

FIGURE 34: Physical Features - Parramore Island



a. Central swale with Parramore Pimples visible along its length. Little Beach is between the swale and Swash Bay. Low berm ridges near Little Beach are clearly visible, as is the shallow salt pond on the swale.

b. Swale south of Little Beach area. Parramore Pimples are seen in the foreground behind the beach ridge. The Swash and Swash Bay are in the background. A line of dark areas extends along the marsh side of the swale. These are remnants of the ancient beach ridge continuing southward from Little Beach.

FIGURE 35: Physical Features - Mid-Parramore Island

noticeable ones range from 100-300 feet in diameter. These features are referred to as Parramore Island Mounds or as Parramore Pimples (see Figures 32 and 35). They are curious features. Most have one or more concentric low ridges ringing a central mound, others have a central depression, and still others lack concentric rings. Most of the larger ones and some of the smaller ones are forested and others are brush covered. There are many of these features, with lower elevations, that are simply covered with grass as is the rest of the swale.

The origin of these mounds has been discussed by others (Melton, 1929; Rich, 1934; Deitz, 1945; Redfield, 1958; and Cross, 1964), and a discussion of their origin will be included later in this report. In addition to these mounds, there are also low ridges (Figure 35b) found on the swale along its western side, particularly near Little Beach and the beach ridge south of it. These ridges are 1-3 feet higher than the swale, and average 25-30 feet in width. Figure 36a shows the grassy swale between two of these brush covered ridges; the brush is beach elder. Figures 36b and 37 show another of these low ridges in the marsh near The Swash and south of Little Beach. Extensive augering was done on this ridge and in the marsh around it. A. P. Pratt and T. E. Rice are shown taking sugar samples in Figure 36b. On the I.R. imagery used for this study, these low ridges appeared to be berm ridges built upon a sandy base, and were interpreted as such. Ground inspection of the area in September, 1975 confirmed this interpretation.

The swale also contains two large salt ponds, and numerous smaller ponds. The depth of the two large salt ponds averages less than a foot, and in many places is only 4-6 inches deep. During the field visit in September, 1975, a deer was observed crossing one of these ponds on a diagonal path, and the animal's legs above the hocks were visible at all times, confirming that the water depth is shallow. Another encounter with the wildlife of Parramore Island is shown in Figure 38b. The picture shows the head of a curious otter that was swimming in the tidal canal that connects these two salt ponds to Swash Bay.

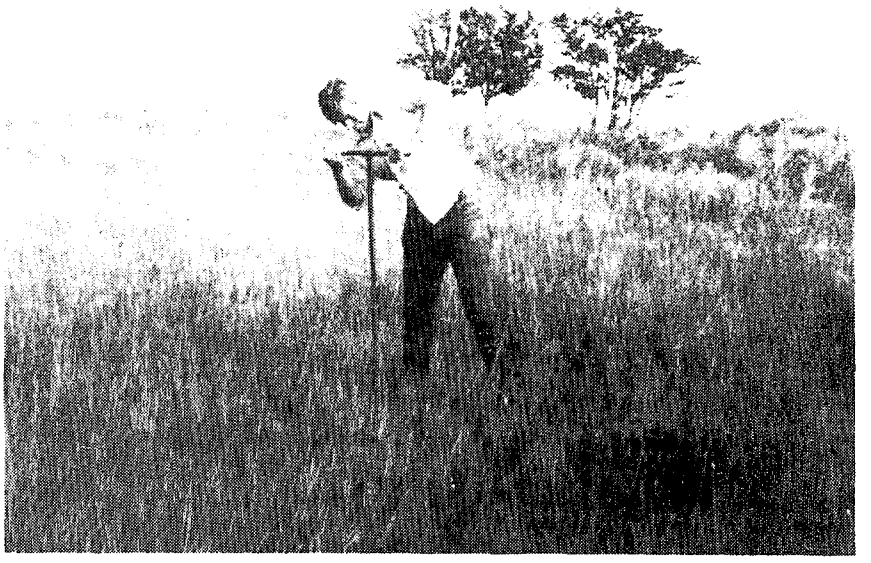
There are deeper channels along the margins of these ponds where water is exchanged with the marsh, across the swale. The swale continues through the gaps in the western beach ridge and merges with the marsh west of the beach ridge. Along the axis of the western beach ridge, the swale is a few inches higher than the marsh. The larger ponds have direct tidal connections to the marsh through a tidal channel at the south end of Little Beach. At the north end of Little Beach there are a number of abandoned tidal channels that formerly connected this pond and other smaller ponds to the marsh through the gap in the beach ridge between Italian Ridge and Little Beach. Where these abandoned channels enter the pond, each is broken into distributary channels across a sandy delta. These blind channels can be seen in the 1949 aerial photography (Photo ANO-IE-170) and in the 1974 I.R. imagery. When the area was visited in September, 1975, two of these channels near the north end of Little Beach were examined. Surprisingly, the sandy deltas still appear to be active.

Further examination of the area in the gap led to the conclusion that these channels are kept open by water coming through the gap on the flood stage of spring and storm tides. This water is conducted through the vegetated area by these channels. The same situation was found at the south end of the next beach ridge unit south of Little Beach. Normal high tide fails to flood through the two gaps by 6-12 inches. The tidal channel at the south end of Little Beach provides normal tidal exchange for these ponds. This large channel has developed in its entirety since 1949. Both headward erosion of one tidal channel, to reach the ponds, and stream piracy by another have had to be involved in developing the present channel. Figure 32a shows an eroding dendritic drainage system west of Little Beach that is involved in the pirating of other marsh canals.

a. Grassy swale between two brush covered berm ridges east of Little Beach.

b. Southernmost ancient beach ridge remnant in marsh south of Little Beach, and north of The Swash.

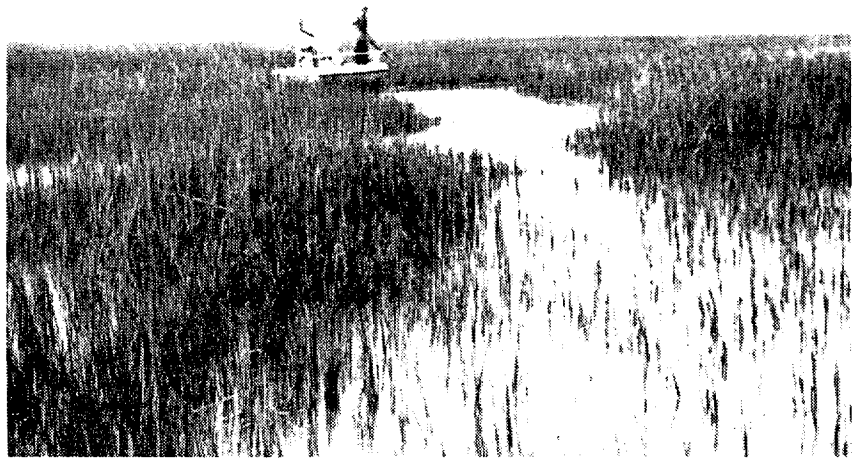
FIGURE 36: Ancient Beach Ridges - Parramore Island



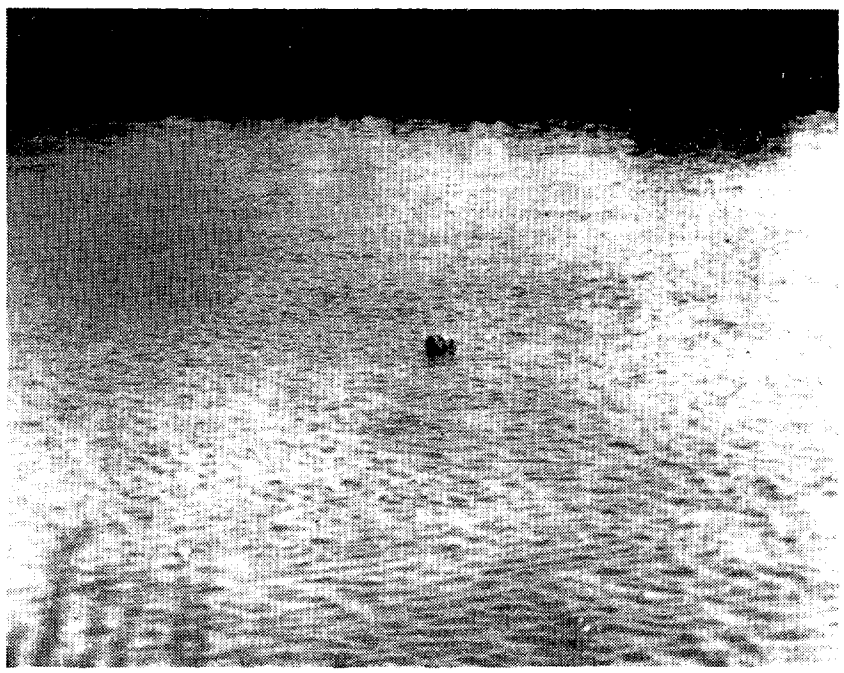
a. Dr. A. W. Niedoroda augering in marsh south of Little Beach.

b. Dr. A. W. Niedoroda and T. E. Rice augering low beach ridge south of Little Beach.

FIGURE 37: Field Work on Parramore Island



a. Waterman David Tyler and A. Pratt returning to Parramore Island through the marsh at high tide to pick up the field party.



b. Otter in marsh canal at south end of Little Beach.

FIGURE 38: Field Scenes

a. Field party in marsh west of north end of Little Beach. Auger site is on a low Parramore Pimple, and another one can be seen behind the field party.

b. Dr. Niedoroda displays grey sandy auger sample taken in the marsh near The Swash. Trees in the background are growing on one of the ancient beach ridge remnants.

FIGURE 39: Field Work on Parramore Island

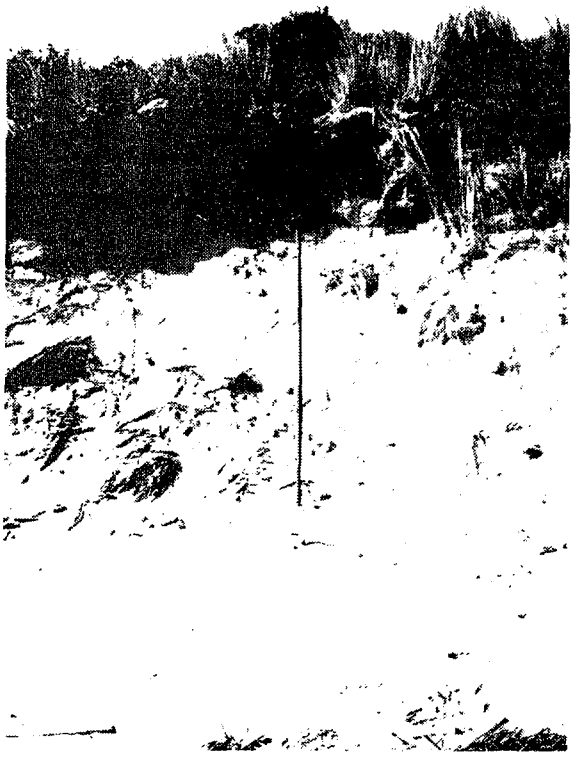
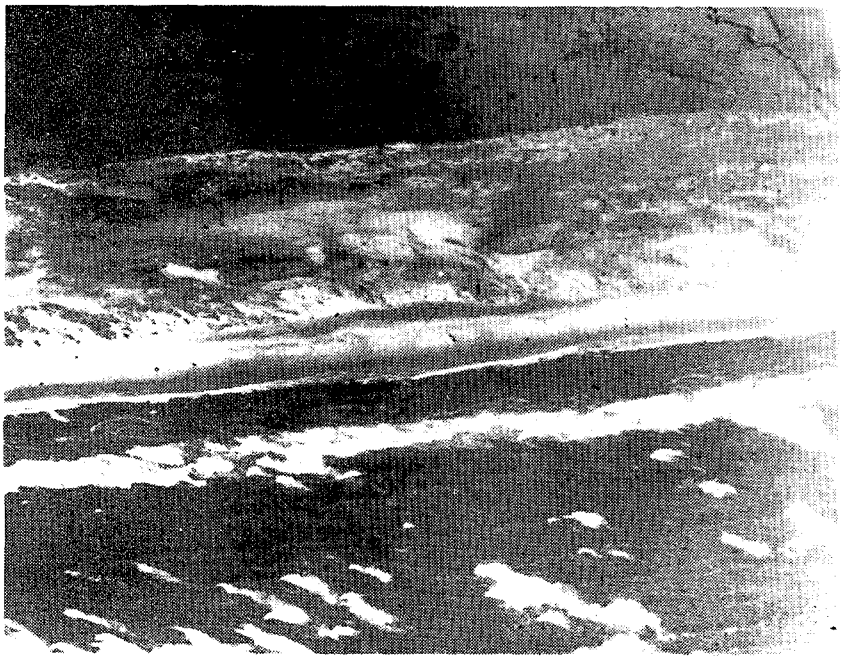


FIGURE 40

Beach Erosion
on Parramore Island

a. Wave cut scarp behind the beach south of the shipwreck. Auger is eight feet long.



b. Appearance of southern end of the island where the rate of beach retreat has been the highest.

The channel at the south end of Little Beach has built an extensive sandy delta eastward from the south end of Little Beach that has divided a former very large salt pond into the two large ponds now found. It is clear that since sometime prior to 1949 the salt ponds have been accreting sand from the marsh side, and are being reduced in area and probably in depth. The source of this sand is not clear. The transition from the grassland of the swale to the sparse Spartina alterniflora cover of the high portion of the marsh occurs west of the western beach ridge at distances varying from 100 to over 800 feet.

Augering in this area in September, 1975, revealed sand to depths of 8 feet beneath both the high marsh and the grassland. At these augering sites (see Figure 37a) a thin, 3-6 inch layer of mud was found at approximately 40 inches below the surface. Below the mud, the auger encountered firm sand. The upper 6-10 inches of each auger hole produced a mixture of sand and mud and the rootmass of living vegetation. The investigation of this area raised as many questions as it answered, and left unanswered the question concerning the source of the sand that is entering the salt ponds. Investigation of this area should be continued.

Along the southern third of the island the beach ridges disappear and are replaced by a ridge of active sand dunes that is frequently cut by small overwash channels. An apron of overwash forms an extensive sand flat behind the sand dunes. The grassy swale of the middle third of the island narrows and curves toward the beach, disappearing under the active sand dunes about midway through this section of the island. Where overwash is spreading over the grassy swale, it builds around the mounds and ridges found on the swale. The strip of marsh behind the swale also curves eastward, ending at the overwash behind the beach and narrowing southward until it ends at the abandoned channel of an ephemeral inlet (see Figure 38b). The southern sand spit of Parramore Island continues south from this point with some new, partially vegetated sand dune ridges on older parts of the sand spit. A small, narrow crescentic inlet island that has been christened Crescent Island by The Nature Conservancy has been formed in The Swash behind this southern sand spit. This island has a large shoal and marsh area associated with it on the north side. Another shoal and marsh island lies just northeast of the first, and near the position of the ephemeral inlet. In the marsh along The Swash, there is a clear pattern of a former tidal channel three times the width of the modern channel. The northern margin of this old channel is in the marsh on Parramore Island, and the southern margin is in the marsh on Revel Island.

This former channel will be discussed later in the section on geology. The 1949 aerial photographs do not show this old channel as clearly as the I.R. imagery does, but they clearly show The Swash is filling in. It now appears to serve principally as a flood tide channel. The photos (ANO-IE-172, and 174) show that The Swash narrows and discharges into Little Sloop Channel in the marsh west of Revel Island instead of directly into Swash Bay as it formerly did. The inlet end of The Swash is clogged with flood tide deposits. The 1966 and 1968 bathymetry for this portion of The Swash gives depths of 2 feet and show no defined channels. The function of The Swash appears to have been taken over by Drawing Channel which discharges to Wachapreague Inlet and shows depths of 15 feet well back into Swash Bay. Green Channel which connects to Drawing Channel shows depths to 21 feet near the central part of Swash Bay. Little Sloop Channel, though narrow, shows depths to 21 feet and connects Swash Bay to Revel Island Bay to Sandy Island Channel which is one of the two main channels from Quinby Inlet.

Physiographically, Revel Island has two beach ridge units that converge near the north end of the island. There is no modern beach on the island, and it has developed fringing marsh on the beach side of the island and a fairly broad marsh area between the beach ridges and again on the mainland side. The marsh extends farther west through

a narrow arm of marsh on the north side of Revel Island Bay, after which it broadens again and continues westward to the mainland between Swash Bay and Upshur Bay. In the marsh west of the beach ridges there are a number of old inlet islands. Just west of the western beach ridge there are three of these inlet islands and there is another near the north end of this ridge. All of these rise above the marsh by 2-3 feet. The beach ridge units are not simple single ridges but are clusters of ridges grouped as single units. Ridge lines have been drawn to try to indicate crests of separate ridges. Between the ridge units there is a narrow grassy swale with scattered small ponds. Tidal drainage reaches into this area from the north and the south. Most of the smaller, branching canals are building levees and many terminate in small deltas.

Along the northern half of Parramore Island the southeast facing beach is retreating into the beach ridge units producing an escarpment up to 10 feet high (Figure 38a). Grasslands as well as brushy and tree-covered ridges are being eroded (Figure 39, a & b). A shipwreck lies awash in the sand on this reach of beach (Figure 40a). On the Geologic Map of Parramore Island, the location of this wreck is shown with the standard cartographic symbol for a wreck. It has been reported (D. Tyler, and G. Hennessey, 1975, personal communication) that the wreck has been recently driven ashore from an earlier grounding off the beach. Tree stumps (Figure 40b) dot the beach and surf zone in this reach of beach, and logs are abundanton the beach. Newman and Munsart (1968) have previously noted these stumps and identified them as "live oak" (Quercus virginiana). Neither the age nor the depth of burial of the stumps was determined in this study. Several aspects of this occurrence suggest that these trees may date from an ancient time when sea level stood at a lower elevation.

First, the stumps appear to be in place and few have their roots exposed, showing only trunks protruding from the sand. Modern trees on the island only grow in well-drained areas more than several feet above present sea level.. Second, the bedpost knob pattern of biologically fostered decomposition agrees with the present high tide levels and matches that seen on watermen's posts driven in the marsh. This indicates that the stumps have remained as they are now for an extended period of time. Third, it is apparent that the trees were buried, and thus preserved, at some ancient time because they have only recently been exposed by the retreat of the beach. The most likely mechanism of burial would have been sand dune growth and migration. This occurrence should be more fully investigated because it could yield data on the extent of a regression discussed elsewhere in this report.

Retreat of the southeast facing beach of Parramore Island has caused the beach to cut into established and vegetated beach ridges. Those ridges come out to the beach at a small angle to the beach so that each is gradually truncated toward the south. The ridges also decline in elevation toward the south so that at a point opposite the south end of Little Beach, small overwash channels begin to breach the older sand dune ridge located there. To the south, these overwash channels become more numerous until the sand dune ridge has been overwhelmed at a location opposite the north end of Revel Island. For the next mile to the south, there is a foredune ridge of new active sand dunes building on overwash with scattered overwash channels leading through the sand dunes. The rest of the way south along the beach to the sand spit shows accreting bars welding to the beach with a narrow foredune ridge building on an older storm berm. Behind the narrow foredune ridge there is a broad ridge of low (5-8 feet) active new sand dunes that are partially vegetated. Numerous narrow overwash channels lead through these sand dunes to an equally broad sand flat that has been built by overwash. The southern sand spit shows a pattern of accreting berms and bars with new sand dunes beginning to form on the higher berms, and beginning to vegetate on the older berms.

The beach at the north end of the island is portrayed in Figure 41, a & b. Along the south shore of Wachapreague Inlet the beach has eroded back into the beach ridge units a slight amount, but does not appear to have truncated the older beach ridges. At the

a. Beach encroachment into maritime thicket of brush and trees.

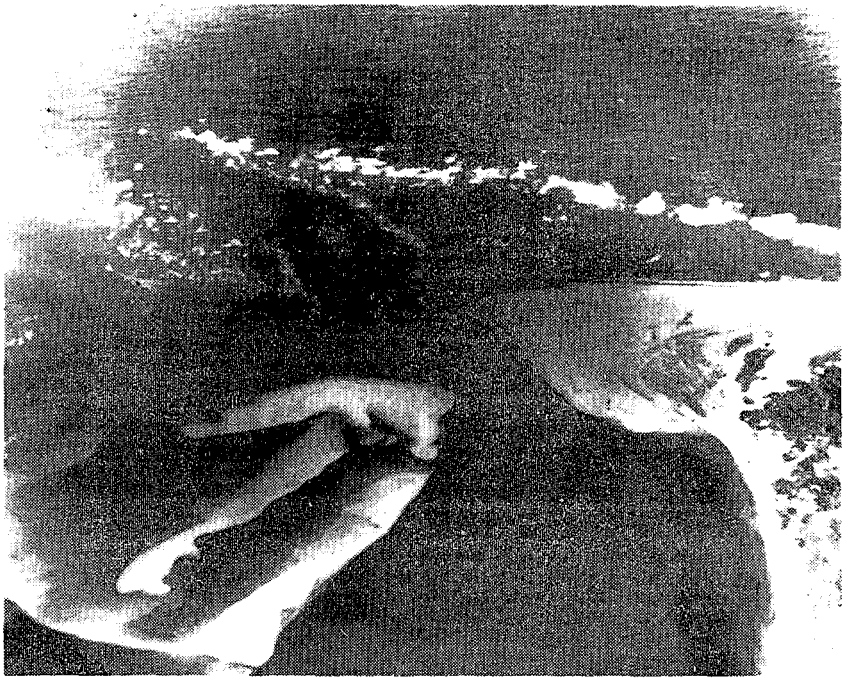
b. Beach encroachment into grassland with scattered trees.

FIGURE 41: Beach Erosion on Parramore Island

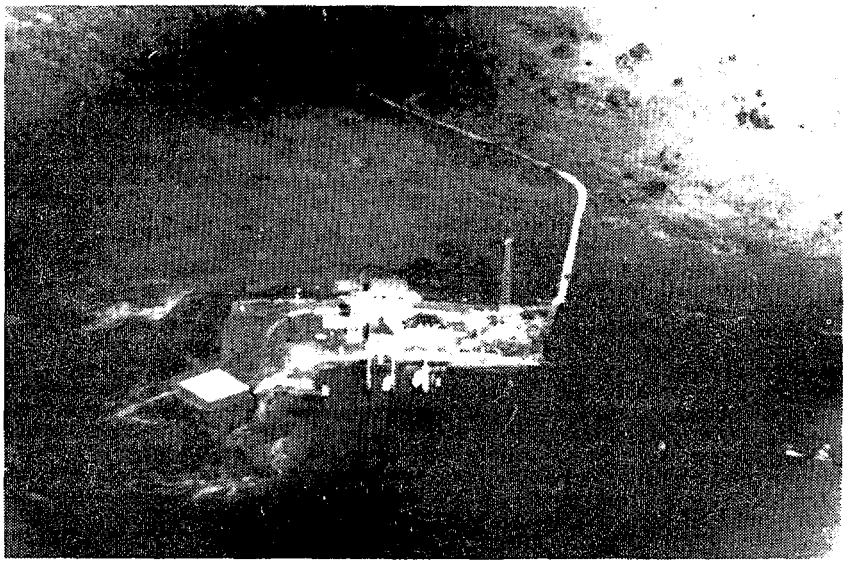
a. Wreck awash in the beach on Parramore Island. Until recently the wreck lay offshore, but was driven ashore by storms.

b. Stumps of former live oak trees in the active beach face on Parramore Island. The roots of the stumps are nowhere exposed, only the trunks protrude.

FIGURE 42: Beach Features on Parramore Island



a. Ebb tide delta at Wachapreague Inlet. Breakers outline the shape of the shallow part of the delta. Main inlet channel is seen where it lies across the delta. Dawson Shoals is at left, Parramore Island is at the right.



b. Coast Guard Station at the north end of Parramore Island.

FIGURE 43: Features - North End of Parramore Island

seaward side of the inlet, the beach displays a wide ridge and runnel pattern with areas of water trapped in the runnel at low tide.

The bordering inlets of Parramore Island are Wachapreague Inlet on the north and Quinby Inlet on the south. Wachapreague Inlet has been discussed previously in the Cedar Island section. Quinby Inlet has shown more changes than Wachapreague Inlet during the historical period covered by this study. There is also geological evidence to support the presence of a major inlet in this area over the longer pre-historical period covered by this study, and this will be discussed in the section covering geology.

Quinby Inlet is presently bordered on the north by the somewhat ephemeral southern sand spit of Parramore Island and on the south by the north end of Hog Island which has also demonstrated an ephemeral nature in its changing shapes. Three large tidal channels which serve an extensive landward system of bays and marshes converge at Quinby Inlet. One of these channels, The Swash, has been losing its significance during the historical period of observation, and changes have been reflected at the inlet and in the other tidal channels.

III. SHORELINE CHANGES

Analysis of shoreline changes for Parramore Island reveals that the shape of the modern island differs greatly from that of the 1852 island. Changes at the north end of the island have been minimal, and largely accretional on the east facing beach located there. The modern shore of Wachapreague Inlet is about 0.15 mile south of the position in 1852, although that portion of the shore has shifted both north and south over a greater range. The southeast facing Parramore Island Beach has also shifted in and out at the north end of the island, with the net change indicating some retreat. However, the southern half of this island has undergone considerable change.

In 1852, the southern end of the island was broader than the present northern half of the island. In 1852, the island bulged seaward more than half a mile further than in 1910-11, and was more than 0.8 mile seaward of its present position. Clearly, significant changes occurred during the time period, 1852-1911; Quinby Inlet migrated south, The Swash began to close,and the southern sand spit of Parramore Island began to grow. In the intervening years, to the present, further changes have occurred along this southeast facing beach.

Examination of the shoreline changes in each section of beach on the island helps to put these changes in perspective. Figures 42, 43, and 44 have been prepared to graphically display these shoreline changes. Measurements have been made from the charts, topographic maps, and photo imagery.

A. Wachapreague Inlet

The shoreline along the channel of Wachapreague Inlet at the north end of Parramore Island showed little net change in position from the earliest charts (1852-1871) to the 1955 chart, although some fluctuations of its position did occur. Since 1955, this section of beach has undergone a series of changes that have produced a counterclockwise rotation of the beach. The net retreat of the beach at the marsh end has been about 650 feet, while the seaward end of the beach has accreted about 100 feet. Periods of retreat of the west end of this beach occurred between 1955 and 1957 (450 feet), 1961 and 1963 (385 feet), and 1958 to 1964 (132 feet), while a period of accretion occurred between 1957 and 1961. At the east end of the beach, accretion took place between 1955 and 1957 (580 feet) and again between 1957 and 1961 (133 feet) while retreat occurred between 1961 and 1963 (385 feet), 1966 and 1968 (22 feet), and 1968 to 1974 (210 feet). The period from 1963 to 1966 showed little net change along

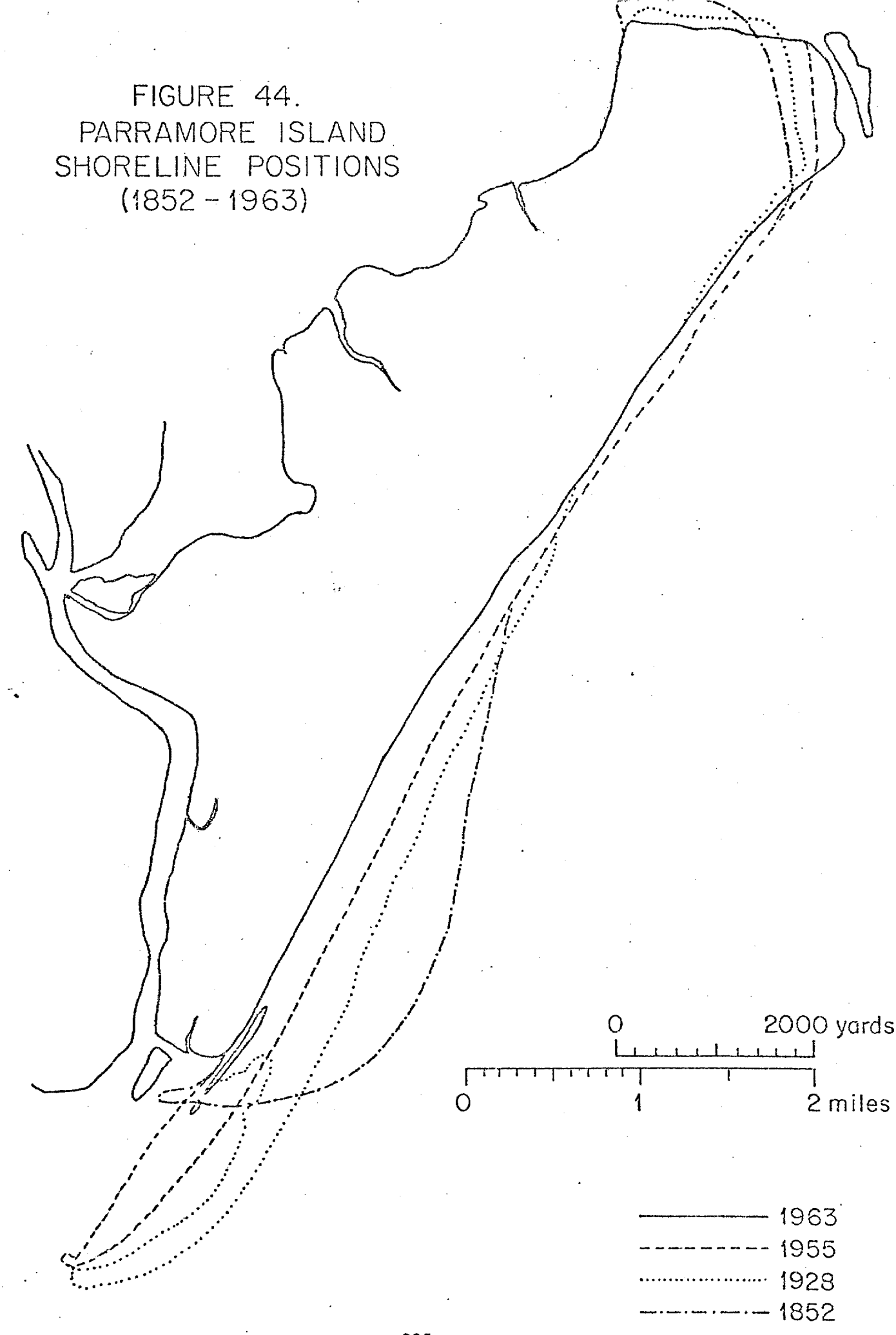


FIGURE 44.
PARRAMORE ISLAND
SHORELINE POSITIONS
(1852 - 1963)

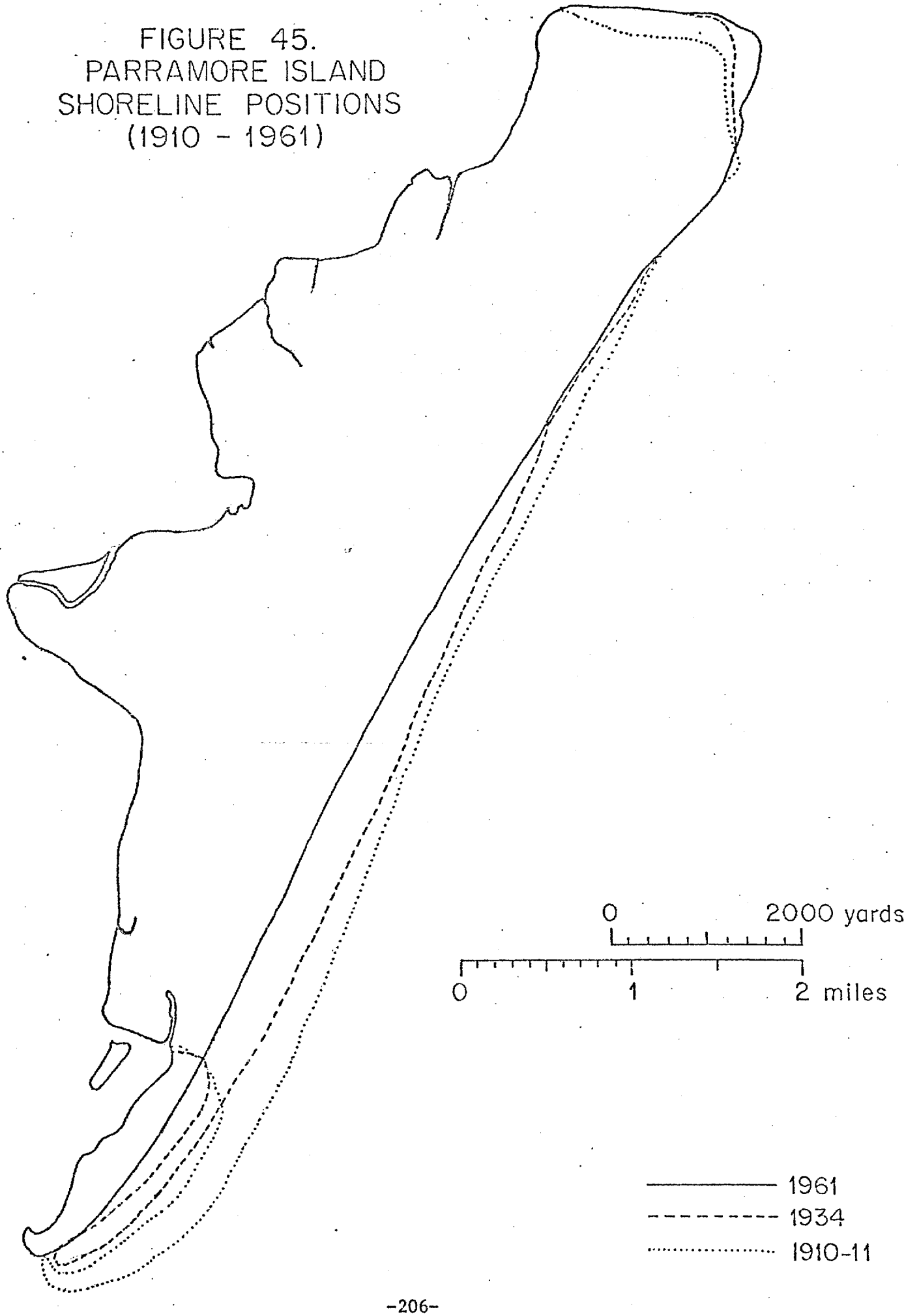


FIGURE 45.
PARRAMORE ISLAND
SHORELINE POSITIONS
(1910 - 1961)

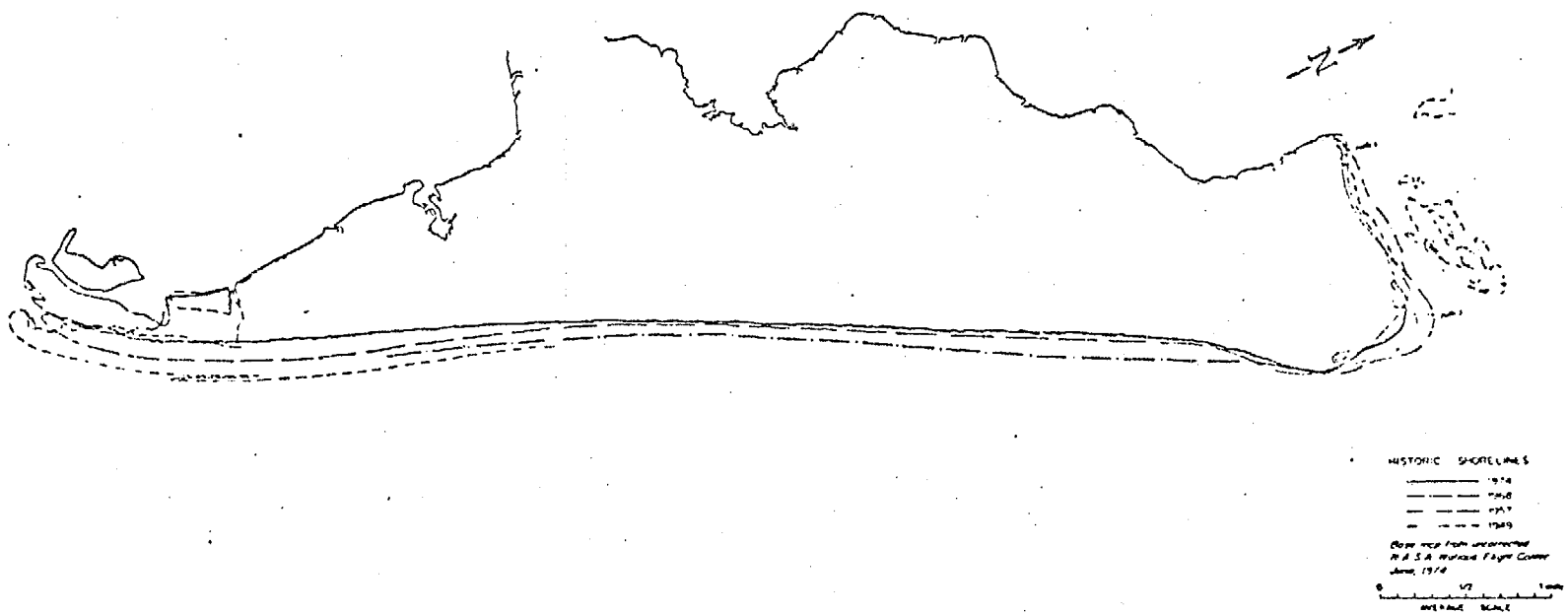


FIGURE 46. PARRAMORE ISLAND, SHORELINE POSITIONS
(1949-1974)

this end of the beach. These figures show that during the period of rapid changes along the Cedar Island sand spit (mid-1950's to mid-1960's), the beach facing Wachapreague Inlet rotated noticeably in a counter-clockwise direction, and that since 1961 or 1962, the beach has retreated southward an average of 550 feet without appreciably changing that rotation. This suggests that changes in the inlet channel related to the rapid growth of the Cedar Island sand spit are still occurring.

B. East Facing Beach

At the seaward side of Wachapreague Inlet there is an east facing beach that is less than a mile in length. It gradually accreted at its northern end while remaining remarkably fixed in position at the southern end. This beach is under the influence of inlet processes, and its accretion during the past century and a quarter would tend to agree with Boothroyd's hypothesis (Boothroyd, 1972). Boothroyd has hypothesized that accretion of a barrier island will occur on shorelines near an inlet where inlet currents, reinforced by wave refraction, dominate over longshore currents. However, analysis of the growth of this beach reveals some other interesting correlations with activity on the Cedar Island sand spit, and thus with inlet processes. From 1852 to 1911, this east facing beach grew seaward by an average of about 900 feet (670 feet at north end, 1450 feet at south end) while the Cedar Island Sand Spit grew south by 1550 feet. From 1911 to 1955, there was no appreciable growth on the east facing beach, and during the same period, the Cedar Island Sand Spit retreated 4200 feet to Trout Channel and shifted west by over 1100 feet. Between 1955 and 1957, the east facing beach grew seaward about 800 feet while the Cedar Island Sand Spit grew south 1500 feet, and widened eastward by 1500 feet. From 1957 to 1963 the north end of the east facing beach had retreated about 640 feet, but the south had grown 220 feet. However, from 1957-1961, the entire beach had retreated, so growth of the southern end occurred after 1961, and retreat of the north end continued through 1963. In this same period, the Cedar Island Sand Spit continued to grow, Wachapreague Inlet Channel apparently rotated counter-clockwise, and a large offshore bar grew seaward and northeast of the east facing beach indicating a redirection of sediment transporting currents offshore from the beach. This implies a change in the configuration of the ebb tide delta, although there is no bathymetry available by which this could be confirmed.

From 1963-1968, minor adjustments occurred on the east facing beach with some net growth in the mid-portion, no growth at the north end, and a retreat of over 600 feet at the south end. The offshore bar disappeared. During this period the Cedar Island Sand Spit grew an additional 750 feet. From 1968 to 1974, the east facing beach has again grown seaward an average of 550 feet, having added a large ridge and runnel to its width. The Cedar Island Sand Spit appears to have continued to grow in width and to recurve westward during this period. The correlation of shoreline changes on this beach with events across Wachapreague Inlet on Cedar Island only serves to emphasize that the inlet processes are intimately involved in these changes. This interrelationship of inlet channel, ebb tide delta, and shoreline changes near Wachapreague Inlet should be studied further.

The intersection of the long, southeast facing, Parramore Island Beach and the short east facing beach marks a location on the island where the beach has remained remarkably stable. This location also seems to demarcate the boundary between inlet influences on sediment transport, and mid-island wave generated longshore sediment transport.

C. Northern End of Parramore Island Beach

Shoreline changes along Parramore Island Beach differ along the length of the island. Along the northern 2.6 miles of this long beach, accretion occurred from 1852 to 1955. The averaged annual advance of the northern half of this section of beach was

6.2 feet/year, while the southern half advanced at a rate of 5.9 feet/year.

Between 1955 and 1957, this northern section of beach retreated irregularly. The retreat was about 600 feet at the northern end, diminishing to 144 feet (about 0.75 mile to the south), advanced 55 feet about 0.4 mile further south, but one mile further south retreat reached 40 feet. From 1957 to 1961, the north end of this section of beach retreated another 400 feet, but retreat diminished to 277 feet about 0.75 mile to the south. The section that previously advanced 55 feet advanced 765 feet in this later period, and the section one mile further south advanced 60 feet.

Over the next two years the entire section of beach retreated, the retreat varying from 312 feet at the north end to 222 feet at the south end. Averaged over the eight-year period, these figures show that the beach southeast of North Pond (north end of this section) retreated at a rate of 164 feet/year, while southeast of the mid-point at Goose Lakes, the beach was accreting at a rate of 50 feet/year. However, the south end of this beach section, southeast of Level Pond, retreated at an average rate of 25 feet/year. Thus, in this time interval, while the east facing beach was accreting and the Cedar Island Sand Spit was growing, the very north end of Parramore Island Beach suffered rapid erosion, while south of that, the northern section of beach first advanced, then began to retreat. Extending these observations to 1968 and 1974 shows that beach retreat southeast of North Pond had slowed to 95 feet/year in 1968 and to 11 feet/year by 1974. Southeast of the mid-point of Goose Lakes the previous accretion rate reversed to a retreat of 100 feet/year by 1968, and slowed to a retreat rate of 12 feet/year by 1974. The south end of this beach section, southeast of Level Pond, had accreted more than 900 feet by 1968, but was retreating at a rate of 4.5 feet/year by 1974. This entire northern section of beach showed a series of adjustments between 1955 and 1968 that reflect changes occurring around Wachapreague Inlet during that time. The return to a slower rate of retreat by 1974 indicates that those rapid adjustments are probably over.

D. Middle and Southern Reaches of Parramore Island Beach

The middle reach of Parramore Island Beach accreted a maximum of 600 feet between 1852 and 1911, an average rate of 8.7 feet/year. During this time interval, the southern reach of Parramore Island Beach retreated a maximum of about 1700 feet, and an average of 1320 feet for an average annual retreat of 18.9 feet/year. By 1911, the prominent bulge of the southern reach of the beach had been erased and a 950 foot wide sand spit grew 1.41 miles to extend this beach southward into Quinby Inlet. This produced a longer and straighter shoreline for the island. From 1911 to 1955, both the middle and southern reaches of beach retreated, with retreat being greatest to the south. The retreat, averaged over the section, was about 950 feet, which yields a retreat rate of about 22 feet/year for the southern two-thirds of the island. The southern sand spit lengthened by another 100 feet. In the interval from 1955 to 1957, retreat of this long section of beach averaged 280 feet, or an annual rate of 140 feet/year. By 1961 the beach had built out an average of 130 feet, the advance being somewhat greater to the south. This yields an average rate of advance of 32.5 feet/year and a very much straighter beach.

Between 1961 and 1963, an ephemeral inlet broke through the southern sand spit at a point 6.7 miles south of the north end of the island. The width of the inlet was about 2100 feet in 1963. The severed end of the sand spit stood as an island 6200 feet long and about 600 feet wide. The beach along the southern half of Parramore Island had retreated sharply, averaging 740 feet of retreat, but reaching more than 900 feet near the ephemeral inlet. Averaged for the two years, this yields 370-450 feet/year of retreat. The severed sand spit retreated about 550 feet to the west. Two bars about 200 feet wide and 3250 feet and 458 feet long had built across and seaward

of the ephemeral inlet with the inlet draining through the gap between them. By 1966, the whole southern portion of the beach had advanced on average of about 120 feet or at a rate of about 40 feet/year. The ephemeral inlet had widened somewhat, and the offshore bars had grown slightly, but maintained their position offshore. The sand spit island also maintained its beach position as it advanced with the beach north of the inlet.

In 1968, the ephemeral inlet was closed, the offshore bars were gone, and the southern sand spit was 3800 feet long and averaged about 680 feet in width. But the beach along the southern half of the island had retreated up to 475 feet. The average retreat was about 320 feet or 160 feet/year during this time period. During the interval 1968 to 1974, the middle reach of Parramore Island Beach retreated about 175 feet for an average annual rate of 28.3 feet/year. The southern reach of this beach showed much greater retreat, averaging almost 500 feet along the southern 2.4 miles of beach. This reflects an annual rate of retreat of 91.7 feet/year. Clearly, the southern reach of beach, and to a lesser degree the southern part of the middle reach of beach, are still under the influence of some process of change that began at least as early as the mid-1800's, and which has primarily affected the southern half of the island. Other changes at and inshore of Quinby Inlet would seem to indicate that shoreline changes are related to changes in tidal circulation, through and around Quinby Inlet, and in the marsh behind Parramore and Revel Islands.

E. Quinby Inlet

Quinby (Little Machipongo) Inlet experienced considerable change during the historical period covered by this report. In 1852, Little Machipongo Inlet was 1.64 miles wide. The 1871 hydrography at this inlet shows three tidal channels merging at the inlet: North Inlet, Sandy Island Channel, and The Swash. Depths reached 54 feet in the inlet throat and the throat discharged northeast, tight against the shore of Parramore Island and along the bulge in the southern reach of the island's beach. North Inlet Channel maintained depths to 47 feet for a distance of 4.5 miles back into Hog Island Bay. Sandy Island Channel maintained depths to 36 feet for a similar distance back to Upshur Bay. The Swash maintained depths up to 13 feet back to Swash Bay where it shallowed at the bay, but still connected through Drawing Channel to Wachapreague Inlet.

The hydrography of 1911 shows that Little Machipongo Inlet had narrowed to about 3000 feet (.57 mile) and was discharging to the southeast; a nearly 90° rotation of the channel axis in 40 years. The axis of the inlet throat had migrated 3000 feet (.57 mile) to the south. Channel depths in the throat remained at 54 feet, and the depths of the three major tidal channels remained about the same. The 1955 hydrographic chart shows that Little Machipongo Inlet had stabilized in its new position, deepened and lengthened the inlet throat and reshaped the ebb tide delta. The three marsh channels remained about the same, although the inlet end of The Swash had shallowed to 2-3 feet. Because no hydrographic survey data of Little Machipongo Inlet could be found for more recent dates, further quantitative comparison cannot be made. The 1949 aerial photos and the 1974 I.R. imagery indicate that abandonment of The Swash is still continuing. From this study, it would appear that for more than the last 125 years, inlet and longshore processes have been removing sand from storage in the beach prism of the southern half of Parramore Island and redistributing it to storage as flood tide deposits in the bay and marsh area, and as ebb tide deposits in the ebb tide delta. The cause of the changes remains unknown, but could be the subject of further investigation.

IV. GEOMORPHIC DESCRIPTION AND INTERPRETATION

The geomorphic units of Parramore Island and Revel Island are considered from oldest to youngest, beginning with the beach ridge units on the marsh sides of the islands.

There are no obvious landforms in the marsh and bay area west of the islands. In reference to the Geologic Map of Parramore Island, it can be seen that a beach ridge unit begins just north and west of the south end of Italian Ridge and continues north against the marsh to about 0.2 mile south of the Coast Guard Station. Near the south end, and again near the north end, this ridge displays a pattern of old dunes cut by frequent narrow overwash channels with an overwash apron on the marsh side. In the marsh west of this ridge, at the south end, there is a pattern of natural levees marking a former tidal canal about 0.1 mile wide that is cut off by the ridge, and north of this, another smaller partially filled-in tidal canal terminates abruptly at the ridge. This ridge is interpreted as an ancient thin barrier island (similar to the modern south end of Metomkin Island) that had been retreating over its marsh area. The data of this study would intimate that this ancient barrier island continued northward into Cedar Island, and that its northern end occurred at an ancient offset inlet east of Cedar Island Bay.

Between the south end of the ridge unit just described and Little Beach, there is found the wide opening of a former ephemeral inlet to Swash Bay and the neighboring marshes. This inlet was 1.1 miles wide between Little Beach and the continuity of the island to the north. The presence of a sand delta behind this inlet and the absence of inlet island deposits indicates that this inlet was a short-lived breach in the ancient barrier island. The inlet now contains a number of broad, low (2-3 feet), northwest trending ridges that are interpreted as berms or sand spits (possibly as inlet islands) built upon a sand delta that spread into Swash Bay through this inlet opening. The western edge of this sand delta can be seen in the I.R. imagery, and lies from 0.15 to 0.30 mile west of the beach ridge axis.

Little Beach and the beach ridge unit south of it are the most prominent remnants of this ancient barrier island, but other beach ridge units that align with it to the south are remnants of the same barrier island that had been retreating westward into the ancestral Swash Bay. These remnants can be seen trailing southward in the marsh toward the north end of Revel Island where the western beach ridge unit represents the continuity of this former barrier island. Between the north end of the Revel Island beach ridge unit and the south end of the Little Beach group of beach ridge units, an inlet opening developed, and remained open, in the vicinity of the modern tidal channel, The Swash.

In the Little Beach part of this ancient island, ephemeral inlets, occurring as breaches, opened at the south ends of Little Beach and the next unit to the south. The pattern of sand deltas spread into Swash Bay through these openings can be seen clearly on the I.R. imagery. Modern tidal channels display intricate dendritic patterns along the delta margins where headward erosion by these channels is cutting back into the deltas. This delta pattern does not extend south to The Swash. The remnants of this ancient barrier island that run north from Revel Island toward Little Beach show a smaller sand delta near the north end of the western beach ridge of Revel Island. North of this sand delta, the deposits appear to be inlet islands, and in the vicinity of The Swash, both the inlet islands and the remnants of the barrier island are absent. Therefore, it is believed that this inlet remained open, and has developed into The Swash.

In the eastern beach ridge unit on Revel Island, the ridge line patterns (at the north end of the southern half) show the north end of a second ancient barrier island that extends away to the south. (See Figure 54 in section covering Hog Island.) This ancient barrier island is truncated 0.6 mile south of its north end, and the extension of this beach ridge unit to the south is younger. An inlet existed between the north end of this ancient barrier island and the ancient barrier island represented by the western beach ridge unit on Parramore Island. This ancient inlet connected southward toward Hog Island Bay, and was probably the ancestral inlet for Sandy Island Channel.

At the north end of Parramore Island, east of the overwashed ancient barrier island previously described, there is a series of beach ridge units that are built against the overwashed barrier island at shallow angles of 15° to 30°. This series of beach ridges extends eastward to include Italian Ridge and is interpreted to indicate a period of prograding to the southeast. The recurved southern end of Italian Ridge is built around and over the older barrier island and indicates the continued presence of a shallow inlet or broad overwash channel south of Italian Ridge during this initial period of prograding.

A series of low beach ridges of probable berm origin lie on the east side of Little Beach and the beach ridge units south of it. At the north end of Little Beach there is a smaller beach ridge unit that is probably part of the ancient barrier island. There is a narrow ephemeral inlet opening between it and Little Beach. The low ridges closest to Little Beach and the northern ridge unit recurve into this narrow inlet opening, but the ridges farthest to the east do not, indicating the closing of the tiny inlet. At the inlet between Little Beach and the next ridge to the south, the low ridges around both beach ridges recurve into the inlet opening, indicating that this inlet remained open. To the south where small ridge segments extend toward Revel Island there are low ridges to the east and parallel to the line of ridge segments. At their south end, these ridges recurve toward the bay as they terminate. On Revel Island at the north end of the eastern beach ridge unit, the ridge line pattern shows a separate beach ridge, 0.6 mile long, lying adjacent to the western beach ridge. This beach ridge has been breached in the middle and a large overwash deposit spreads west against the western ridge. It has also been overwashed where the southern end curves into the old inlet to the south, and this overwash, too, is spread toward the western ridge. The beach ridges, out to Italian Ridge, the low ridges to the south along the Little Beach sections, and the separate beach ridge at the north end of the eastern beach ridge unit on Revel Island are all taken to be synchronous prograding events.

The eastern beach ridge unit begins at the north end of Parramore Island and extends down the eastern shore of the island until it is truncated by the modern beach east of the south end of the Little Beach Unit. This is a complex ridge unit. No attempt was made to delineate all of the ridge lines or to interpret the complex history of this unit. The ridge unit is the eastern geomorphic expression of a larger unit that includes the central swale and extends south eastward from Italian Ridge and the Little Beach berm ridges to the modern beach. The southern limit of this larger unit is found east of Revel Island where modern beach and overwash deposits truncate and cover the unit. The western portion of this larger unit is a broad sand flat on which old, now drowned, tidal and overwash channels, and a confusing array of Parramore Pimples can be found. Some attempt at recovering old ridge lines through these feature was made, but the complete task is left for another study. This whole unit is interpreted as representing rapid progradation to the southeast during which time the barrie island was repeatedly overwashed through the gaps in the western ridge line and into th bay area. As the active beach migrated eastward, overwashing repeatedly breached newly formed dune lines, leaving dune remnants to be added to by wind blown sand. This overwashing built the overwash sand flat westward to the gaps in the western beach ridge and perhaps into the gaps. A modern area that exhibits these overwashed characteristics can be seen today on Assateague Island, north of Scotts Lodge and south of Sugar Point, which is about midway along the length of that island. In time the growth of the eastern beach ridges isolated this washover area from the beach. Southward, on Revel Island, the inlet between the two ancient barrier islands narrowed as beach deposits grew southward until the channel was reduced to about 500 feet in width.

Near the south end of Parramore Island, about 0.5 mile north of the south end of the marsh, there is a narrow beach ridge unit that curves westward, then northwest through

the marsh until it lines up with another ridge a half mile north and set in the marsh on the north side of The Swash. The more southerly curved ridge is interpreted as a sand spit that built westward from the south end of the island at a more ancient time. It recurves into a former inlet to Swash Bay. Parramore Island was offset to the east of the next island to the south at this time. The more northerly ridge is associated with a group of inlet islands that built in the inlet channel where a tidal channel branched through the old inlet on Revel Island. The younger, southern part of the eastern beach ridge unit on Revel Island was added during the period. It formed as a curving beach that turned into the inlet channel on the north and recurved westward in open water at the south end. The recurvature at the south end indicates that the island south of Parramore Island had been breached during this time. (See section on Hog Island.)

In the southern half mile of marsh on Parramore Island there are several small, narrow, beach ridge units in the marsh. These have been overwashed in the past (and are being overwashed again by the modern beach). These are interpreted as former sand spits marking the southward extension of the island. The channel from an old ephemeral inlet through these spits still stands open in the marsh, and was maintained by marsh drainage until recent modern overwash began to fill it.

V. GEOLOGIC HISTORY

The geologic history that can be drawn from the older geomorphic features indicates that at some ancient time, a barrier island system was retreating toward the mainland. The area between the islands and the mainland appears to have been nearly all lagoon. In the vicinity of the modern Swash Bay, the northern of two ancient barrier islands began to breach into the ancestral lagoon. North and south of the breached section the islands remained intact. The breaching left isolated beach sections separated by inlets, most of which were shallow. One of the inlets became established and has survived to the present as The Swash. Some of the beach sections had well developed beach ridges on them. Following that ancient time, conditions governing the barrier island processes changed, and for a period of time the northern end of the section accreted to the southeast while along the southern part of the section sand deltas continued to grow westward through the inlets while low berm ridges accreted around the remnant island sections. Near the south end, at what is now Revel Island, a beach ridge grew to the east of the old island remnant. During this time period, with a new inlet to the ancestral lagoon becoming established, the older inlet between the two southernmost ancient barrier islands began to narrow.

Following this period of slow accretion, the rate of accretion increased and Parramore Island grew rapidly southeastward, extending itself both to the north and to the south. Extension of the island at the south end resulted in the migration of the inlet to the south, and the lengthening of the tidal channel leading to Swash Bay. The tidal channel that cut between the ridges on Revel Island was abandoned, and tidal drainage became established through the breach to the south of Revel Island. How far Parramore Island grew to the southeast is unknown, but the southern end and the inlet tidal channels located there apparently stabilized near where the modern marsh behind the islands ends. The southeasterly growth and migration of the island was eventually halted by a return to a condition of rising sea level, and the beginning of the modern period of slow retreat of the beach.

HOG ISLAND AND ROGUE ISLAND

I. DESCRIPTIVE GEOGRAPHY

Hog Island is the sixth island from the north in the Virginia Barrier Island Group. It lies south of Parramore Island, and north of Cobb Island. It is bounded at the north by Little Machipongo(Quinby) Inlet, and on the south by Great Machipongo Inlet. The north end of the island lies 8.7 miles off the mainland coast and the south end about an equal distance. The island is seven miles long. The Town of Nassawadox, on Interstate Highway 13, lies on the mainland west of the north end of the island. Exmore, a larger community on the Interstate, is north of Nassawadox. These are the only communities of any size along the mainland. Access to the island by boat may be made from Wachapreague, Quinby, Willis Wharf on the Machipongo River, and Red Bank Boat Landing east of Marionville.

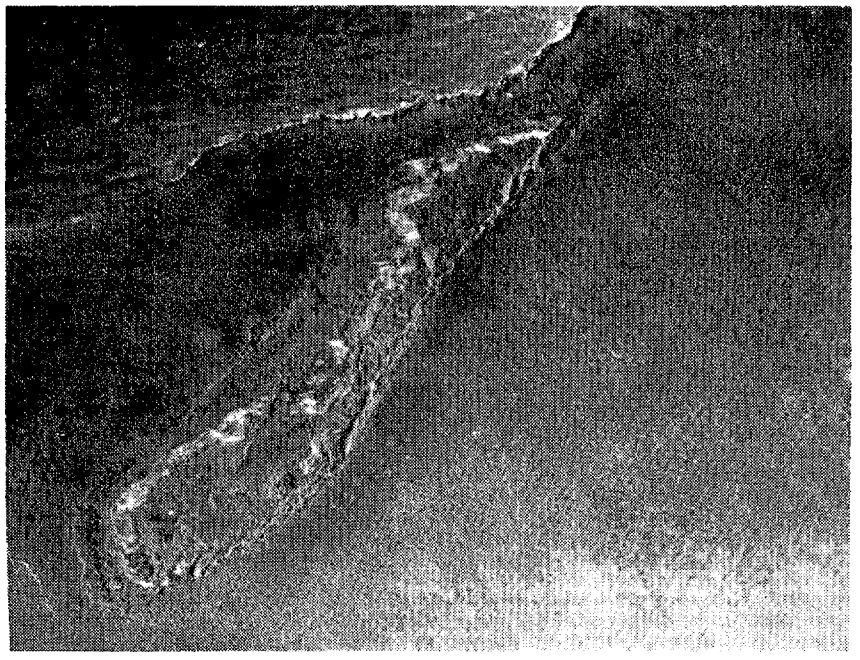
Hog Island is apparently the only island in the Virginia Barrier Island Group, other than Cobb Island, that was extensively colonized by people, although there were development schemes for other islands. It has been reported by various people, including Hennessey (1976, personal communication), that prior to the 1933 storm, a village of about 400 people existed on Hog Island, and that both a cemetery and a guest hotel for tourists were features of this community. The 1933 storm appears to have finally threatened the community, damaged one home, and begun the exodus of the population to the mainland. The town was officially closed when the Post Office was decommissioned in 1943. (Hennessey, op. cit.) Further retreat of Hog Island has eliminated all trace of this community, which was known as Broadwater. The 1942 (U.S.G.S. Topo. Series) map shows 13 buildings, a cemetery, a light, and a pattern of roadways in an area east of the present Coast Guard Lookout Tower and that area has since been eroded away. Many of the buildings of the Broadwater community were moved to the mainland before beach erosion destroyed them (Hennessey, op. cit.) Local (at Wachapreague) watermen report encountering headstones from the former cemetery in the shallow waters offshore of the modern Hog Island. Figure 47 portrays the evidence of continued human activity on Hog Island.

Most of the area between Hog Island and the mainland is occupied by Hog Island Bay. Although Hog Island Bay is laced with deep tidal channels, most of the bay area is within the range of the tide; tidal flat at low tide, and about four feet of water at high tide. Hog Island Bay is ringed with marsh areas at the north, inland of Quinby Inlet and Revel Island. The most notable marsh areas are Chimney Pole Marsh, directly inshore of Quinby Inlet, Sandy Island Marsh to the northwest of Quinby Inlet, and a large marsh area between Upshur Bay and Hog Island Bay that extends back to the mainland. Of these, Chimney Pole Marsh and Sandy Island Marsh are probably floodtide deposits inside Quinby Inlet. Both areas exhibit a sandy character with elevations in excess of two feet above mean high tide. Chimney Pole Marsh has an active beach, with new dunes facing into Quinby Inlet.

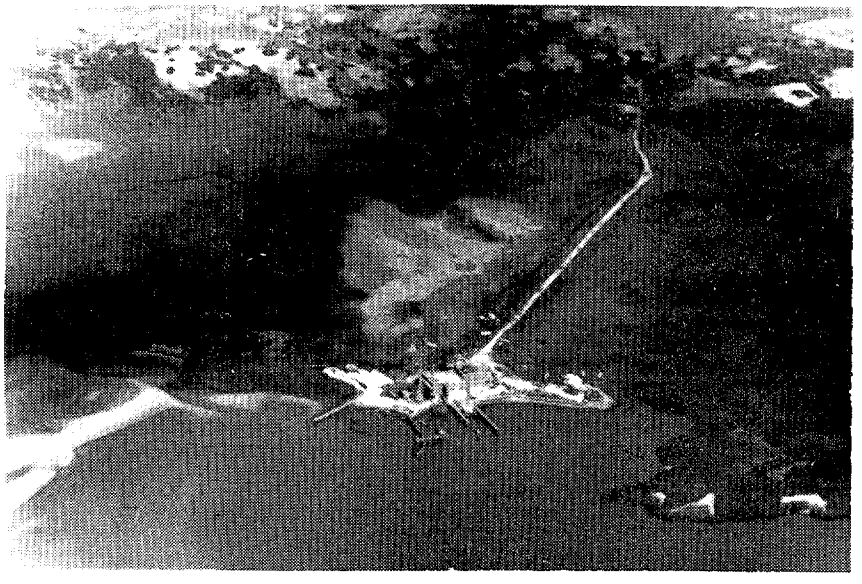
At the mainland, westof the southern portion of Hog Island, a triangle of marsh has built eastward into Hog Island Bay; Short Prong Marsh forms the eastward point of this triangle. There are small marsh islands around the eastern and southern margins of Hog Island Bay. Deep tidal channels called The Deeps and Gull Marsh Channel reach out from Hog Island Bay into Ramshorn Bay, Outlet Bay, Spidercrab Bay, and even south to Cobb Bay.

II. PHYSIOGRAPHIC DESCRIPTION

There is some noteworthy physiography in the area west of Hog Island. On the mainland,



a. Diked dredged spoil disposal site in the marsh near the north end of Hog Island.



b. Machipongo Club facilities in the marsh near the north end of Hog Island.

FIGURE 47: Human Activities on Hog Island

a well-defined terrace riser (the Mappsburg Scarp) can be seen striking N26°E about 0.5-2.0 miles inland of the mainland coast. The mainland coast in this area is defined by a series of very ancient beach ridges trending N38.5°E that have tidal marshes between them and the true mainland. The true mainland coastline bows westward in this section, and is highly indented with drowned valleys that cut back into the inland terrace. The ancient beach ridges have been driven back into this bowed coastline. The most prominent of those ancient beach ridges, which may be considered to form the modern mainland coast, are Upshur Neck, The Hammocks and Brock House Neck. Southeast of the trend of the mainland coastline, there is a series (there may be as many as seven) of very old, semi-drowned beach ridges. Obscure, topographically high areas in the marsh behind Parramore Island may relate to these very ancient semi-drowned beach ridges. There are no significant ancient features in the area between these ridges and Hog Island, except the deposits of Gull Marsh. The sandy deposits of Gull Marsh rise 2-4 feet above high tide levels and probably record yet another very old beach ridge, or barrier island. The marsh islands of Gull Marsh string out along a curved north-south line 4.9 miles long that strongly suggests the form of a drowned beach ridge or barrier island. Other configurations of peripheral marsh and marsh islands in Hog Island Bay would suggest even other ancient drowned barrier islands or beach ridges. The sharp bend in the very deep Gull Marsh Channel at the north end of Gull Marsh suggests the maintenance of a former inlet channel that may have been entrenched in older coastal plain strata. Byrne (1974) has reported that the Wachapreague Inlet channel is entrenched in older consolidated sediments, and the inshore position and depth (40 feet) of Gull Marsh Channel at this bend would not be inconsistent with such a hypothesis.

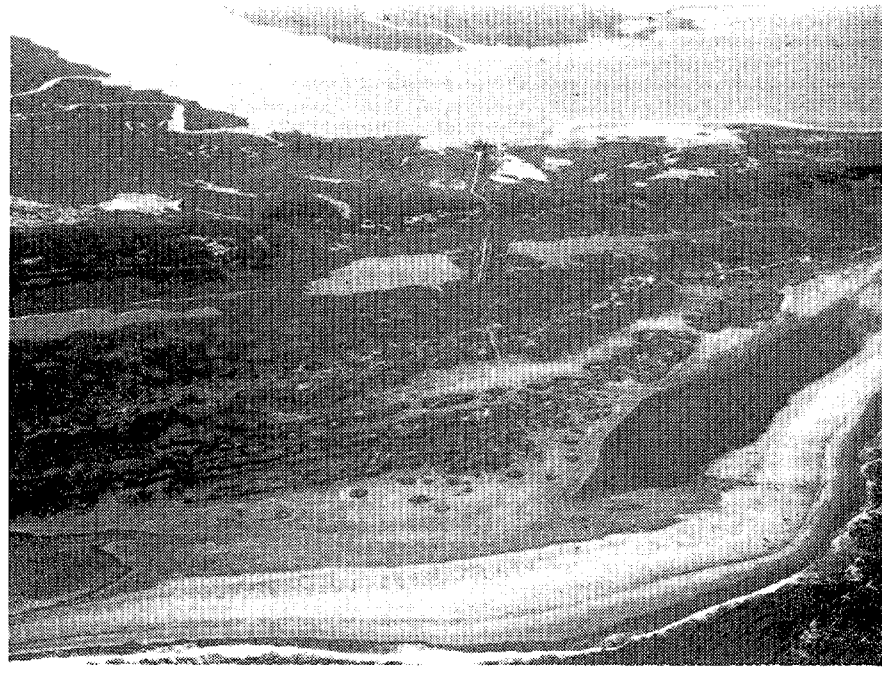
Physiographically, Hog Island may be described as a long, thin barrier island with a narrow marsh area on the inland side of the northern two-thirds of the island. At present, the island is seven miles long. At its northern end, the upland land mass of the island reaches a maximum of 0.67 mile wide, but averages 0.5 mile in width. Beach ridge units extend a little more than half way along the island from the northern end. The southern half of the island is narrower (1000-1900 feet), and consists of a broad barrier beach with scattered sand dunes and marsh areas.

Like Parramore, Hog Island shields a small barrier island behind its southern tip. Rogue Island occupies this protected site. Rogue Island displays several beach ridges, five to eight feet of relief above the marsh, and other beach areas several feet above high tide. From at least 1852 to 1933, Rogue Island lay well behind the southern end of Hog Island. From then until the mid-1950's, Rogue Island was at least partially exposed to wave attack at the southeast end, but not along the northeast shore. The interior beach ridges on this island therefore predate the historical portion of this study, and are represented on the 1852 coastal charts.

The southern third of Hog Island lacks a continuous beach ridge. Most areas (see Figures 48b and 49), show recent overwash and along the southern sand spit, there are areas of new sand dunes and patterns of accreting berms. There are two stable sections of this part of the island; a vegetated sand dune area with 5-10 feet of relief that is located east of Rogue Island, and another area of 5-10 feet relief at the Broadwater Lookout Tower. Both areas are about 2500 feet long from north to south and up to about 1000 feet wide from beach to marsh.

The northern two-thirds of Hog Island has been accreting in recent years. There is an older semi-continuous beach ridge behind the beach along this section of the island. The southern portion of this beach ridge has been modified by recent overwashing and new sand dune formation.

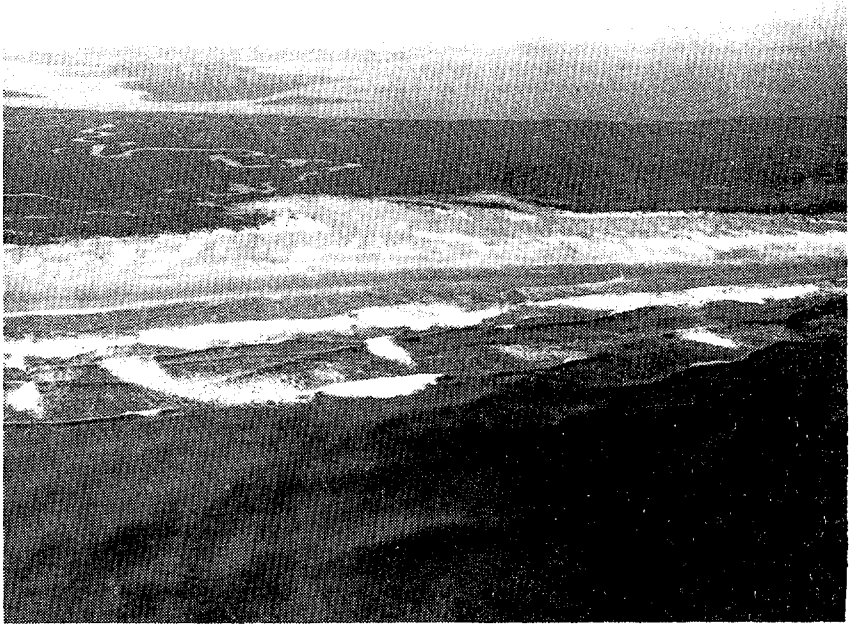
The middle third of the island has built southeastwardly by about 800 feet in recent time. This new portion of the island may be described as a broad back beach sand flat that is intermittently flooded, but on which new sand dunes are accreting along the old



a. Beach ridges, Parramore Pimples, modern ridge and runnel at the north end of Hog Island.

b. Breached dune line and overwash area at Upper Landing Creek near the middle of Hog Island.

FIGURE 48: Views of Hog Island



Large overwash channel that is located in the mid-section of Hog Island, north of Broadwater Lookout Tower. The site appears to be a reactivation of an ancient overwash channel through the ancient beach ridge that ends just south of the lookout tower.

FIGURE 49: Hog Island - Overwash Channel

berm lines. At the seaward margin of this broad back beach area, sand dunes are forming along a storm berm. The modern berm is close against the storm berm. The active beach is broad, and there are numerous bars welding on to the beach. The broad back beach sand flat area may develop into a grassy swale, similar to the one on Parramore Island. This will depend upon the rate and manner by which tide, waves, and wind move sand from the beach into the back beach area. Overwash and wind driven sand have (by 1974) already raised much of the southern half of this back beach area above the normal tidal range.

The northern third of the island also shows an accreting beach. A large ridge (Figure 48a) has welded to the beach and created a wide (200-300 feet) runnel behind it. New sand dunes are forming on the ridge, and a pattern of berms lies seaward of the sand dune area. The runnel is divided into three segments; the southern segment drains through a temporary inlet through the ridge, and the northern two are connected by a narrow channel and drain northward behind the recurving sand spit at the north end of the island.

At the north end of the island, and on the bay side, sand spits have grown around the end of the island and into the tidal channel behind the island. The runnel is presently filling in with sand carried in on the flood tide, and with sand carried into it from the seaward ridge by waves and wind. In time, it should become a broad back beach sand flat with the unfilled areas remaining as shallow ponds. About one-quarter mile to the west of this modern runnel there is an older runnel with a ridge along the east side. This runnel was formed in the decade between 1926 and 1937. The shallow ponds of this older runnel may be seen in Figure 48a. This photograph also shows the older beach ridge unit behind these ponds, and shows the extent to which the runnel has filled and become colonized by vegetation.

III. SHORELINE CHANGES

Examination of the historical shoreline maps (Figures 50 and 51) prepared for the study of Hog Island reveal that the shoreline of this island has experienced far greater changes than the shorelines of the islands previously described. The maps are based on hydrographic information beginning with the 1871 survey. Additional information concerning shoreline positions was obtained from Byrne's (1972) Historical Shoreline Positions maps. A visual comparison of Figure 50 with Figure 51 shows that in 1871 Hog Island was a broad island at the southern end and tapered to a more slender island broken by ephemeral inlet at the northern end. Today, Hog Island has reversed its shape, and in 1975 is broad at the north end and tapers to a long slender island at the southern end. In working these changes, the island shoreline has shifted greatly, and very little of the pre-1871 island remains today.

Prior to 1871 the northern two-thirds of the island's shoreline had been retreating toward the west. Between 1852 and 1871, this part of the shoreline retreated up to 900 feet. The average rate of retreat varied from 35-45 feet/year, but was closer to 35 feet/year for most of this length of northern shoreline. In this 19-year period, the north end of the island retreated southward about 2100 feet. Also, during this time interval, the southern third of the island was accreting eastward with a growth of up to 1800 feet along more than a mile in the mid-part of that end of the island. Over the 2.5 miles of shoreline which comprises the southern third of the island, this progradation averaged 1260 feet. This yields an averaged annual accretion rate of 66 feet/year for the southern third of the island. The village of Broadwater was located midway along this accreting section of the island.

Subsequent to 1871, the north end of the island accreted, reaching a maximum advance of more than 3300 feet by 1974, and an average advance of 3000 feet along the northern

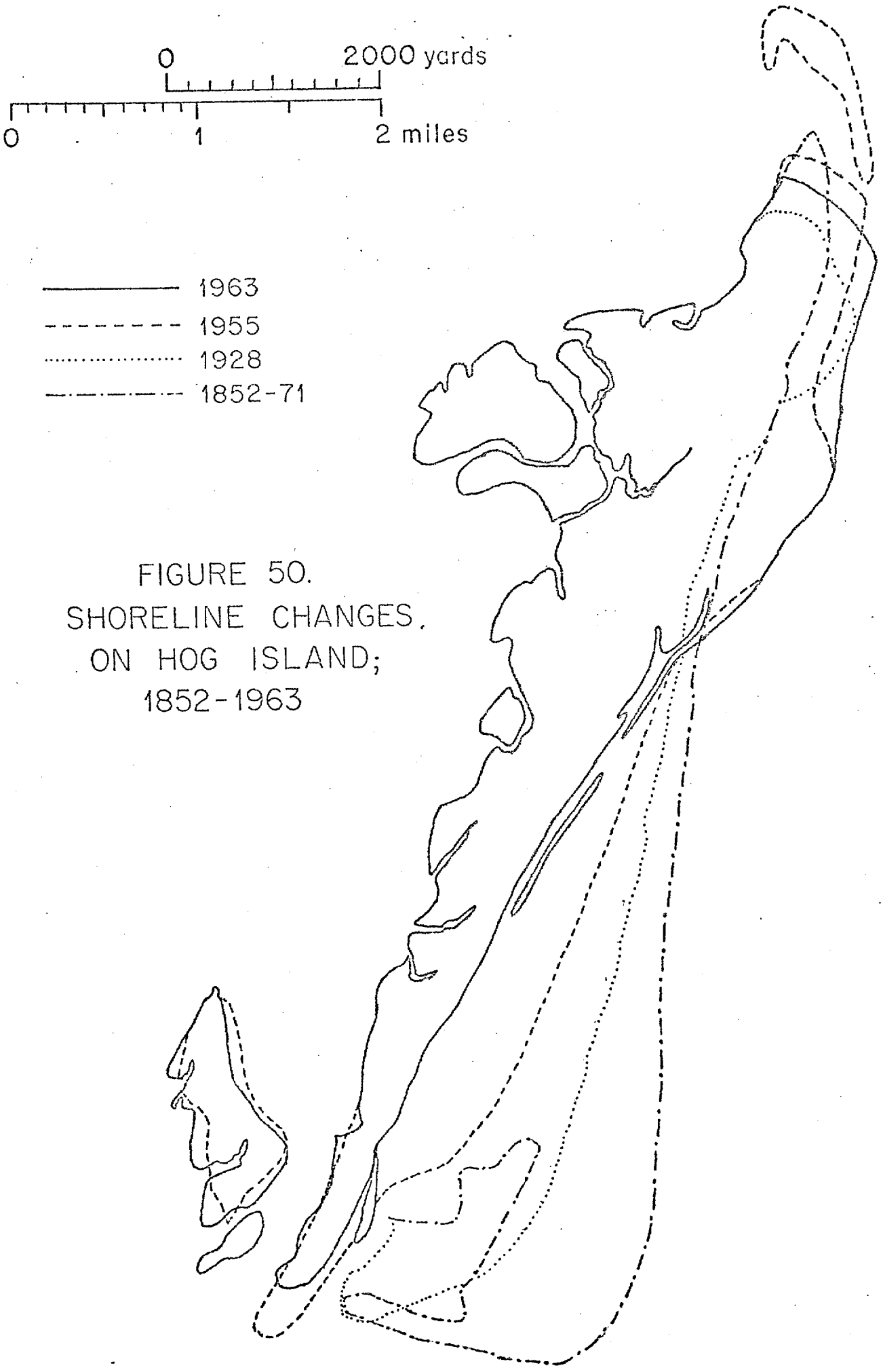


FIGURE 50.
SHORELINE CHANGES,
ON HOG ISLAND;
1852-1963

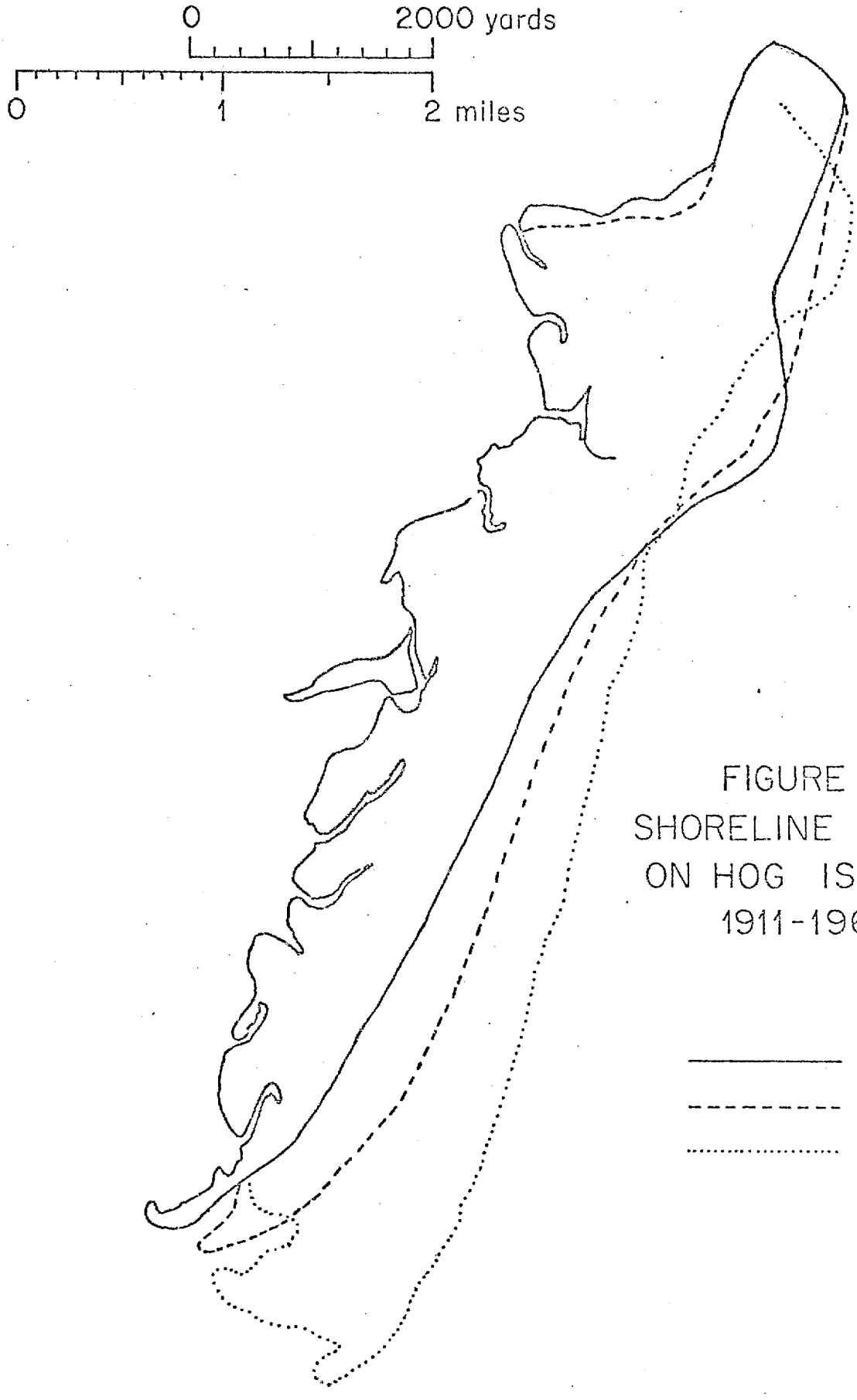


FIGURE 51.
SHORELINE CHANGES
ON HOG ISLAND;
1911-1961

1.9 miles of the island. As the historical shoreline maps show, this accretion has been accompanied by abrupt and striking changes in the seaward shape of this north end of the island. Periods of rapid accretion at one location were followed by periods of partial erosion and reshaping of the shoreline. Consequently, only net accretion figures have been used for this end of the island, and they yield an averaged accretion rate of 33 feet/year for the 90 years from 1871 to 1961.

Examination of Figures 50 and 51 shows clearly the patterns of retreat of the south end of the island from 1871 to 1961. This retreat has continuously affected the southern 4 miles of the island, and initially affected the southern 5.2 miles of the island. In more recent years the northern mile or so of this southern part of the island stopped retreating, and most recently has been accreting slightly. This section of shoreline begins east of Marsh Point (1968 U.S.G.S. Topographic Map) and extends 1.0 to 1.25 miles northward along the island. Within this reach of shoreline, the historical shoreline changes have been the least of any location on the island. The shoreline at this location also has remained within a north-south zone about 2200 feet wide throughout the 90-year period.

Between 1852 and 1911, the shoreline lay nearly north to south through this zone and retreated about 1200 feet to the west. After 1911, the shoreline began to turn to a more north-east-southwest alignment, remaining within the zone while accreting at the north and retreating on the south. By 1961 the shoreline lay diagonally across this zone from the northeast corner to the southwest corner, and it has accreted slowly to the southeast since then.

The retreat of the southern four miles of the island has been most pronounced at the southern end, where the 1963 beach front lay 1.57 miles west of the 1871 beach front. This is a position 0.2 mile west of the western end of the 1871 sand spit at the south end of the island, about 0.25 mile west of the 1871 Life Saving Station. Figures 50 and 51 show that in effect, the southern end of the island has rotated westward about a center of rotation located within the zone described in the preceding paragraph. This rotation has totaled about 25.5° in that 92-year period. Study of Figures 50 and 51 reveals that this rotation occurred in four different time periods, while in two other time periods, no appreciable rotation occurred.

Between 1871 and 1911, the southern end of the island rotated 7.5° to the west. This produced a maximum shoreline retreat of about 0.45 mile near the south end of the island. Shoreline retreat steadily diminished to zero about 4 miles north of the south end of the island. This period of rotation was followed by a period of 17 years (1911-1928) when the beach followed a pattern of parallel retreat with beach loss varying from 300 feet to over 1000 feet at various locations along the shoreline. Average retreat was about 800 feet which yields an annual rate of about 50.0 feet/year. Two periods of rotation followed; the first from 1928 to 1934 produced a little over 6° of rotation, and the second from 1934 to 1955 produced a little over 5° of rotation. Total rotation was about 11.5°. The first of these periods of rotation caused a retreat of 0.45 mile at the southern end of the island and zero retreat about 4.6 miles to the north. The second caused about 0.13 mile of retreat at the eastern limit of the beach near the south end of the island and no retreat 3 miles to the north. Obviously, this second rotation occurred about a different center than the first, and thus affected the south end of the island less in terms of shoreline retreat.

During this latter period, a broad sand spit grew about 0.75 mile to the south to re-establish a shield between the open sea and Rogue Island. This protection had been lost for a time between the mid-1930's and the mid-1950's. A second period of parallel beach retreat followed from 1955 to 1961. Retreat varied from 0.1 to 0.2

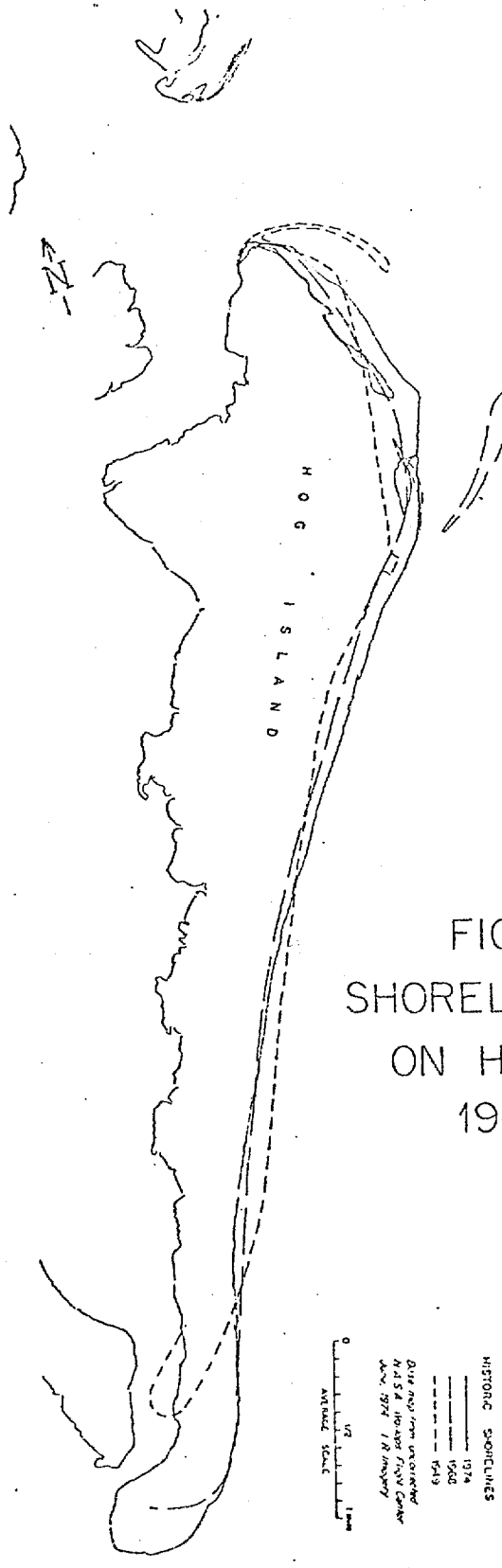


FIGURE 52.
SHORELINE CHANGES
ON HOG ISLAND;
1949-1974

mile, averaging nearly 0.2 mile. This retreat, averaged for the period, equalled about 175 feet/year. The fourth and final rotation occurred between 1961 and 1963, and produced another 6.5° of rotation of the southern end of the island. Maximum retreat of 0.28 mile occurred about 1.2 miles north of the south end of the island, and the center of rotation lay about 3 miles north (4 miles from the south end of the island). Along the southern 1.2 miles of the island, the sand spit had recurved to the west and diminished in width between 1955 and 1961. From 1961 to 1963, it grew southward, widened, and straightened to make a southern extension of the island about 1100 feet in width.

Since 1963, the shoreline changes have shown both accretion and retreat along the length of the island, but no clear sense of retreat. Figure 52 shows shoreline position for 1949, 1968, and 1974. Comparison of the 1949 shoreline to the 1968 shoreline shows the effects of irregular erosion and accretion in changing the shape of the northern half of the island, and shows in part the western rotation of the southern half of the island. Changes in the length, width, and position of the southern sand spit are also easily seen in Figure 52.

In 1963, most of the northern 2.5 miles of beach at the north end of Hog Island was experiencing a period of net retreat, as the shape of the beach was changing. This period of change continued through 1967, and is reflected in the position of the 1968 shoreline. Between 1963 and 1967, retreat averaged 350 feet. However, those losses have been more than made up by accretion since 1968, which has varied between 525 and 550 feet along this part of the island.

To the south, the most recent shoreline changes also seem to be a response to changes in the shape of the beach, rather than real movements of the island. This southern section of the island is about 5.5-6.0 miles long (along the beach) from Great Machipongo Inlet north to the area described in the preceding paragraph. The northern two miles of this reach of the shoreline has accreted since 1963. About two miles north of the Broadwater Lookout Tower, accretion has been greatest, totaling about 1375 feet. North of that, accretion diminishes to about 540 feet which about equals accretion along the northern 2.5-3.0 miles of the island. At the Lookout Tower itself, accretion and retreat have balanced so that the 1974 shoreline occupies essentially the same position as the 1963 shoreline, although in 1968 the shoreline may have lain about 150 feet to the east. About a mile south of the Lookout Tower, the beach advanced seaward as the sand spit grew south and became straighter. Since 1967, there has been no appreciable change in this portion of the beach. However, the sand spit has been growing at an increasing rate. Between 1963 and 1967, the sand spit grew southward by more than 800 feet, and the beach advanced seaward about 520 feet. From 1967 to 1974, the sand spit grew 1320 feet more to the south but the beach did not accrete seaward.

In summary, it would appear that over the past 12 years, Hog Island has grown in both length and breadth. The shoreline has advanced along the northern half of the island while holding its position along the southern half of the island. The sand spit has lengthened by at least 2100 feet. This moderate growth and relative stability contrasts sharply with the rapid changes that occurred in the preceding 111 years. The interpretation of the events of the past 12 years will be discussed further in a later paragraph.

IV. INLET CHANGES

A. Little Machipongo Inlet

The changes to Little Machipongo Inlet (Quinby Inlet) have been previously described in the section on Parramore Island. However, in respect to this section concerning Hog Island, some additional observations should be made. In 1871, when the main inlet channel was discharging northeasterly against Parramore Island, the central portion (apex) of the ebb tide delta lay north of the inlet opening and seaward of Parramore Island. The south edge of the ebb tide delta curved inshore to meet Hog Island about a mile south of the north end. Prior to 1871, the north end of Hog Island had been retreating and where the ebb tide delta met the island, the island had been overwashed and a breach formed through the beach ridge of the island.

An ephemeral inlet developed through this breach and briefly connected marsh canals to the ocean. The 1871 charts show an inlet with only minor marsh canals leading to it. Both the I.R. imagery and the black and white photography used in this study indicate that a major inlet never fully developed. Instead, this opening appears to have oscillated between periods of connecting the marsh canals with the ocean and periods when it was blocked by beach and overwash deposits. After a few years, it became permanently blocked.

By 1911, the main channel of Little Machipongo Inlet had shifted direction and was discharging in a southeasterly direction. The central portion of the ebb tide delta lay southeast of the inlet opening, and 1.8 miles south of the north end of Hog Island. A large portion of the former ebb tide delta had been abandoned and lay seaward of the beach on Parramore Island about 2.6 miles north of the south end of the island. The north end of Hog Island had begun to accrete rapidly because it was protected from storm waves by the relocated ebb tide delta, and it had been brought under the influence of inlet currents.

By 1926, two of the major tidal channels leading to Little Machipongo Inlet had deepened; North Inlet to 57 feet, and Sandy Island Channel to 41 feet. The Swash had shoaled at 2 feet. The sand spit at the south end of Parramore Island had grown south, Hog Island had accreted further seaward at the north end, and the inlet throat had shifted seaward in the inlet channel.

When the hydrography was resurveyed in 1934, the two major tidal channels had diminished slightly in depth, as had the throat of the inlet, but the position and direction of the inlet channel remained essentially unchanged. The abandoned portion of the ebb tide delta that had been off the beach of Parramore Island was gone. But, the southern sand spit on Parramore Island was longer, and the embayed area behind it was partially filled in. The active ebb tide delta had grown measurably, and had extended south until the southern margin curved in to meet Hog Island 2.2 miles south of the north end of the island. That same 2.2 miles of Hog Island had accreted significantly in the southern half so that this part of the island had a long smooth east-facing beach. These were major changes for both the north end of Hog Island and for the ebb tide delta. Since that time, the ebb tide delta has continued to grow slowly southward, and the north end of Hog Island has been steadily accreting.

B. Great Machipongo Inlet

At the south end of Hog Island, Great Machipongo Inlet has also undergone some changes since 1852. Until 1871 or later, the main inlet channel lay close against the south end of the very much broader Hog Island. Water depths of 61 feet were found within 0.1 mile of the shore at the tip of the island. The inlet throat reached 67 feet. The main inlet channel was oriented roughly east-northeast and three major channels branched from it.

One of these, with minimum channel depths of 12-15 feet, branched north and hugged the

shore of Hog Island for more than a mile before it turned abruptly east away from the beach. The other two lesser channels branched southeast, the deeper one (21 feet) lay along the north end of Cobb Island. The northern side of the ebb tide delta lay east of Hog Island for more than a mile north of the main inlet channel. The southern half of the ebb tide delta (including the two branch channels) extended across in front of the inlet opening between the islands and down Cobb Island for a mile before curving in gradually to meet the island.

By 1911, a large ebb delta island, called Pig Island, had grown in the inlet northeast of the north end of Cobb Island. The main inlet channel was discharging east-southeast on the north side of Pig Island. A shallow branch channel called North Channel discharged northeasterly on the seaward side of Hog Island. This channel, in part, was holding the position of the former main channel. Another branch channel, South Channel, discharged south along the north end of Cobb Island. The inlet throat had shifted westward by about 0.1 mile and diminished in depth to 52 feet. Tidal channel depths inside of the inlet had shallowed greatly. The ebb tide delta had shifted south until its apex lay east of the inlet opening. It had also grown seaward and southward until the southern margin met Cobb Island east of Little Easter Marsh.

By 1929, Pig Island had moved inshore toward Cobb Island and had choked off South Channel. The main inlet throat and major tidal channels had deepened and re-established depths of 62 to 67 feet without shifting position. Seaward of the inlet opening, the main inlet channel had lengthened through the delta and turned southward to discharge to the southeast. North Channel had deepened to 18 feet, but maintained its position along the south end of Hog Island. The ebb tide delta had continued to grow to the south and east until the apex lay southeast of the inlet opening.

In 1934, Pig Island had welded on to the north end of Cobb Island. The main inlet channel, laying east-west through the inlet opening, curved southward at the seaward end to discharge to the south-southeast. The inlet throat had shifted westward by about 0.4 mile, and increased in depth to 81 feet. North Channel had maintained its position and was now relatively farther offshore because of retreat of Hog Island. The depth of North Channel had increased to 14-26 feet, and it had increased in width. The ebb tide delta had shifted further to the south until its apex lay south of the north end of Cobb Island, and the southern margin curved in toward Cobb Island more than 3 miles south of the inlet. Since then, the ebb tide delta has changed very little. North Channel has held its position, but has assumed greater importance as it has widened and become more uniform in depth. Inlet throat depths have diminished to 64-66 feet. By 1966, the main channel through the inlet was forked at the seaward side of the inlet, with North Channel being the lesser of the two channels.

V. INTERPRETATION: INLET AND SHORELINE CHANGES

It is clear that significant and major changes have occurred at both inlets that influence Hog Island. When these changes are considered in relation to the shoreline changes on Hog Island, one obtains a clearer picture of what has happened. Figure 53 has been prepared to portray the situation more clearly. In Figure 53, the 1871 and 1963 positions of the ebb tide delta at each inlet are shown. Main channel positions are also shown for 1871, 1911, and 1963. The 1942 channel position is also shown for Great Machipongo Inlet. The large dot at the inlet end of each channel arrow marks the position of the deep inlet throat for that date. The 1871 and 1940's shoreline position is shown for the south end of Parramore Island, and the north end of Cobb Island to aid in visualizing the inlet positions. For Hog Island, straight lines have been employed to represent the island at various times. These lines were selected to best represent the axis of the island at the date shown. Shorelines have been sketched at the ends of each line to show the trend of the ends of the island. Arrowheads on each island axis indicate the direction in which the axis had been moving prior to

the date shown. The dated circles at certain axes intersections represent pivot points about which the island appeared to be rotating during the indicated interval.

Figure 53 shows that from 1852 to 1871, Hog Island was rotating its position counter-clockwise about a point south of the middle of the island. This resulted in the retreat of the northern part of the island, with the effects of retreat being most pronounced at t north end of the island. In the same time, the southern third of the island was prograding seaward. Consideration of the positions of the ebb tide deltas shows that the northern two-thirds of Hog Island was vulnerable to attack by storm waves during this time, while the southern third was less vulnerable. Inlet currents and longshore drift patterns favored the buildup of the south ends of both Hog Island and Parramore Island, but were working to take sand out of storage in the beach prism along the northern shore of Hog Island.

Something happened between 1871 and 1911 to cause both inlets to rotate their main channels clockwise until they were discharging in a southeasterly direction. Insufficient data are available to narrow the time interval for this shift in channel position. Because both inlets are large inlets, and because both changed significantly in the same large time interval, it would seem that one could look for a major storm or series of storms within that time period as the cause of the change. There were at least ten tropical storms of consequence (Truitt, 1968) to strike the coast during this time interval, and perhaps more. An October hurricane in 1894 was reported to be the worst storm in a generation. The storm drove island residents to higher ground for survival, and destroyed oyster houses and boats all along the islands of the Delmarva Peninsula. However, another storm in 1904 caused considerable bottom disturbance in the bays and severe economic losses due to burial of oyster beds. The time of the change to the inlets could probably be recovered by a search of local literature and maritime records. Because of the nature of the changes that had occurred by 1911, an early date in this time period would be expected. The fact that a part of the 1871 ebb tide delta of Little Machipongo Inlet was abandoned when that inlet channel shifted would suggest a sudden abandonment of the former channel, which would favor a severe storm as the cause.

The rapid change of direction of both inlet channels produced rapid shoreline changes on Hog Island. The shift of Little Machipongo Inlet brought the north end of Hog Island under the influence of inlet processes and the offshore protection of a new and growing ebb tide delta. Accretion was rapid and the change in island dimensions, startling. The source of the sand for accretion is uncertain, but may, in part, have been derived from the reworking of the former ebb tide delta by inlet currents of the new channel position. A great deal of change took place at the south end of Parramore Island, and large volumes of sand were removed from storage in the former beach and beach ridges. However, a significant portion of this sand was undoubtedly put back into storage as the south end of Parramore Island grew south, and the Swash filled in. There is no indication that the sand was derived from the south end of Hog Island.

At Great Machipongo Inlet, the 1871 ebb tide delta had been situated so that its apex was east of the south end of Hog Island. But the delta was asymmetrical, and the southern lobe extended south of the north end of Cobb Island. When the inlet channel changed position, the apex of the ebb tide delta shifted south until by 1911, it lay east of the inlet opening. In 1911 the north lobe of the 1871 delta was greatly reduced in volume, and the south end of Hog Island had experienced severe erosion. Large volumes of sand had been removed from these two former storage areas and transported elsewhere.

The inlet channel and the tidal channels leading to it were much shallower in 1911,

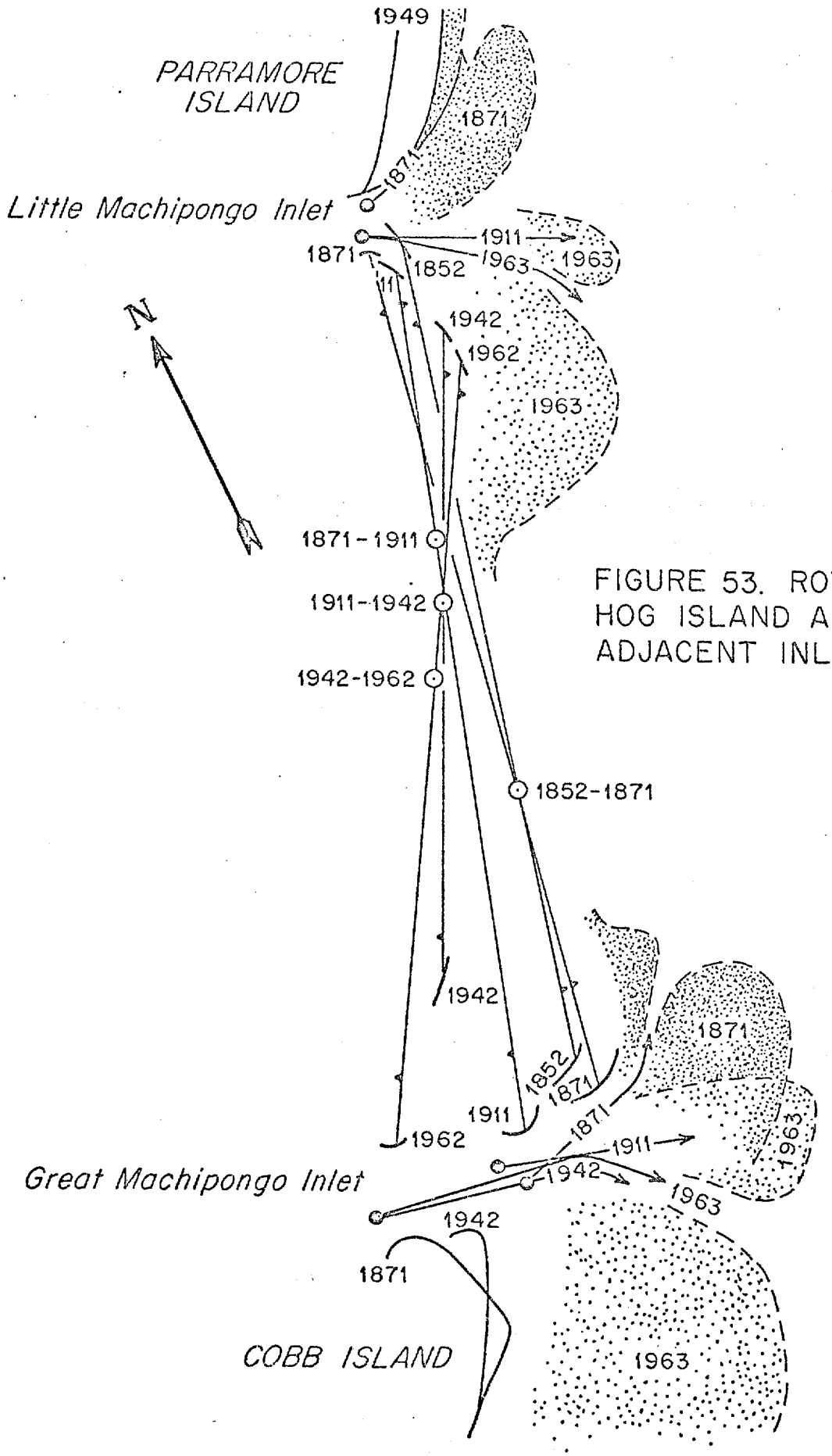


FIGURE 53. ROTATION OF HOG ISLAND AND ADJACENT INLETS

indicating that flood tide currents were bringing large amounts of sand into, and through, the inlet. However, a large portion of the sand was carried across the inlet channel by currents and added to the south lobe of the ebb tide delta as seen by the growth of Pig Island and the south lobe of the delta.

The coincidence of both inlet channels turning clockwise in the same time interval and the changes in inlet processes that this brought about caused Hog Island to change shape. The accretion of the north end of the island and erosion at the south end produced the effect (see Figure 53) of rotating the island's axis in a clockwise direction about a pivot point located approximately one-third of the way south from the north end of the island. For convenience, the term rotation is being used to describe the effects of erosion and deposition in changing the shape and position of the island. It is not meant to imply actual physical rotation of the island. The initial clockwise rotation of Hog Island was followed by a 17-year period during which no apparent rotation occurred and the beach along the southern two-thirds of the island suffered only parallel beach retreat. When rotation began again, the pivot point had shifted south. During the period of parallel beach retreat, the southern lobe of the Little Machipongo Inlet ebb tide delta also had grown south. The pivot point and the south lobe of the ebb tide delta continued to move south through 1963. As the pivot point approached the middle of the island, the effect of rotation on the south end of the island was reduced, and correspondingly was increased at the north end. Accretion took place further to the south along the northern half of the island as the ebb tide delta grew southward, and this increased the breadth of the island and the apparent rotation. At the south end retreat continued but the island began extending southward by building a sand spit.

Since the early 1960's, there has been a different character to the changes in Hog Island. The southern sand spit had previously shown a repeating pattern of southerly growth of a narrow sand spit, followed by retreat and recurving to the west. After the early 1950's, it grew southward again, but as a broad (1100 feet wide) extension of the island which did not begin to recurve west until the tip was south of Rogue Island. This growth represents a large quantity of sand being put into storage in the beach prism. In the 90 years following 1871, this had not occurred along the southern half of the island.

Another difference is the growth of sand dune ridges on the newly formed sand spit which also indicates more sand being put into storage. The shoreline at the south end of the island along the sand spit has been advancing seaward as has the shoreline along the northern two-thirds of the island. Only a short section of shoreline south of the Broadwater Lookout Tower (and south of the Little Machipongo ebb tide delta) has shown any retreat. For the first time in more than a century, the island had shown no significant retreat for more than a decade. This would suggest that something has changed in the system that controls the position and configuration of Hog Island. Because it is quite clear that the inlet processes dominate the system influencing the island, it is there that the source of the change should be found.

The north end of Hog Island has continued to accrete during this most recent interval, as it had been since before 1911. Therefore, there is no indication of a change in inlet processes at Little Machipongo Inlet. The southern limit of accretion for the northern portion of the island seems to occur just north of the Broadwater Lookout Tower. At Great Machipongo Inlet there has been a change. North Channel has increased in depth and width, and therefore, importance to the inlet processes. Without further study, it is conjecture to attribute recent stabilization of the south end of the island to changes in North Channel. However, it is constructive to point out that when North Channel was the main inlet channel in 1871, the south end of Hog Island was accreting. If the increasing importance of North Channel is the cause, then one could expect that the south end of Hog Island will grow seaward.

VI. GEOMORPHIC DESCRIPTION AND INTERPRETATION

The oldest geomorphic units found in the area covered by this section on Hog Island are the very ancient beach ridges located at the mainland, west of Hog Island. These ridges have been described previously in the section on physiography. They have been studied by Mixon and others (Mixon, et al., 1974) and found to be of late Sangamon to early Wisconsin age. If correct, this would mean that they had formed during the early stages of the drop in sea level associated with the Wisconsin stage of glaciation. The beach ridges of this group begin at the Mappsburg Scarp and extend southeastward into the bay area behind the modern barrier islands. They obviously record the progress of sea level retreat as the coastline advanced onto the former continental shelf. Gull Marsh and other marsh islands previously described may be part of this very ancient sequence of beach ridges.

The next oldest geomorphic units are found in the beach ridge units of Hog Island and Rogue Island. These features relate to the post-Wisconsin rise of sea level and are therefore very much younger than the beach ridges cited in the preceding paragraph. They are shown on the Geologic Map of Hog Island. Generally, on both islands, the older units are found closer to the bay and marsh areas, in locations to which they had retreated prior to more recent events which have shaped the remainder of the islands.

On Rogue Island, there is a beach ridge unit that begins at the northern end of the island and follows along the northeast shore before it curves sharply to the west near the eastern end of the island. Midway along the northeast shore of the island there is a low section where the beach ridge almost dies out. This low area marks the location of a former opening. Whether this opening was a breach or an inlet, or whether Rogue Island formerly had been two islands, is unclear but the present ridge shows recurving secondary ridges on both sides of the opening which formed before the opening closed. Near the eastern end of the island the old beach ridge abruptly turns westward to form a western arm of the beach ridge unit.

There are two distinct, and separate, beach ridges in the western arm, indicating two stages to its formation. The beach ridge closer to the mainland is the older of the two, and is the same ridge as the single ridge along the northeast shore. This older ridge was later attacked by waves from the east-southeast. The bend where the ridge curves westward was cut through, and several new ridges were built across the inside of the bend, while a short sand spit grew to the southeast. At a later time the second of the beach ridges was added parallel to the western arm of the older ridge. This younger ridge declines in elevation and recurves sharply at its eastern end, but it then can be traced as a low berm ridge around the bend and along the northeast shore of the island. These ridges are portrayed on the 1852 and 1871 charts, at a time when Rogue Island was far from the open sea and from Great Machipongo Inlet. The 1852 shoreline of Rogue Island closely conformed with the southeastern edge of the younger beach ridge. This older portion of Rogue Island is therefore interpreted as a remnant of an ancient barrier island, or an ancient inlet island, that became isolated from the sea when Hog Island grew seaward of it.

There is a line of very old beach ridge units along the edge of the marsh north of the midpoint of Hog Island. The beach ridge units are separated by gaps of various widths, but the line of units can be traced to near the north end of the island. Another very old beach ridge unit is located further south at Broadwater Lookout Tower. The westernmost ridges in these units are believed to be the oldest features on Hog Island. They represent an ancient barrier island that had been retreating landward. (See Figure 54) The beach ridge of the southern part of that island had been cut by overwash channels at a number of locations, and sand had spread westward into the ancient lagoon. There may have been a narrow strip of marsh landward of parts of the

island, and one or more of the overwash channels may have been shallow breaches. Northward the beach ridge of the ancient barrier island was continuous along Hog Island until after 1852.

Figure 54 is a sketched reconstruction of the ancient barrier island on Hog Island, and of the one previously described on Parramore Island. The reconstruction is based on the geomorphology of Cedar Island, Parramore and Revel Islands, and Hog and Rogue Islands. The beach ridges of the ancient barrier islands are shown as shaded areas overlain on tracings of the 1871 island shorelines. The full extent of the ancient islands is not shown. The 1871 shoreline was employed to give some indication of the amount of progradation that occurred after the ancient barrier islands had stopped retreating.

About a mile south of the north end of Hog Island (see geologic map), the ancient beach ridge unit is broken by inlet opening symbols. This inlet is the ephemeral inlet that is shown on the 1871 chart. Prior to that time, this part of the ancient barrier island had been intact, and had continued northward more than a mile beyond the inlet. At present, the ancient beach ridge north of the inlet curves slightly toward the bay and Revel Island before it then curves sharply into the bay. The sharper curve is due to historical reworking of the ancient ridges as the north end of Hog Island retreate southward after 1871. The offset pair of ridge lines at the western edge of the northernmost beach ridge unit (on the geologic map) represents the ancient beach ridges.

There is a slight curvature of the present remnant of the ancient barrier island toward Revel Island. The older charts, which show the portions of Hog Island that have been lost to erosion, extend this curving ancient beach ridge closer to Revel Island. The Quinby Quadrangle (U.S.G.S. 7.5 Minute Topographic Series) shows an alignment of the eastern beach ridge on Revel Island with the ancient portion of the beach ridge at the north end of Hog Island. This apparent alignment of the two ancient barrier island segments is further reinforced by the 1972 I.R. Imagery which includes all of these areas in a single frame so that alignments and indicative color patterns are more conclusive. The geomorphology and geologic history of Parramore Island and Revel Island provides further evidence to suggest that this ancient "Hog Island" barrier island originally extended northward to an ancient inlet on Revel Island.

South of the 1871 ephemeral inlet, the ancient barrier island had been battered by the sea. It was broken through in numerous places so that the ancient beach ridge is represented by a line of beach ridge remnants. Historical retreat of Hog Island has carried modern sand dune ridges over the southern end of the line of ancient beach ridge remnants. The southernmost of those ancient beach ridge segments near the midpoint of Hog Island is the longest. It has a double ridge that runs along the edge of the marsh. Where this segment is truncated at its northern end, two younger beach ridge units curve into the opening. North of the opening there is a small beach ridge unit that is believed to be another segment of the ancient barrier island. There are several more beach ridge remnants northward in this line, which makes this part of the ancient barrier island resemble the Little Beach Section of Parramore Island. It is interpreted in the same manner; that is, as an ancient barrier island that was beginning to breach and overwash into a lagoon area behind the island.

The remaining part of this ancient barrier island is found farther south at the location of the Broadwater Lookout Tower. Here a high ancient beach ridge unit is found. Recent overwash has truncated the northern end of it (see Figure 49), but has not yet encroached upon the southern part of it. The I.R. imagery reveals that this is the southern end of the ancient barrier island. The beach ridges in the unit recurve from the north toward the bay and Rogue Island. The 1949 black and white aerial photography shows five other beach ridges on the seaward side of this remnant which since

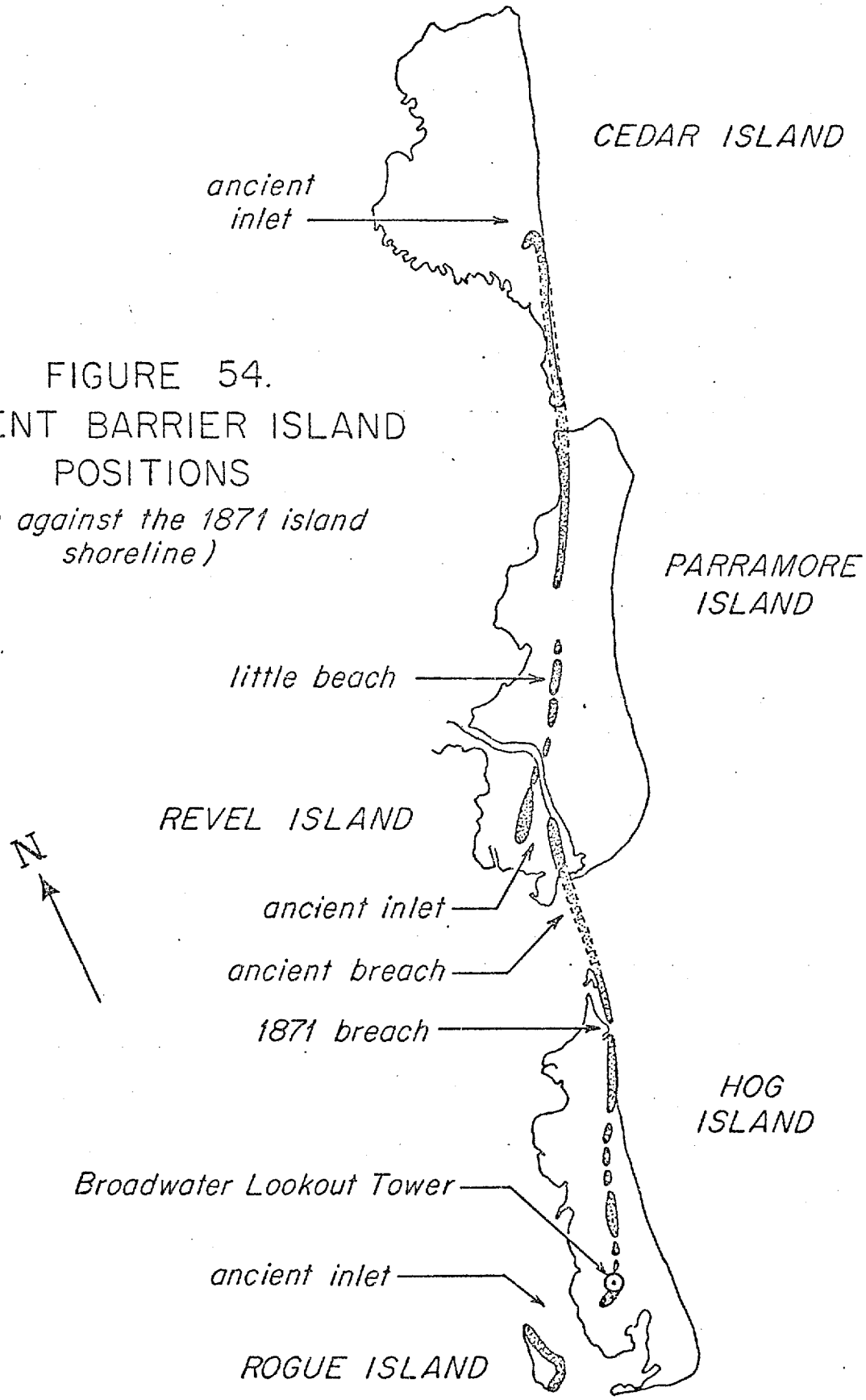


FIGURE 54.
ANCIENT BARRIER ISLAND POSITIONS
(shown against the 1871 island shoreline)

have been destroyed by erosion. Each of those ridges recurved from the north toward the bay and Rogue Island, and northward they merged with, or paralleled, the oldest beach ridges of the ancient barrier island. Overwash since 1949 has destroyed the northern portion of all of those ridges. The 1871 chart shows this ancient beach ridge unit, and it also shows that it continued north and curved to merge with the other segments of this ancient barrier island. Retreat of Hog Island since 1871 has destroyed this connecting section of ancient beach ridge. Harrison, et al. (1965) have cited an outcropping of marsh peat above a shell bed in the ancient barrier island remnant that has survived at Braodwater Lookout Tower. Their data indicate that the outcropping is 1-2 feet above modern high tide level. Radiocarbon dating of the shell bed yielded an age of 1905 ± 75 years before the present. Their dating thus gives some indication of the antiquity of the ancient barrier islands shown in Figure 54.

The geomorphic evidence of this study indicates that at an ancient time a narrow barrier island extended northward from the vicinity of the Broadwater Lookout Tower to the middle of Revel Island. This ancient island had been retreating against a lagoon along most of its length. Rogue Island lay somewhat to the southwest in a position where it may have lain within the southern inlet. The crescent shape of the ancient ridges on the island would suggest that it probably originated as a flood tide island just inside of the ancient southern inlet.

The next youngest geomorphic units are also beach ridges. They are found on the northern half of Hog Island, and they lie just east of the ancient barrier island previously described. In the beach ridge unit at the northern tip of the island, there is a second ridge line along the eastern edge of the unit and between that and the western ridge line there are several discontinuous ridges. The discontinuous ridges are believed to correlate with the recurving berms and other small ridges two miles south, in the section that resembles the Little Beach area on Parramore Island. These features are taken to indicate a stage of progradation during which all but the 1871 breach in the ancient barrier island were healed. An ancient strandline can be recognized along the eastern edge of this unit, and it can be seen to curve into the 1871 breach. To the north the discontinuous ridges represent the accretion of sand dune ridges.

The eastern ridge line in the beach ridge unit at the north end of the island correlates with the middle ridge line south of the 1871 breach. This was a continuous ridge that extended south past the next large breach in the ancient barrier island. (The ridge line shown on the map turns slightly east at this point and follows a younger part of the ridge unit.) The continuity of the original ridge is indicated by a string of Parramore Pimples across the area shown as a sand flat. These features in turn line up to the south with a corresponding ridge east of, and parallel to, the old strand line on the east side of the breached area in the ancient barrier island. The portion of this ridge represented by Parramore Pimples indicates that the accreting barrier island was repeatedly overwashed through the northern breach in the ancient beach ridge. This process eventually filled the breach sufficiently to reduce overwashing and, slightly to the east, the ridge extended south until it met its counterpart to the south and closed the breach to overwashing. What is interpreted as the southern edge of this overwash area and the continuity with the beach to the south at that time is shown with a strand line symbol. This ridge is taken to indicate the onset of a period of progradation of the island. Two other ridge lines are shown east of the ridge just described, and they indicate continued progradation of the island. This ridge unit terminates against an old strand line or against the modern dune ridge at its southern end. At the north, it has been cut through by the 1871 ephemeral inlet, and at the north end of the island it has been truncated and reworked by historical erosion. These units are all that remain of the ancient deposits of Hog Island.

The easternmost strand line shown on the map, in the area east of the breached portion of the ancient barrier island, is a shoreline of historical times. It is believed to be a segment of the shoreline from the period just subsequent to 1911 when modern progradation of this part of the island began. At the north end of this strandline, the geologic contact between the back beach flat and the beach ridge unit west of it is the approximate position of the shoreline at the limit of retreat in the late 1800's when the 1871 ephemeral inlet was active. North of the ephemeral inlet this same shoreline is indicated by the contact on the east side of the ancient beach ridge unit. South of what is recognized as the "1911" shoreline, the contact between the modern sand dune ridge and the ancient beach ridge deposits, for about a mile to the south, is parallel to, but west of the shoreline position of the 1940's. The actual shoreline position is now beneath the western part of this sand dune ridge. The area of back beach flats east of this modern beach ridge began to form as a broad prograding beach in the late 1930's and 1940's. A substantial portion of these back beach flats can be seen in the 1949 aerial photos. The area of back beach flats and the sand flat area that continues north along the ancient beach ridge unit, (see Figure 48a) were added during the period between 1928 and 1937, and the beach ridge unit east of it began to form thereafter as sand dunes grew on the berm or ridge at the eastern edge. This new beach ridge unit has two ridge lines running its length. The western ridge line is the older and was still forming as distinct sand dunes in 1949, while the eastern one was beginning to form as a more continuous sand dune ridge. The old berm ridges east of this unit were also beginning to form in 1949. Also, the area shown on the map as back beach flats and sand flat was a runnel in 1949, and was subject to flooding on the peak of the tide. By 1975, part of that area had built up sufficiently to become a grassland above the level of the tide (area of back beach flats), but the area shown as sand flat had not, and is still within the tidal range (Figure 48a). These features continued to grow by accretion through the 1950's and 1960's, but by 1967 another ridge had moved ashore to form the easternmost ridge and runnel. These are shown on the geologic map as the easternmost sand flat with two large ponds on it, and the ridge of new sand dunes to the east of that. As can be seen in Figure 48a, this area has not yet become vegetated, and accretion of the sand dunes and sand flat is continuing to the present.

Along the mid-portion of the island, the back beach flats, previously mentioned, had become isolated from the sea by 1973 as a series of berms built along the seaward edge of them. New sand dunes presently are growing on these berms, but this area is subject still to rapid change by storm waves and flooding by storm high tides. Comparison of the April, 1973 aerial photography to the June, 1974 I.R. imagery shows that the 1974 berm and dune ridge is reduced from what it was in 1973, but does not indicate any shoreline retreat.

The overwash area shown on the geological map north of the Broadwater Lookout Tower and in Figure 49 is an old overwash area. It is not known how far back in time it was formed. The overwash area can be identified on the 1949 aerial photographs, but it was not active at that time. In fact, there were cottages or other buildings within the overwash area. The beach ridge of the ancient barrier island was broken through at the south edge of the overwash area, and remnants of the ridge trace its position across the overwash area on those photographs. The breach in the ridge, and the original overwash may be very ancient, and date from the earlier period of retreat of that ancient barrier island. Recent overwash through this area must have begun in the late 1950's or early 1960's when the beach eroded rapidly at this location. Roads and buildings shown on the 1955 chart are not shown on the 1963 chart, nor on the 1968 U.S.G.S. Tophoraphic Map. The 1973 aerial photos show an active overwash area with sand encroaching on the marsh behind the beach. Figure 49 shows that the overwash area was still active when it was visited in 1975.

South of the Broadwater Lookout Tower, the increase in width and length of the island began in the mid-1950's, and had reached its present general configuration by the early 1970's. The 1973 aerial photos show the area of stabilized (vegetated) sand dunes and the same configuration of geologic units that were mapped from the June, 1974 I.R. imagery. However, most of the area is still subject to overwash, and has not been stabilized by vegetation.

VII. GEOLOGIC DESCRIPTION AND INTERPRETATION

The geologic history that can be drawn from this examination of the geologic units on Hog and Rogue Islands would indicate that at some ancient post-Wisconsin time, a thin barrier island had been retreating westward from a former position farther to the east. This ancient island (Figure 54) was retreating against a lagoon (the ancestral Hog Island Bay) along most of its length, and apparently had only a discontinuous narrow strip of marsh behind it. A beach ridge ran the length of the island. At the south end, Rogue Island stood in an inlet, as an inlet island. Northward, this ancient island extended up to Revel Island. South of the mid-point, the island had been breached and near the southern end, it had been overwashed and the beach ridge partially destroyed.

Following the time when the island had reached this state, the island began to prograde slowly. A second beach ridge began to form east of the first, the numerous breaches in the mid-section healed, and low berm ridges developed around the former beach ridge segments. At the south end, a series of recurving beach ridges were added to advance the shoreline seaward. During this time, the ancient island was breached 0.6 mile south of the north end (near the south end of Revel Island), and the breach developed into an inlet opening that has shifted position, but remained open to the present. Shifting of the inlet, the development of North Inlet Channel, and the reshaping of the north end of Hog Island by inlet processes, had eroded away about a mile of this ancient island prior to 1852.

Following the opening of the new inlet, the island began to prograde rapidly to the east. How far progradation may have advanced the island is unknown, as is the shape that the island may have developed. At the beginning of the historical period of this study, the beach east of the south end of the ancient island was 1.3 miles east of where it was when prograding began, and the island had grown south by more than a mile. At the beginning of the historical period, the island was prograding at the south end and retreating along the northern portion. However, these changes were dominated by inlet processes, and as has been shown elsewhere under shoreline changes, these processes can occur even though general retreat of the island is taking place. Evidence from other islands would indicate that the present period of barrier island retreat began well before 1852, and that progradation had probably advanced Hog Island more than the 1.3 miles indicated before retreat began again.

COBB ISLAND AND LITTLE COBB ISLAND

I. DESCRIPTIVE GEOGRAPHY

Cobb Island is the seventh island from the north end of the Virginia Barrier Island Group. Little Cobb Island is an inlet island situated in the bay at the south end of Cobb Island. Cobb Island is separated from Hog Island on the north by Great Machipongo Inlet and from Wreck Island on the south by Sand Shoal Inlet.

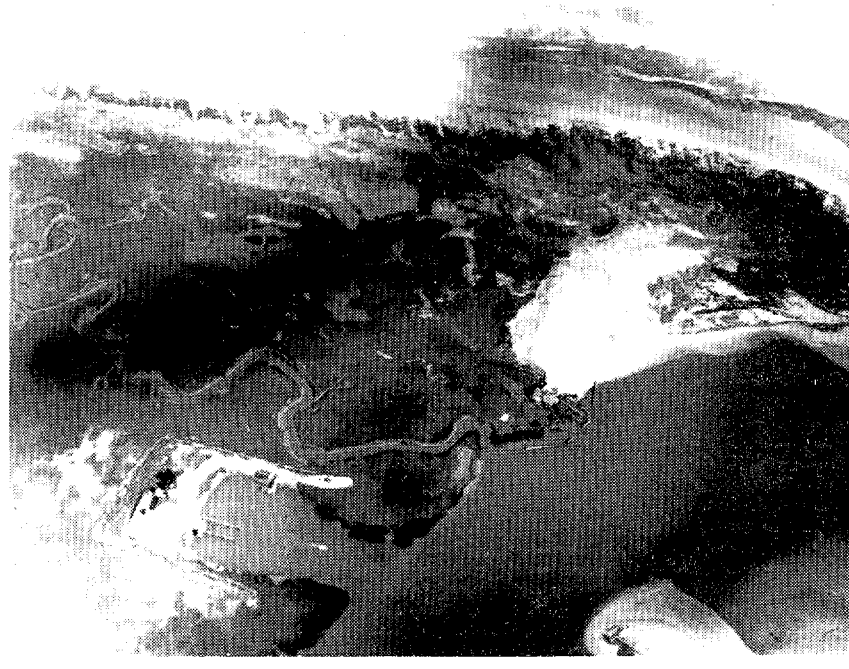
Nearby communities on the mainland are more numerous than for other islands along the Eastern Shore of Virginia, but most are very small. Oyster is west of the south end of the island, and Simkins and Eastville Station lie west of the middle of the island. Eastville and Cheriton on Interstate Highway 13 are larger towns with more facilities. Many older records for this area are stored in the Courthouse at Eastville. Access to Cobb Island by boat is best made from Oyster via Sand Shoal Channel. There is a public boat launching ramp and parking area at Oyster which is most directly reached from Cheriton on Route 13.

Cobb Island is smaller than the islands to the north of it. It also differs in that it has no large marsh area associated with it and appears as a long narrow barrier island. Its length is 5.1 miles from inlet to inlet, but is somewhat greater along the beach front. Along the northern half of the island, where a narrow marsh is present, the island averages about 0.6 mile in width with approximately half of the width representing marsh. There is no significant marsh area associated with the southern portion of the island except at the southern end where a triangular marsh area lies behind the last mile of beach (Figure 55a). Most of this portion of the island varies between 0.1 and 0.25 mile in width. Where the marsh is present at the south end, the island widens to a maximum of 0.5 mile. Little Cobb Island is 0.8 mile long and varies in width from 0.05 to 0.10 mile, averaging about 0.07 mile.

The north end of Cobb Island is 9.2 miles east of the mainland, while the south end of the island is only 7.75 miles from the mainland. The ocean front of the Virginia Barrier Island Group is indented toward the mainland at Sand Shoal Inlet, and both Cobb Island, north of the inlet, and Wreck Island, south of the inlet, lie along opposite sides of that indention. The bearing of the axis of Cobb Island is N37°E. Wreck Island, south of the inlet, has a curved axis, but the trend of the main part of the island away from the inlet bears about N13°E. (The axes of Hog Island and Parramore Island lie at N27°E.) The mainland west of the south end of Cobb Island trends about N14°E, and maintains that trend to the south. However, the mainland west of most of Cobb Island bears N30°E, and maintains that trend northward out of the area described in this section. The abrupt change in the bearing of the mainland coast occurs south of Indian Town Neck. No immediate explanation for this change in the trend of the islands or the mainland is obvious. However, this and other shoreline orientations will be discussed later in this report.

Between Cobb Island and the mainland there is a wide expanse of bay, with scattered marsh islands. The bay area is divided into partially separated bays by the marsh islands. Hog Island Bay extends behind the north end of Cobb Island, and Cobb Bay extends behind the south end of the island. Two marsh islands, Big Easter Marsh and Little Easter Marsh, separate the two bays. West of Hog Island Bay the islands of Gull Marsh separate it from Outlet Bay, and further west, Elkins Marsh separates Outlet Bay from Ramshorn Bay. West of Cobb Bay lies the south end of Elkins Marsh which is isolated from the mainland by Ramshorn Channel and a small marsh and bay known as Brockenberry Bay. Crow Bay and Shallow Bay are embayments in the margins of Elkins Marsh, and Spider Crab Bay is the name given to the area between Gull Marsh

a. Triangular old marsh area behind the south end of Cobb Island. North end of Little Cobb Island is at left corner.



b. South end of Cobb Island. The dune line is cut by multiple narrow overwash channels with small fans. Large overwash apron at the right of center has partially filled old marsh canals. Note peat outcrops in surf zone.

FIGURE 55: South End of Cobb Island

and Elkins Marsh where Outlet Bay and Cobb Bay meet. Elkins Marsh is the only large marsh area.

The bays west of Cobb Island are very shallow, and are shown as tidal flats on the most recent U.S.G.S. Topographic Maps and U.S.C. & G.S. Hydrographic Charts. They do not drain to mud flats on the low tide, but water depths at that time are insufficient for navigation by most modern power boats. Tidal range at Sand Shoal Inlet is 4.1 feet, being somewhat greater on the spring tides. Two tidal channels reach south into Hog Island Bay from Great Machipongo Inlet to drain the bay behind the north end of Cobb Island. Sand Shoal Channel runs west from Sand Shoal Inlet to within a mile of Oyster, with depths of over 40 feet all the way and depths of 61 feet and 59 feet at the western end where it branches to form the Ramshorn Channel which runs north along the mainland, and Mockhorn Channel which runs south between Mockhorn Island and the mainland. Sand Shoal Channel permits ocean-going fishing vessels to reach harbor at Oyster through only a short length of dredged channel at Oyster Harbor. Between the inlet and the western end of Sand Shoal Channel, Mittigy Channel branches north to Gull Marsh, and Echichy Channel branches north to connect to Crow Bay, Shallow Bay, Outlet Bay, and Spider Crab Bay. This deep channel connects through Outlet Bay to the deep Gull Marsh Channel in Hog Island Bay. There are numerous other minor channels branching north and south from Sand Shoal Channel.

II. PHYSIOGRAPHIC DESCRIPTION

In the area covered by this section on Cobb Island and its associated bays and marsh areas, there is a reasonable diversity of physiographic forms. At the mainland, the Mappsburg Scarp rises 25-30 feet from the narrow fringe of marsh along the coast. The dendritic valley systems of numerous creeks are trenched into the scarp, and the creeks reach back 1-1.5 miles toward the watershed divide along Route 13. The larger of these creeks are Indiantown Creek, Taylor Creek, and Cobbs Mill Creek. This is a greater number of mainland streams draining into the bays than occurred further north. However, no data is available on discharge from mainland streams, and therefore the significance of this larger number of streams is not known.

In the fringe of marsh along the mainland there are numerous short linear sand ridges which lie in two rows parallel to the Mappsburg Scarp. The ridges are up to 1000 feet in length, 250 feet in width, and many exceed 5 feet in elevation. To the north, this double row of sand ridges lines up with Holt Neck, but to the south they die out north of Brockenberry Bay. These are the crests of drowned beach ridges whose south end was driven ashore against the Mappsburg Scarp at Indiantown Neck, but whose north end at Holt Neck was not. Indiantown Creek has, in the past, eroded its valley across the ridges of this marsh area.

To the east of the mainland, in the bay area, the marsh islands string out in lines. These lines roughly parallel the Mappsburg Scarp on the west side of the bay area, but more nearly parallel the modern barrier islands in the eastern part of the bay area. The pattern of this arrangement suggests that the marsh islands are built on and around drowned beach ridges. West of Cobb Island, both Little Easter Marsh and Big Easter Marsh have sand ridges on them that rise several feet above the general level of the marsh. The pattern of the ridges resembles that found on inlet islands, rather than that of barrier islands, or drowned beach ridges.

The north end of Cobb Island, near the inlet, has been accreting in recent years (see Figure 56a). As a consequence, it shows two sand spits, an older one extending off the end of the island and recurving west beyond the inlet, and a younger one recurving into the inlet from the end of a long ridge that has welded onto the beach about a mile south of the north end of the island. The pattern of berms and low sand dune

a. Beach ridges and accreting bars at the north end of Cobb Island. Note the breach in the beach ridge nearest to the marsh, at bottom center.

b. Overwash fan occurring midway along Cobb Island.

FIGURE 56: Northern Portion of Cobb Island

ridges on the older sand spit show that it had been accreting seaward before the long bar welded onto the island. The long bar curves seaward from the trend of the beach along Cobb Island before it curves back toward the inlet, and this produces a prominent bulge at the north end of Cobb Island. A low sand dune ridge has formed along most of the length of the bar. Just offshore from the recurved ends of these two sand spits an inlet island lies seaward of the sand spits and curves protectively around the end of the island. In this position it shields the end of the island from wave attack from the northeast and east. This inlet island is part of the ebb tide delta deposits of Great Machipongo Inlet.

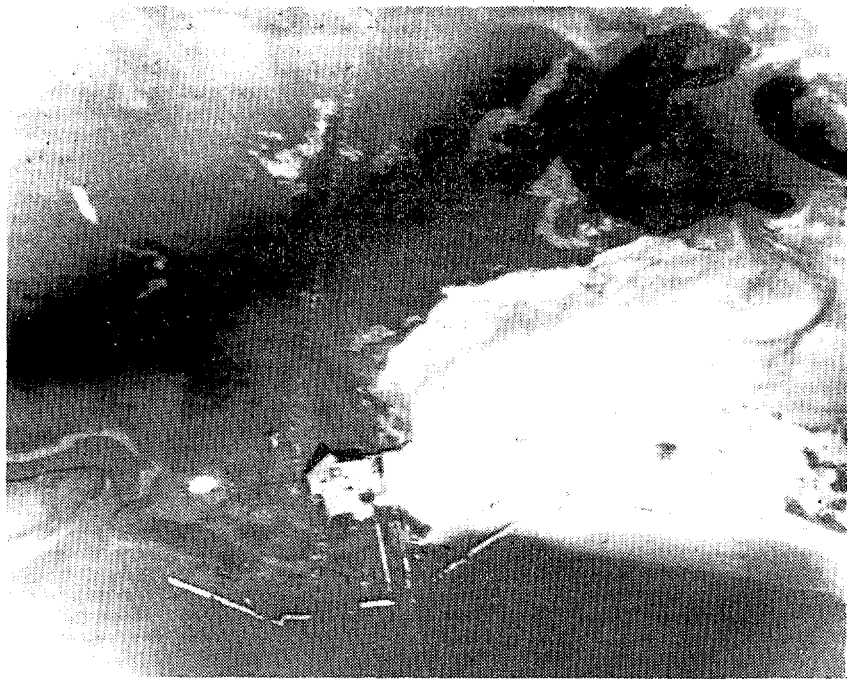
Further south along the northern half of Cobb Island, there is an area of beach ridges between the marsh and the seaward sand dune ridges. Along the beach side of the island there is a series of sand dune ridges that meet the beach ridge at angles of about 20°. They lie behind the present foredune ridge and they are all separated from each other by low back beach flats. These landforms are a set of ridges and runnels that formed when the beach was accreting rapidly. The present active beach is broad and has numerous bars welding on to the beach.

Near the middle of the island, east of Little Easter Marsh, the beach ridge area narrows rapidly and terminates in the modern sand dune ridge. The marsh area behind the island also terminates just south of Little Easter Marsh. At this same location, the sand dune ridge has been overwashed for a distance of nearly 0.2 mile and an overwash fan has spread into the marsh. Figure 56b shows the features near this overwash area.

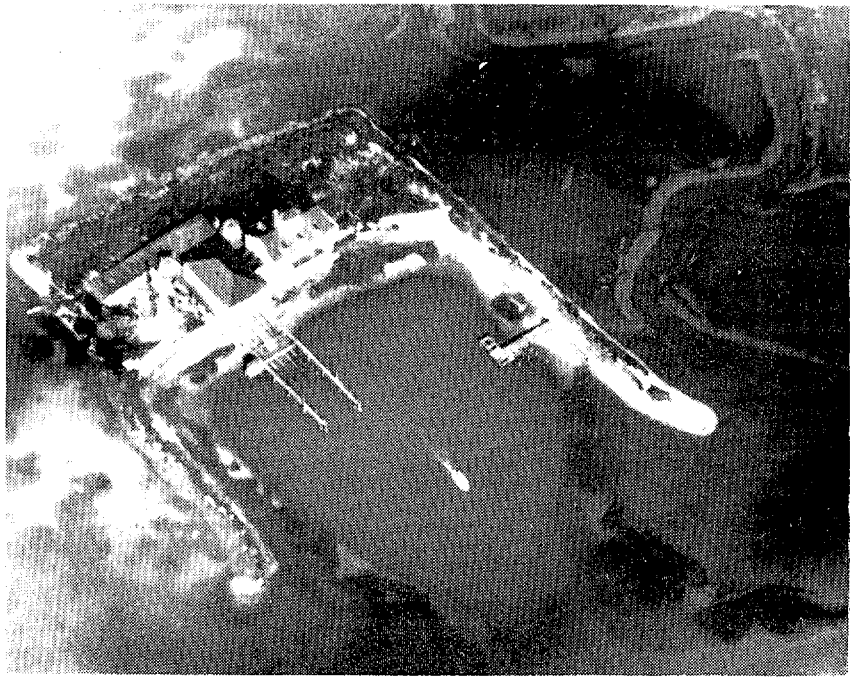
The southern half of Cobb Island is best described as a long narrow sand spit with a large pennant shaped marsh area at the south end, and smaller patches of marsh behind it at other points. From the large overwash fan at the midpoint of the island to the south end of the sand spit, the island recently has been subjected to overwash. At three locations the sand dune ridge has been overwhelmed by overwash and partially destroyed, and at all other locations small overwash channels reach back into the dunes. Two large vegetation stabilized sand dune areas and two smaller ones remain behind the beach along the southern half of the island. The largest of these runs south from the midpoint of the island for a distance of almost 0.8 mile and the other large area runs along the beach for 0.4 mile at the north edge of the marsh near the south end of the island. The narrow, 0.2 mile long part of the island between this vegetated dune area, and the next small one to the north, marks the site of an ephemeral inlet that formed in the mid-1940's. The narrow strand of beach and new sand dunes that closed the inlet is still susceptible to overwash.

The active beach all along the southern half of the island is about 200 feet wide, and bars are moving ashore and welding to the beach. At both ends of this southern reach of shoreline, ridge and runnel patterns can be seen in the berms. But, in the mid-portion these are lacking. At the southern end of the island (see Figure 55b) the sand spit recurves sharply. Recent overwash has spread sand back into the marsh behind the sand spit, filling former marsh canals. Overwash along the southern half mile of the sand spit has spread an apron of sand (Figure 57a) into the marsh and this also has encroached on marsh canals.

Little Cobb Island is best described as a linear strip of beach, 0.8 mile long, with small areas of marsh behind it. The beach has a double line of low, active, sand dunes along its entire length. The beach is retreating over the marsh area and small fans of sand spread into the marsh. At its east end, the island is separated from Cobb Island by a deep and well-defined tidal channel. The recently abandoned Coast Guard Station (Figure 57b) lies directly across the tidal channel from the east end of Little Cobb Island. Seaward of Little Cobb Island, a system of bars nearly parallels



a. Abandoned Life Saving Station at south end of Cobb Island. The large light area is a sand apron that is forming behind the southern sand spit.



b. Abandoned Coast Guard Station at south end of Cobb Island.

FIGURE 57: Abandoned Coast Guard Facilities

the island, and at the east end have begun to weld to the island.

III. SHORELINE CHANGES

When compared to the islands of the Virginia Barrier Island Group described previously, the position of Cobb Island has remained remarkably stable. Little Cobb Island, however, is a new island that made its appearance in the decade between 1936 and 1946. Cobb Island has retreated and advanced during the past 125 years, and perhaps longer. Shoreline changes from 1871 to 1963 are shown in Figures 58 and 59. At the beginning (1852) of the historical period covered by this report, the island resembled the present portion of Metomkin Island east of Metomkin Bay. It was breached by three inlets and broken into four segments.

The position of Cobb Island today is west of the former locations, yet everywhere along the length retreat has been less than 2200 feet. At most locations retreat has been closer to 900-1000 feet. These figures would give an average retreat of 8.25-9.1 feet/year and a maximum retreat of 20.2 feet/year for the period 1852 to 1962. Though retreat occurred, the rate is much less for this time period than on the other islands previously described. The greatest changes in the island have occurred at the north end where Great Machipongo Inlet was undergoing significant changes during this time. The northern end of the island quickly advanced and retreated, bars built up and welded to the island, inlet islands formed and were driven ashore, and the ebb tide delta outside the inlet grew south, seaward of the north end of Cobb Island. Surprisingly, the shoreline of the inlet island that lay wrapped around the north end of the island in 1974 is at about the same positon as the shoreline of the south side of the inlet in 1853, 1871, 1913, 1936, 1942, 1946, 1955, and 1960. In other years, 1888, 1891, 1930, 1962, 1963, it was farther south, sometimes by as much as 4200 feet. These rapid changes are not due to shifting of the inlet channel, but rather are associated with sediment drift in the south lobe of the ebb tide delta. Therefore, they occur rapidly in response to induced changes in the inlet processes, often as responses to storm effects. It is reasonable to expect that such changes will continue to occur in the future.

At the south end of the island the retreat of the island's beach has been larger. Greatest retreat has occurred along the southern third of the island. The modern beach was about 1800 feet to 1900 feet west of the 1853 position by 1962. This yields an average retreat of 16.5-17.4 feet/year during that period. The southern tip of the island retreated rapidly northward about 2600 feet before 1911, but since then its position and the configuration of the inlet opening made with Bone Island/Wreck Island have remained quite stable. In more recent years, with the appearance of Little Cobb Island, the tidal circulation around the southern tip of Cobb Island has changed slightly, and the shape of the tip has changed, recurving more strongly toward the bay.

A more detailed examination of shoreline changes shows that in 1853 (Byrne, 1972), the island was badly breached, and consisted of four islands. The largest of these islands (Cobb Island) was at the south end of the group, and the entire upland position of that island lay east of the southern half of the present island. The marsh behind the present island continued eastward to the former island. The north end of this island was extended as a sand spit into open water beyond the northern edge of the marsh area. By 1962, retreat of Cobb Island had pushed the shoreline back a maximum of 2100 feet, but an average of 1800-1900 feet. No part of the upland of the original island remained, and a large area of marsh had been lost.

The next largest island lay at the north end of the group. The date of this study suggests that this island was probably the island known as Pruit's Island in the mid-

FIGURE 58.
SHORELINE CHANGES
ON COBB ISLAND;
1870-1963

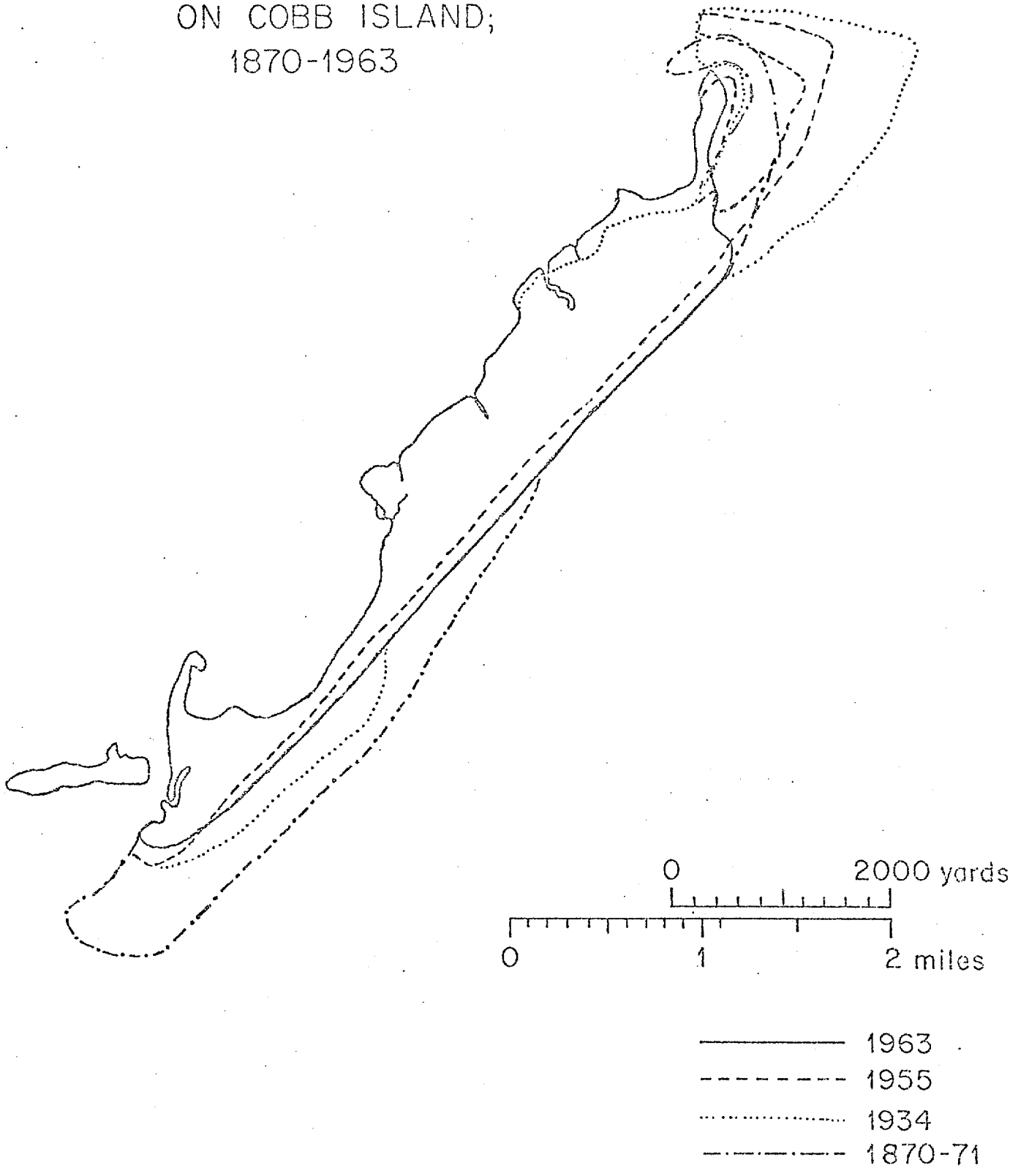
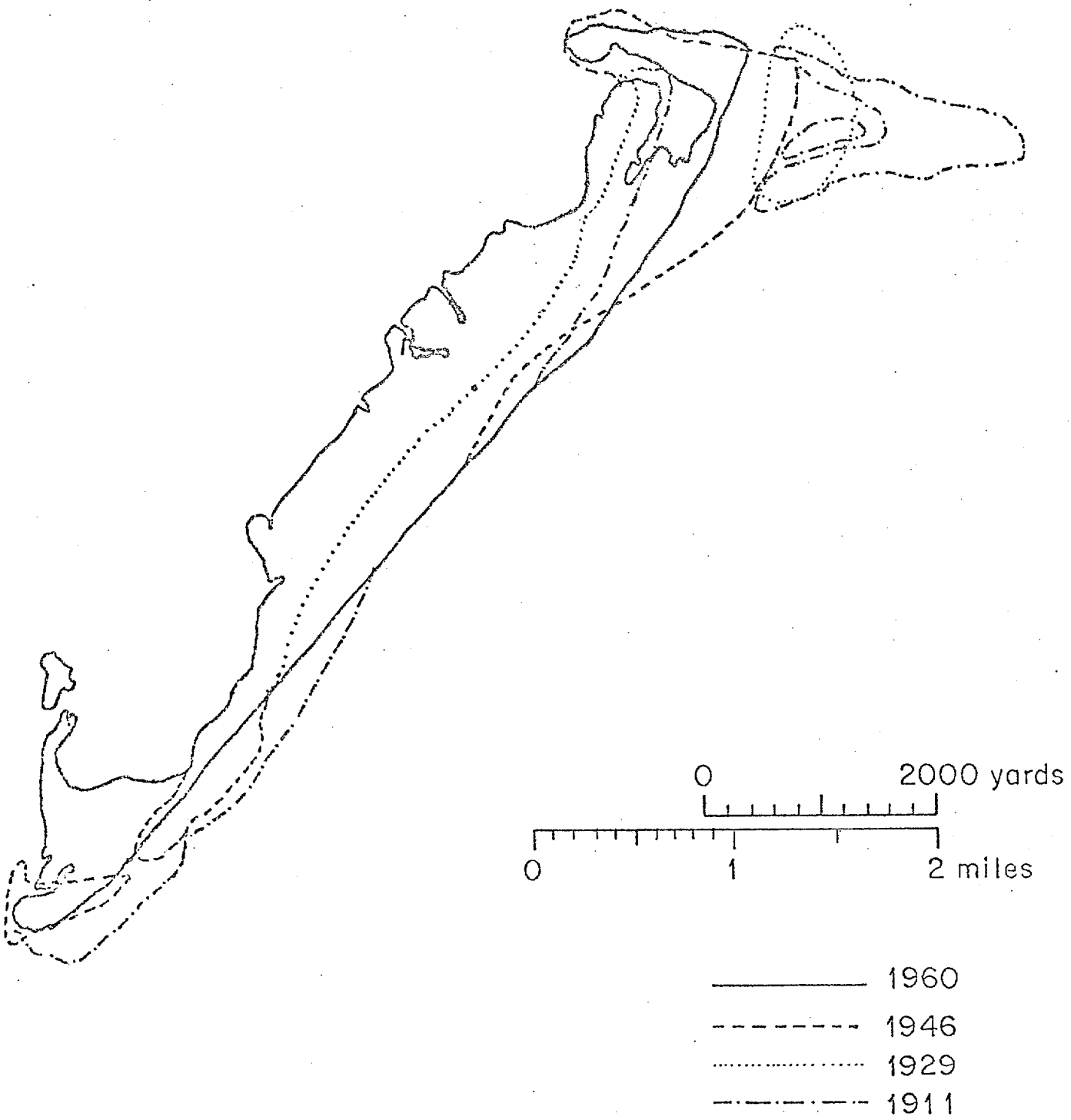


FIGURE 59.
SHORELINE CHANGES
ON COBB ISLAND;
1911-1960



1850's (Graham, T.C.R.S., 1976). The north end of the island had two sharp bends in it. The easternmost of these bends turned the island almost 90° toward the north and the inlet opening. The second bend turned the island into the inlet opening. At the 90° bend, and for more than 1800 feet to the south, the island was only a thin ribbon of sand. North of the bend the island was a broad sand spit, up to 750-800 feet in width, which recurved into the bay at the inlet opening. Near its south end the island again attained widths of up to 750 feet. There was an older marsh island behind the southern half of the south arm of this island, and the island was firmly anchored to that marsh island. By 1911 all of this island, except the western half of the southern sand spit, had been lost to erosion. The remaining two islands were very small. The largest was less than 2000 feet long, was oriented northeast-southwest, and lay about 900 feet south of the southern sand spit of the northern island. By 1911, all but the western tips of the north and south ends of this island had been eroded away. The smallest island lay several hundred feet off the southern end of the other small island, was oriented northwest-southeast, and was 1200 feet long with an average width of about 100 feet. The southeastern half of this island was destroyed by 1911. There had been another older marsh island where these two small islands were located, and they were apparently built as beaches on the southeast and southwest faces of the marsh island. The two older marsh islands had lain east of Little Easter Marsh and Cobb Island had retreated into them.

In 1852 when Cobb Island was a string of thin islands, the channel of Great Machipongo Inlet was discharging east-northeast across the southern end of Hog Island and Hog Island was accreting seaward rapidly. The active portion of the inlet's ebb tide delta lay north of the inlet opening, and the southern lobe that lay seaward of the north end of Cobb Island was less active. Inlet circulation at this time was operating to deprive Cobb Island of a supply of sediment, and the island was instead losing sand and retreating. These conditions prevailed until after 1871, and until the inlet channel between Cobb and Hog Islands shifted position and the ebb tide delta began to move south.

Despite retreat, by 1871 a continuous beach had become established from Sand Shoal Inlet to Great Machipongo Inlet and Cobb Island was one island. Except at the very southern end of the island, the barrier island was very narrow, varying from 300 feet to 400 feet in width. At the north end of the island the beach had remained in place along the inlet, but just southward the beach along the sand spit had retreated. Maximum retreat of 1500 feet had occurred where the "90 " degree bend had been in the former island, but retreat occurred all along the sand spit, reaching 700-900 feet at the southern end where the sand spit joined the marsh-backed part of the island. Further south where the two small islands had been the beach had advanced seaward by 750 feet to 900 feet. The southern half of the island had retreated uniformly by 350 to 400 feet, but the south end of the island lengthened by several hundred feet. The accretion of the section of beach north of the midpoint of the island had straightened the beach somewhat, and was undoubtedly the result of normal beach front long-shore sediment transport. Conditions at Great Machipongo Inlet were still unchanged, and Cobb Island was still deprived of a good sediment supply.

In 1911 Cobb Island was still a continuous island but it had retreated significantly. From about the midpoint of the island northward, the shoreline lay west of the 1962 shoreline by as much as 900 feet, having retreated between 700 and 1300 feet from the 1871 shoreline position. Along the southern half of the island retreat averaged about 1400 feet, and the shoreline lay west of the position of the entire upland barrier island in 1871. The barrier island was still very narrow, as narrow as 150 feet in some places, and never more than about 350-400 feet wide. About 1.5 miles south of the north end of the island a major overwash channel began and continued for the next 0.4 mile to the south. Overwash deposits were spread over one of the

older marsh islands. About two miles north of the south end of the island, near the southern edge of the older marsh island, there were numerous places where the barrier island was overwashed. Some of these features are visible at the north end of the island in the 1974 I.R. imagery as well as on black and white aerial photography of the island. In Figure 56a, the old 0.4 mile overwash area can be seen in the beach ridge near the center of the picture.

At the north end of the island, the end of the sand spit had retreated 1400 feet to the south, and the sand spit had shifted west by 1500 feet. The sand spit did not recurve at the inlet, but was just a linear continuation of the barrier island. A large inlet island, Pig Island, had grown on the ebb tide delta to the east of the north end of Cobb Island, but an inlet channel called South Channel lay between it and Cobb Island. Minimum depths in this channel ran 7-9 feet. The south end of Cobb Island had also retreated about 1400 feet. By 1911 the inlet channel in Great Machipongo Inlet had turned in a southward direction and the inlet processes were changing in response. This change was discussed in the section on Hog Island and will not be repeated here.

By 1942 the northern part of the island had accreted significantly. Along the middle third of the island the beach advanced an average of 1200 feet. The northern third of the island had advanced by 1800 feet to 2100 feet, and by 2700 feet at the north end of the island where the sand spit had advanced to the east along the inlet. Pig Island was apparently added to the north end of Cobb Island between the surveys of 1926 and 1934, and the north end of Cobb Island took on a broad appearance which it maintained for more than a decade. The time interval between 1934 and 1946 saw little change in the shoreline of Cobb Island, with one exception; an ephemeral inlet opened at the north edge of the marsh near the south end of the island. This left the south end of Cobb Island as a separate triangular island, 3100 feet long on the seaward side, with the altitude of the triangle across the marsh measuring 2000 feet. Little Cobb Island was born during this decade, and grew to a length of about 1800 feet and a maximum width of 450 feet.

By 1949 the broad north end of the island had eroded, losing more than 50% of the area that had accreted from Pig Island. The 1949 shoreline is shown with more recent shorelines in Figure 60. Beach retreat along the northern quarter of the island had averaged 1800 feet and reached a maximum of 2000 feet. But, the next 2 miles of beach to the south remained constant. The ephemeral inlet near the south end of the island had closed, and the south end of the island had begun to retreat again. A small inlet island had developed 500-600 feet offshore of the north end of the island. On the map and photographs, the north end of the island in 1949 looked like an inverted boot, with the older, 1912 spit, protected from the sea and sticking up behind it. The north end of the island retreated more slowly during the 1950's, and the island retained this shape until sometime after March, 1960. After the March, 1962 storm, the boot-shaped spit was gone, and the straight spit of 1912 had been driven about 750 feet west of its former position, and shortened by nearly 1500 feet. The north end of the island was about 2400 feet south of the inlet channel, and almost 4000 feet southwest of its position in 1942. Between 1942 and 1963, beach erosion along the island varied from less than 300 feet to over 1300 feet. Erosion averaged about 600 feet along the northern two-thirds of the island, was greatest along the middle third of the island, and was least along the southern third of the island where retreat averaged only 300 feet. Averaged annual erosion rates on the beach thus varied from 14.2 feet/year to 62 feet/year along the northern two-thirds of the island. During this time interval, Little Cobb Island grew to a length of 4000 feet, a width of over 800 feet, and migrated north by more than 800 feet. Except for the major changes at the north end of the island, most of the changes to Cobb Island took place prior to 1955. In the interval from 1955 to 1963, the southern three-quarters of the

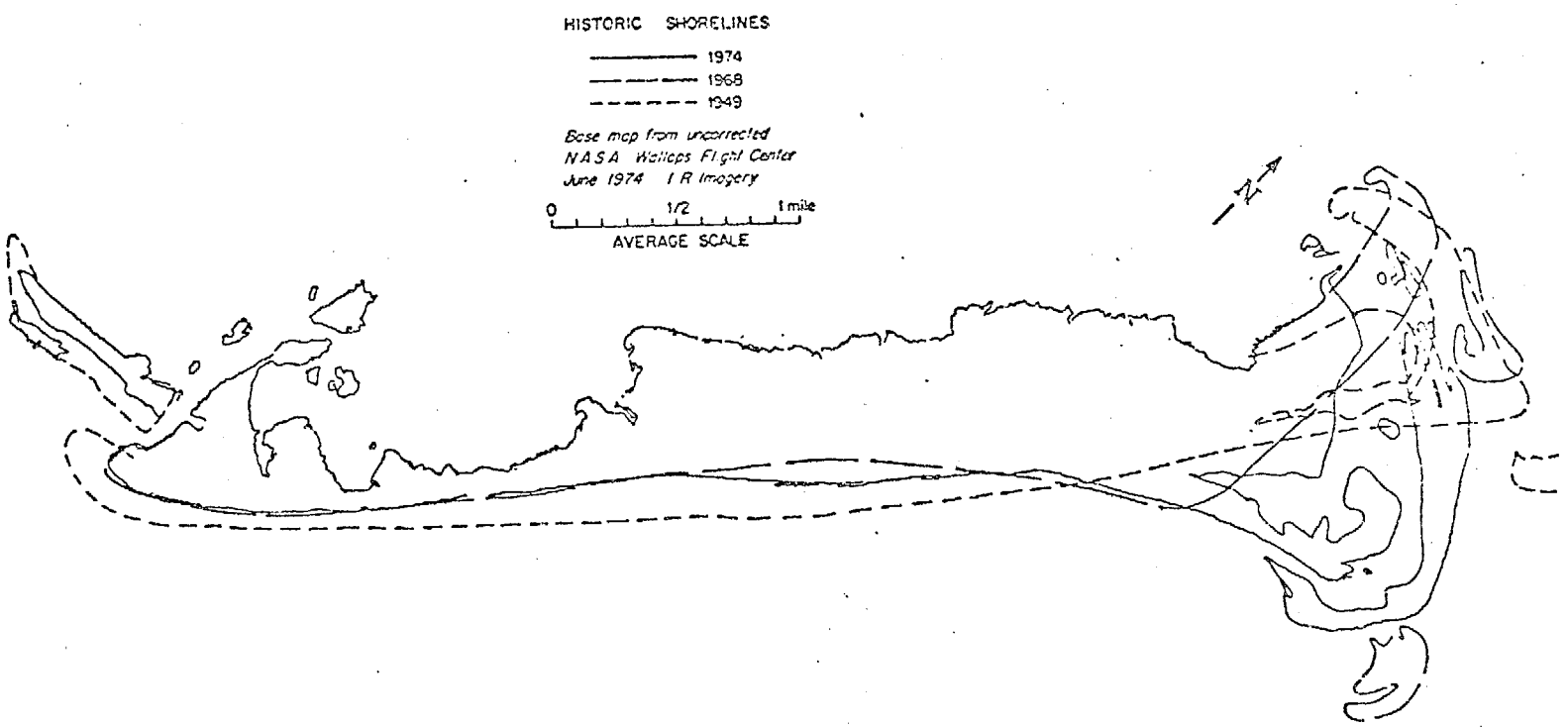


FIGURE 60. RECENT SHORELINE POSITIONS ON COBB ISLAND

island remained quite the same.

After 1963 a new sand spit grew north from the beach at the north end of the island, and by 1966 had attained a length of 4200 feet before it recurved along the inlet for more than 4600 feet. The inverted boot of the 1950's had been restored by 1966, complete with the 1963 sand spit behind the boot. But by 1968, the 1963 sand spit was gone, and the whole northern sand spit had changed. The new 1968 sand spit was about a mile long and recurved into the inlet. It averaged more than 1400 feet wide, and was more than 2000 feet wide at some places. In 1968, two new inlet islands had grown on the ebb tide delta offshore from the north end of the island. The northernmost of these islands was 800 feet offshore of the easternmost point of the north end of Cobb Island. It was more than 2500 feet long and over 500 feet wide. The southernmost new island was 2200 feet long, over 900 feet wide, and about 4700 feet offshore of Cobb Island about 1.15 miles south of the north end. By 1974, these islands had merged into a longer island that wrapped around the whole north end of Cobb Island and protected it from wave attack. Between 1963 and 1967, the southeast facing beach along the seaward side of Cobb Island accreted. Accretion at the north end of the island reached nearly 1300 feet but was less than 50 feet along the southern three-quarters of the island. From 1967 to 1975 all but the very north end of the island maintained its position. Except for the very north end of the island, the island had changed very little in the past decade.

At the south end of Cobb Island, Little Cobb Island had shrunk to 1300 feet in length with a width of 270 feet between 1963 and 1966. But, by 1967, it had grown again to more than 4600 feet and a width in excess of 900 feet. In 1974, Little Cobb Island remained the same, but a new inlet island about 0.3 mile long had grown seaward of it, near the west end, against the inlet.

In summary, it may be said that the modern Cobb Island is a creation of the past 100 years; or more correctly a recreation of a former island, for the small islands from which it began in 1852 were undoubtedly the remnants of a former island. The charts used for this study only go back to the surveys of 1847 to 1853. Other records would be needed to make that determination. The position of Cobb Island in 1974 is not much different than the positions of the 1852 islands. At the north end, the 1974 sand spit and bar actually lie slightly seaward of the 1852 position of the sand spits. Farther south, to the midpoint of the island, where it is backed by marsh, the 1974 shoreline does lie seaward of the 1853 islands, and nearly as far seaward as the maximum advance in 1949. It is only south of the midpoint of the island that there has been retreat since 1853, but here the retreat was steady until 1967 when it had reached a maximum of more than 2600 feet at the south end of the island and nearly as much for the 1.8 miles of beach to the north. North of that retreat decreased steadily to zero near the midpoint of the island. Since 1967, there have been no significant changes in the shoreline south of the midpoint of the island, and the mapping of this study (Figure 60) shows the two shoreline positions to be essentially coincident. It is worth noting here, that the south lobe of the ebb tide delta at Great Machipongo Inlet curved in to merge with Cobb Island just north of the midpoint of the island in 1966. Figure 60 shows that the 1974 shoreline is indented at the midpoint of the island, immediately south of where the ebb tide delta stops. It is obvious that the growth of the north half of the island has been under the influence of inlet processes at that end of the island.

IV. INLET CHANGES

It is difficult to evaluate or discuss changes at Sand Shoal Inlet because the most recent hydrographic survey as determined by this study was done in 1921. Hydrographic

Charts through October, 1964, and the U.S.G.S. Topographic Map Series of 1968 simply reprint the same bathymetry from the 1921 survey. The hydrographic charts contain the note;

"SAND SHOAL INLET

The Channel is subject to continued change. Entrance buoys are not charted because they are shifted frequently in position."

Therefore, it is difficult to document or even know, what changes have occurred. Hydrographic surveys were done in 1853, 1870, 1911, and 1921. These surveys showed a deep, straight main inlet channel discharging to the southeast through the ebb tide delta. Channel depths decreased seaward from 70-72 feet at the inlet throat to 18 feet 2.75 miles out to sea. The 1973 black and white aerial photographs indicate that this channel still occupies the same position, but give no information on changes in width, depth, or length. The earlier surveys showed two branch channels. Northeast Channel curved around the south end of Cobb Island and along the beach for a mile or so before turning seaward. South Channel branched south along the shoreline of the north end of Wreck Island. The early surveys show that Northeast Channel increased in width and depth up to 1911 when it was more than 2300 feet wide with minimum depths of 16-20 feet. By the 1921 survey, the width had diminished to about 1300 feet but the depth remained unchanged. These surveys also show that until after 1911, the north lobe of the ebb tide delta was being reduced in size, until 1911 it lay along a line southeastward of the present Coast Guard Station, and parallel to the main inlet channel. By 1921 three small fan-shaped lobes had been added to the north face of the ebb tide delta; one just seaward of Northeast Channel had pushed that channel close to the beach for a greater distance to the north. The 1949 and 1973 black and white aerial photography confirms that Northeast Channel is still functioning. It has apparently held its position very well because in the 1973 photograph, the position agrees well with the position in 1921 and with shoreline changes that have occurred since.

The most reasonable explanation for the retreat of the southern half of Cobb Island would be found in inlet trapping of sand in the longshore drift system. Northeast Channel is ideally situated to draw large volumes of sand from the longshore drift system through the inlet on the flood tide. The appearance and growth of Little Cobb Island suggests that this is indeed happening, and that the sand lost from Cobb Island can probably be found in this flood tide deposit, and on the floor of the bay.

V. GEOMORPHIC DESCRIPTION AND INTERPRETATION

A consideration of the geomorphic units in the area described in this section on Cobb Island indicates that the oldest units are at the mainland edge of the area. The beach ridge, described in the section on physiography, that was driven against the Mappsburg Scarp north of Oyster, would be the oldest geomorphic unit. Mixon, et al. (1974) suggests "latest Sangamon or early to middle Wisconsin?" age for these deposits. Eastward into the bay area, Elkins Marsh and Gull Marsh are interpreted as having origins as beach ridges or barrier islands. Gull Marsh would be considerably younger in origin than beach remnants in Elkins Marsh.

Further east in the bay area, Big Easter Marsh and Little Easter Marsh are interpreted as inlet islands or flood tide delta islands. These marsh islands predate the historical period of this study and are therefore considered to be ancient, but they relate to the present barrier island system and are therefore post-Wisconsin in age.

Little Easter Marsh is shown on the geologic map of Cobb Island, Two other inlet islands stood east of Little Eastern Marsh before Cobb Island overran most of them. Small remnant areas from these islands can be found in the marsh near the old inlet in the northern third of the island. Cheryl McCaffrey, in her work on the vegetation of the islands, recognized these old inlet island remnants because of a more compact substrate and a different vegetation pattern (1975, personal communication). Parts of these two older inlet islands were recognizable on the 1871 hydrographic charts. There may have been other islands in this group further to the east. Of interest is the fact that the islands had lain along an east-west line with fairly close spacing. A similar string of older inlet islands on an east-west line can be found west of Trout Channel near the south end of Cedar Island. The ridge patterns in Big Easter Marsh and Little Easter Marsh indicate they were built at some ancient time by flood tide currents from the northeast. The north ends of both marsh islands are still being added to by flood tide currents moving through Rowes Hole Channel.

On Cobb Island itself, there are no ancient geomorphic units except the remnants of the marsh islands already mentioned. All of the other geomorphic units date from 1853 to the present.

The old inlet symbol near the north end of the island marks the location where the 1911 shoreline had cut back into the barrier island deposits and broken through to the marsh. It is not believed that an ephemeral inlet formed here, but rather that the area served as a broad overwash channel. There is no trace of any inlet channel in the marsh behind this. The inlet opening symbol was used to more clearly designate the area. The position of the beach ridge unit west of the northern old inlet line represents the beach ridge that had become established after 1853 and prior to the erosion before 1911. At the southern end of this overwash area, there is probably contained the recurved sand spit at the south end of the northernmost island of 1853. The portion of the beach ridge unit west of the southern old inlet line represents what is left of the beach ridges that had built up as the island advanced after 1853. The pre-1911 period of erosion had removed a large volume of barrier island deposits south of the 1911 overwash area.

The old strandline drawn through the middle of the beach ridge unit is the 1962 shoreline of Cobb Island. The beach ridges and sand flat west of the strandline are the remains of the island's accretion subsequent to 1911. Everything east of the old strandline has accreted since 1962. The beach ridge unit contains several ridges that lie at slight angles to the older ridges, and intersect and merge to the south. These are truncated still further to the south where a number of short strandline ridges angle sharply against the beach ridge unit. The erosion that truncates the beach ridges predates 1968, and the gently curving position of the eastern contact of the beach ridge unit corresponds to the indentation of the 1968 shoreline at this point. The strandline ridges and back beach flat were added very soon after 1968 because on the April, 1973 aerial photos, they and the back beach flat are present, and the ridges have vegetation growing on them.

VI. GEOLOGIC HISTORY AND INTERPRETATION

Not much geologic history can be drawn from the features described for this island. The very ancient geomorphic features west of the island relate to the retreat of sea level during the Wisconsin stage of glaciation, and there are no significant prehistoric features to interpret on Cobb Island. The recent geologic history of Cobb Island is best understood from the descriptions of shoreline changes and geomorphic units already given. Briefly, the recent geologic history shows that the south end of Cobb Island has remained a thin barrier island with a narrow beach ridge, and has retreated steadily since before 1853. As retreat progressed, all earlier geologic evidence was destroyed

by erosion. The northern portion of the island accreted from three small, thin barrier islands in 1853. The period of accretion advanced the shoreline seaward and lengthened the island at the north end. This phase of accretion was terminated by a period of rapid erosion prior to 1911 that drove the shoreline of the island back over nearly all of the post-1853 accretion to the most westerly position occupied by the shoreline. A second period of accretion began after 1911 and lasted until sometime in the late 1940's when the shoreline began to retreat again. This second period of erosion was initially rapid, slowed through the 1950's, and ended with very rapid retreat between 1961 and 1962. More than half of what had been gained by accretion was lost during this period of retreat. Accretion since 1962 has rapidly replaced much of what had been lost during the preceding period of retreat. The accretion of the northern portion of the island is continuing at the present time.

WRECK ISLAND

II. DESCRIPTIVE GEOGRAPHY

Wreck Island is the eighth island from the north end of the Virginia Barrier Island Group. It is the sixth island covered by this study. It is located between Cobb Island and Ship Shoal Island in the barrier chain. It is bounded on the north by Sand Shoal Inlet, and on the south by New Inlet. The north end of the island is due east of the village of Oyster and the large town of Cheriton which is on U.S. Route 13. Access to the island by boat is from the village of Oyster by way of Sand Shoal Channel which leads to the north end of the island. Landing on the marsh side of the island by boat should be attempted only near high tide, because at lower phases of the tide there is insufficient water for small power boats to operate without grounding.

Wreck Island is 2.75 miles long from inlet to inlet. Because the island is curved like a bow, its seaward facing beach is 3.0 miles long. The barrier island upland averages about 1100 ft. in width throughout its length. There is marsh behind the southern three-quarters of the island that averages about 2000 feet in width, but the bay side of the marsh is quite irregular and width of marsh drops to as little as 800 feet at indentations. There is a narrow fringe of marsh behind the southern half of the sand spit that makes up the northern quarter of the island's length.

At the northern inlet, Wreck Island lies 6.7 miles from the mainland. At the southern inlet the island is 7.25 miles from the mainland. The axis of the island, from inlet to inlet lies within a degree of being a true north-south line. However, because the northern third of the island curves westward toward the inlet, a better axis to use for orientation of the island is the axis of the southern two-thirds of the island. That axis is oriented about N13^{o}E. The mainland coast west of Wreck Island is located at the base of the Mappsburg Scarp, and its orientation is about N14^{o}E. As previously mentioned in the section on Cobb Island, the seaward face of the Virginia Barrier Island Group is indented at Sand Shoal Inlet. Wreck Island forms the southern edge of that indentation. Besides having its axis turned counter-clockwise in respect to other islands, it occupies a position nearly 1.5 miles inshore of the trend of the seaward face of the barrier island chain established by the other islands.

The area between Wreck Island and the mainland is estimated to be about 40 percent marsh and 60 percent bay and channel areas. Most of the marsh area is contained in the marsh at the north end of Mockhorn Island which also extends south for miles behind Ship Shoal Island, Myrtle Island, and Smith Island. A second large marsh area is New Marsh which lies against the north end of Mockhorn Island on the east side. Another, smaller, marsh area of note is Man and Boy Marsh which lies between Wreck Island and New Marsh. There are other small marsh areas along the mainland and in the bays.

There are three large bays west of Wreck Island. Cobb Bay extends south between Wreck Island and New Marsh until it merges with South Bay about a mile south of Man and Boy Marsh. The third bay is Mockhorn Bay which lies between the north end of Mockhorn Island and the mainland. There are only two major channels in the area being described. Sand Shoal Channel, which runs west along the north edge of the area from Sand Shoal Inlet to a point a mile east of Oyster, is the largest. Mockhorn Channel, which turns south from Sand Shoal Channel a mile east of Oyster, is the second major channel. It parallels the mainland as it runs south through Mockhorn Bay to Magothy Bay. Both of these channels are wide and deep, with minor

channels branching from them. There is no major channel associated with New Inlet, only a network of small channels branching into South Bay. One of these, Black Rock Channel, turns south behind Ship Shoal and Godwin Islands to connect into Main Ship Shoal Channel.

II. PHYSIOGRAPHIC DESCRIPTION

At the mainland side of the area described, the mainland coast begins at the riser of the Pleistocene terrace (the Mappsburg Scarp). At the base of this scarp, between the mainland and a small, irregularly shaped, fringing marsh, there is a narrow strip of sand deposits varying from 100 to 400 feet in width. Near Oyster these deposits lie between mean sea level and an elevation of less than 5 feet, but near the south end of Mockhorn Bay they reach an elevation of 10 feet. These deposits are believed to be an old beach. About a half mile east of the mainland there are a number of small, narrow marsh islands. These islands are about 100 feet wide, up to 1100 feet long, and are oriented roughly parallel to the mainland coast. Together they form a line 2.3 miles long that begins at the south end of Brockenberry Bay near Oyster, and ends at the straight front of a marsh area near the south end of Mockhorn Bay. This line of marsh islands appears to be a southward continuation of the linear strip of marsh that forms the east edge of Brockenberry Bay. This same trend, miles to the south, forms the edge of Magothy Bay east of Townsend, and still farther south can be followed as sand ridges through the marsh. It is clear that this trend is a former shoreline, and that the string of marsh islands are formed on the drowned beach ridge.

Further east a number of nearly parallel sand ridges are contained within the marsh of Mockhorn Island. West of Ship Shoal Island these ridges rise several feet above the marsh and are forested. In the area west of Wreck Island these ridges do not rise noticeably above the marsh, and their presence cannot be determined surely from topographic maps. However, the occurrence of linear drainage divides in the marsh and a parallel arrangement of the larger marsh canals at the north end of Mockhorn Island strongly suggests that the initial development of the marsh drainage was controlled by drowned beach ridges. Examination of black and white aerial photographs reveals that the ridges are there, indeed, and that they end abruptly, at the line of the south edge of the small bay in the north end of Mockhorn Island. Similar ridges are found in New Marsh. These ridges are all drowned beach ridges, and the sequence of them eastward from the mainland records a very ancient regression of sea level. The age and significance of these ridges will be discussed further in the section of Smith Island.

In Man and Boy Marsh, and on a smaller marsh island further east, the topographic maps show no physiography except a spot elevation marking high ground in the marsh. The black and white aerial photographs show that the high ground is part of a low ridge pattern of the type found on inlet islands, built as flood tide deposits. This characteristic and the orientation of the ridge patterns establishes these two marsh areas as part of the modern, retreating, barrier island system.

On Wreck Island there are two physiographic provinces, the marsh area, and the upland barrier beach deposits. The marsh area contains a number of low ridges, some of which are sand spits related to former island positions, and others which are apparently former inlet islands. Auger boring of these features in the marsh showed that they are made up of compact fine sand to a depth of eight feet. The marsh also contains a number of abandoned and partially filled tidal canals that are truncated by the barrier island. These canals are several orders of magnitude wider than the modern canals, or the size of the marsh area would warrant. Their pattern shows that they formerly drained southeastward. Present drainage in the

marsh is to the west. Portions of the marsh clearly associated with one of these old canals, near the south end of the marsh, were sampled by augering at eight locations. It was found to have a root mass in sand and mud down to 8 inches or more, and below that it was composed of mud, with no appreciable sand present. Elsewhere, augering in the marsh near the middle of the island (in marsh associated with the abandoned canals) revealed that that marsh also was established on mud.

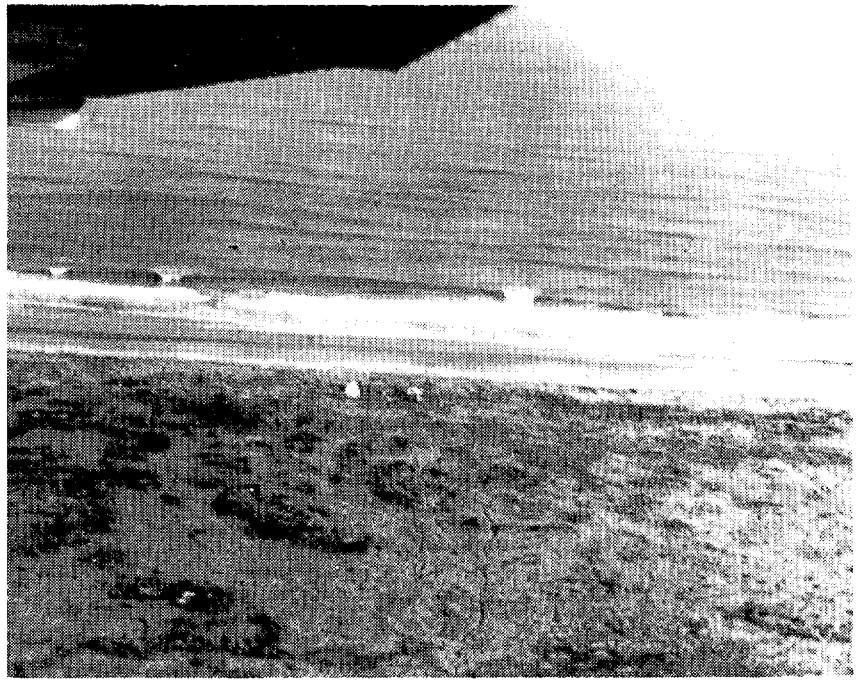
Along the barrier island, inshore of the beach, there is a complex system of very low beach ridges. Figures 61 and 62b show the nature of these low relief features. Figure 61a shows some campers tents that are pitched between two low beach ridges that parallel the shoreline. In Figure 61b, a higher (6-8 feet) wooded beach ridge can be seen. This ridge is part of the historical island known as Bone Island which formed the nucleus of the north end of the present Wreck Island. Figure 62b shows the area just to the north of Figure 61b, where the northern sand spit is joined to the main island. In this interior beach ridge unit, there are several ephemeral inlet openings and at least three former sites of broad overwash channels with overwash fans spread out into the marsh. This physiographic unit forms a broad grassland in which the crests of ridges rise several feet above the average level of the area. Relief is generally about 3-4 feet above high tide level except along the ridges where elevations reach up to 8 feet. Near the bend of the island a small area of wax myrtle trees has become established on a ridge along the edge of the marsh.

Elsewhere on the ridge unit there is grass cover. At the back of the beach the foredune ridge rises 3 to 6 feet above high tide level, and is grassed. The active beach along the length of the island is broad and gently sloping. Figure 62a shows the foredune ridge and beach in the foreground of the picture. In many places low bars are welding to the beach, and at both ends of the island sand spits are building. The sand spit at the south end of the island is growing south of another recently formed sand spit, and the most recent sand spit shows a berm pattern, indicating rapid growth.

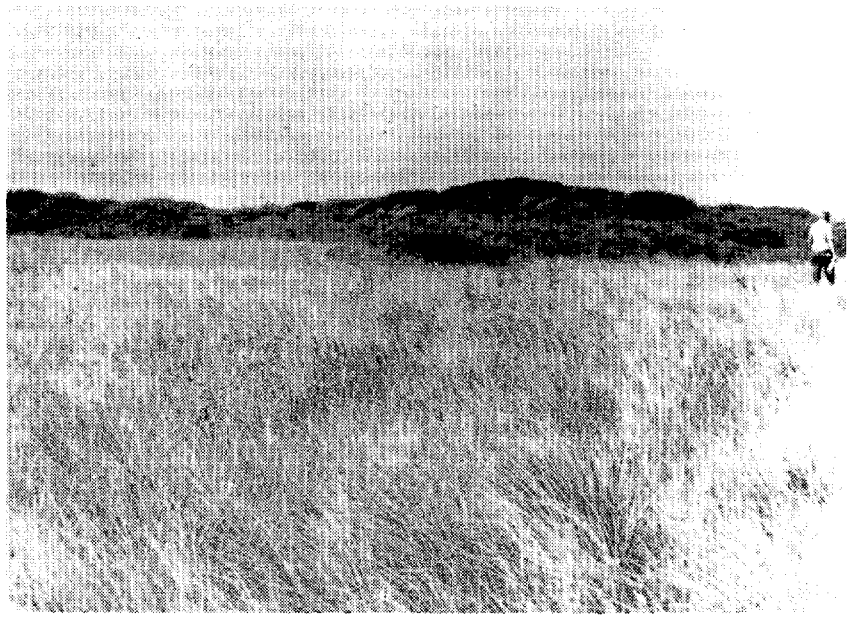
III. SHORELINE CHANGES

At the beginning of the historical period for which this study of shoreline changes has been done, two islands occupied the position in the barrier chain now occupied by Wreck Island. Bone Island occupied the position near Sand Shoal Inlet and Wreck Island was south of it in a position farther to the east and reaching further to the south. Bone Island Inlet separated the two islands. Because both islands had names, it is likely that they had held such a configuration for some time. At Ship Shoal Inlet the opening was only half as wide as at present, and the inlet opening faced southeast. Today the inlet opening faces south, and this has been mostly brought about by the northwesterly shift of the north end of the Wreck Island sand spit. A northeasterly shortening of the south end of Cobb Island has contributed to the widening of the opening and accounted for a small northward shift in the position of the opening. The changes have only been in the inlet opening, the inlet throat and deep channel have remained essentially unchanged. The opening at New Inlet has changed radically. It has shifted west and increased more than four times in width, and the facing of the inlet opening has rotated from facing southeast to facing east northeast.

The southern end of the seaward beach of Wreck Island was more than a mile southeast of the present position in 1853 when the first hydrographic survey was conducted. Near the middle of the island, about half a mile south of the bend in the shoreline, the westward retreat has been on the order of 3600 feet. However, there has been no retreat at the bend in the island. The shoreline at the bend has not varied its position by more than 300 feet, and since the late 1930's has occupied a position seaward of the 1853 shoreline. North of the bend in the outer beach, the shoreline



a. Grassland south of mid-point of Wreck Island. Dark areas are low sand dunes. Trails lead from camper's tents to a marsh canal used for access.



b. Grassland near the north end of Wreck Island. Wooded beach ridge is a remnant of Bone Island.

FIGURE 61: Grasslands on Wreck Island

a. View along Wreck Island where the beach bends toward the inlet. This section of the island has been relatively stable for many years. The view is also across Sand Shoal Inlet toward Little Cobb Island.

b. View across the grassland of the sand spit at the north end of Wreck Island. Wooded beach ridge is the northern end of the remnant of Bone Island.

FIGURE 62: Northern Portion of Wreck Island

along the inlet channel has not retreated significantly since 1853, and the sand spit has actually grown in length along the channel. There have been changes in shoreline position as this northern beach has shifted west, then rebuilt to the east, and the net change shows a westward retreat of the tip of the sand spit that increased to about 2500 feet by 1974. But this is deceptive, due in large part to the lengthening of the sand spit, combined with a gradual counterclockwise rotation of the sand spit. Midway between the tip of the modern sand spit and the bend in the beach, where rotation alone has shifted the beach, the 1974 beach is only 525 feet west of the 1853 beach on Bone Island. Taking rotation into consideration, the shoreline of the modern sand spit is only 750 feet westward of the beach at the north end of Bone Island in 1853. Figures 63 and 64 show relative shoreline positions between 1871 and 1963. Figure 65 shows relative shoreline positions from 1949 to 1974.

In 1853 (Byrne, 1972) Sand Shoal Inlet was only 2300 feet wide and faced to the southeast. The slender northern sand spit of Bone Island formed the south shore of the inlet, and Bone Island stretched 1.25 miles to the south. At the south end, Bone Island curved sharply into Bone Island Inlet (a 600 feet wide inlet that separated it from the north end of Wreck Island). The nearly straight beach of Bone Island, along the seaward channel from the inlet, was more than 1.1 miles long.

Wreck Island jutted out from Bone Island Inlet more than 2800 feet farther east than the beach on Bone Island, before it curved abruptly to its north-south seaward beach. The seaward facing beach was more than 1.9 miles long, and the length of the island from inlet to inlet was 2.25 miles. New Inlet at the south end of the island faced to the southeast, and was 1200 feet wide.

1853-1871. Changes had occurred to both islands by 1871. The seaward facing beach on "old" Wreck Island had retreated rather uniformly westward a distance of 650 feet and New Inlet had widened to 2300 feet. New Inlet faced northeast as a consequence of the retreat at the south end of "old" Wreck Island. At the north end of "old" Wreck Island, Bone Island had narrowed by 120 feet to a new width of 480 feet. The length of "old" Wreck Island from inlet to inlet had changed little, shortening by about 450 feet. The 1871 shape of the island is shown on Figure 63.

To the north, Bone Island had increased in length by more than 300 feet through growth of the northern sand spit. The beach along the inlet channel was now 1.25 miles long. Beach retreat on Bone Island had the effect of rotating the island counterclockwise. Retreat was zero at the south end of the island, 540 feet near the middle of the island, and 925 feet near the north end. Retreat was accomplished by migration of the island, because the width of the sand spit remained about the same. The beach was no longer straight, but was hollowed gently in the middle of the island. With the westward migration of the island, and some retreat of Cobb Island, Sand Shoal Inlet had turned to face south southeast and widened by 650 feet to a width just less than 3000 feet.

1871-1911. The hydrographic survey of 1911 showed that Bone Island had been joined to Wreck Island to make a single island 3.2 miles long, inlet to inlet. This represented a net loss in length of 0.4 mile and most of this loss had occurred at the south end of the island, where the island had been shortened by 0.25 mile. The remaining decrease in length was due to bending of the island. New Inlet had increased in width to 3800 feet and turned easterly to face east northeast. Sand Shoal Inlet at the north end was still facing south southeast, but had increased in width to 4000 feet as a consequence of the shortening of Cobb Island, and the continued rotation of the north end of Wreck Island.

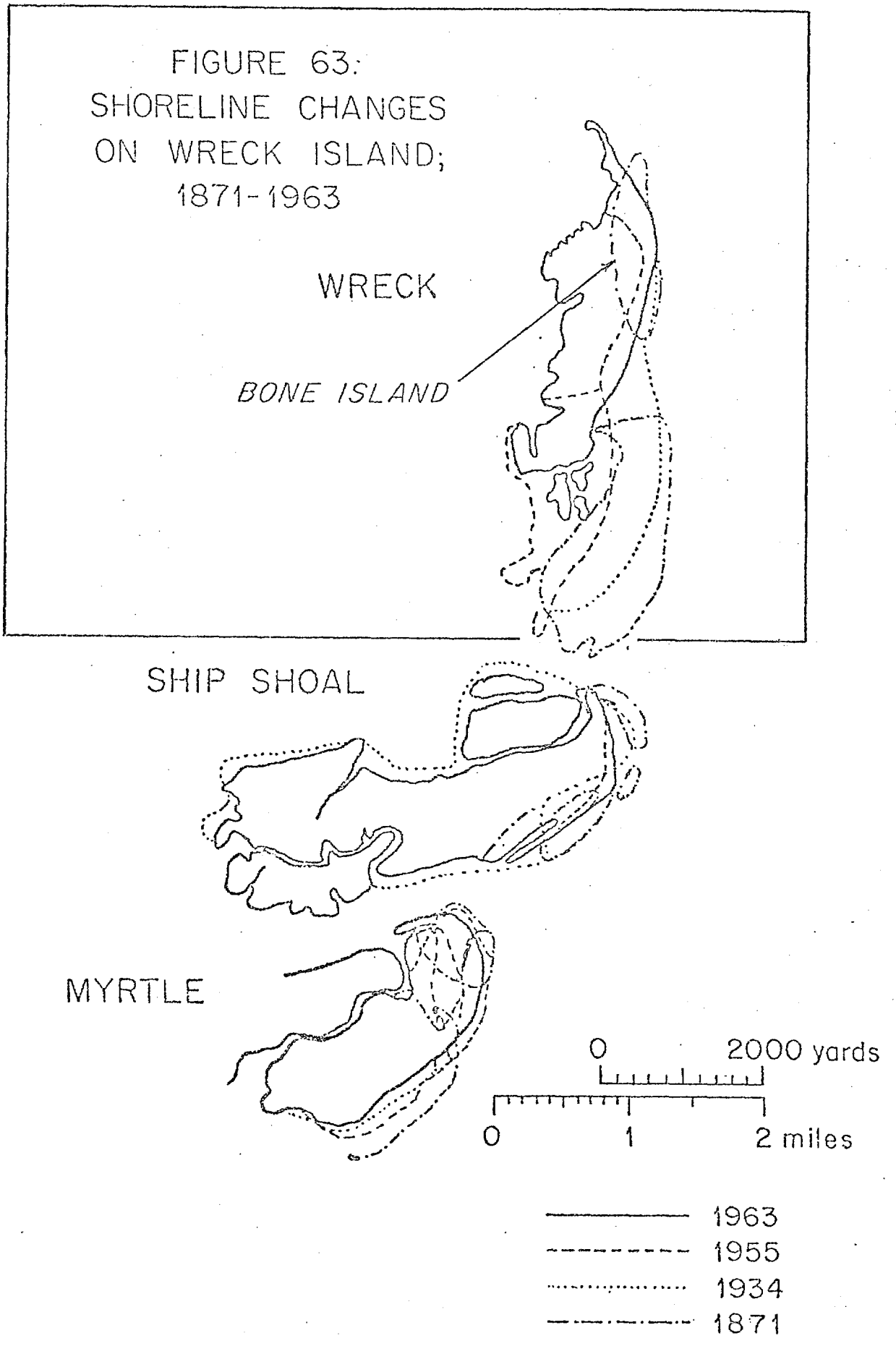


FIGURE 63: SHORELINE CHANGES ON WRECK ISLAND; 1871-1963

The beach along the newly lengthened Wreck Island was irregular. There were bulges where the older island's seaward beaches had been, and an indentation south of where Bone Island Inlet had been located. Beach retreat of the "old" Wreck Island portion of the island had been about 1830 feet along the northern half, but increased to 2700 feet near the southern end. The southern end of the island had curved toward the southwest. This can be seen in Figure 64.

Where Bone Island Inlet had filled in, the beach on the new island had advanced 630 feet to partially remove the former strong indentation at this location. The indentation had actually shifted about a half mile to the south of the former inlet due to erosion of the bulging north end of the "old" Wreck Island. The beach for 2000 feet north of the position of Bone Island Inlet remained in the same position, but north of that it advanced, reaching a maximum of 600 feet at a location 3100 feet north of the old inlet. North of there, beach advance diminished to the north end where the tip of the sand spit remained essentially unchanged.

1911-1942. The 1942 topographic maps reveal that the processes of change on Wreck Island had been continuing, and this was borned out by the hydrographic charts of the intervening years as Figures 63 and 64 indicate. The 1942 topographic maps show that the island changed little in length from inlet to inlet (the change being on the order of 150 feet increase in length). The irregularities of the beach had become more pronounced, but smoother. A prominent bulge was located midway along what had been Bone Island, and a second was located midway on what had been Wreck Island. Both ends of the island were bent westward from the trend of the island, and a broad gentle indentation lay between the bumps. At the north edge of the northern bulge, an ephemeral inlet had broken through the sand spit, and the sand spit had been reduced to little more than a broad sand bar running north northwest along the inlet opening.

In spite of a bulging beach, the southern end of the island had retreated westward by an average of 1200 feet and was still curved to the southwest. Northward to the old inlet, retreat averaged 900 feet, but rapidly declined to zero north of the old inlet where accretion began. The northern bulge in the beach was more than 0.5 miles long and within it the beach had advanced an average of 200-300 feet. However, at the north end of the bulge, where the ephemeral inlet was located, the advance of 200 feet rapidly reversed to a loss of 900 feet. Along the narrow sand spit north of the inlet, retreat rapidly increased from 900 to 1800 feet.

By 1942 a sand spit had grown at 90° to the beach at the south end of Wreck Island to create a narrow dangling appendage to the island. The facing of New Inlet, because of the appendage, was northeast, and the inlet was 3150 feet wide. If one discounts the sand spit appendage, as the sea obviously did in ensuing years, the inlet had increased in width to 4300 feet. Sand Shoal Inlet at the north end of Wreck Island had also increased in width, from 4000 feet to 6000 feet. Most of this increase in width was due to the reduction in width of the sand spit at the north end of Wreck Island, and to the 900-1800 feet migration of the sand spit to the west. Cobb Island lost a little of its length to help widen the inlet.

1942-1949. The 1949 aerial photos of Wreck Island show that the processes of change were continuing still. The northern sand spit had become reestablished and the 1942 ephemeral inlet had been closed. The rebuilt sand spit had grown until its northern end lay opposite the west end of Little Cobb Island. Little Cobb Island (a newly formed island) had grown westward during this time period. The extension of these two sand prominences framed the inlet opening to Cobb Bay, and the south end of Cobb Island fronted against Northeast Channel at the inlet, and not against the main channel. The width of the inlet from Cobb Island to the sand spit on Wreck

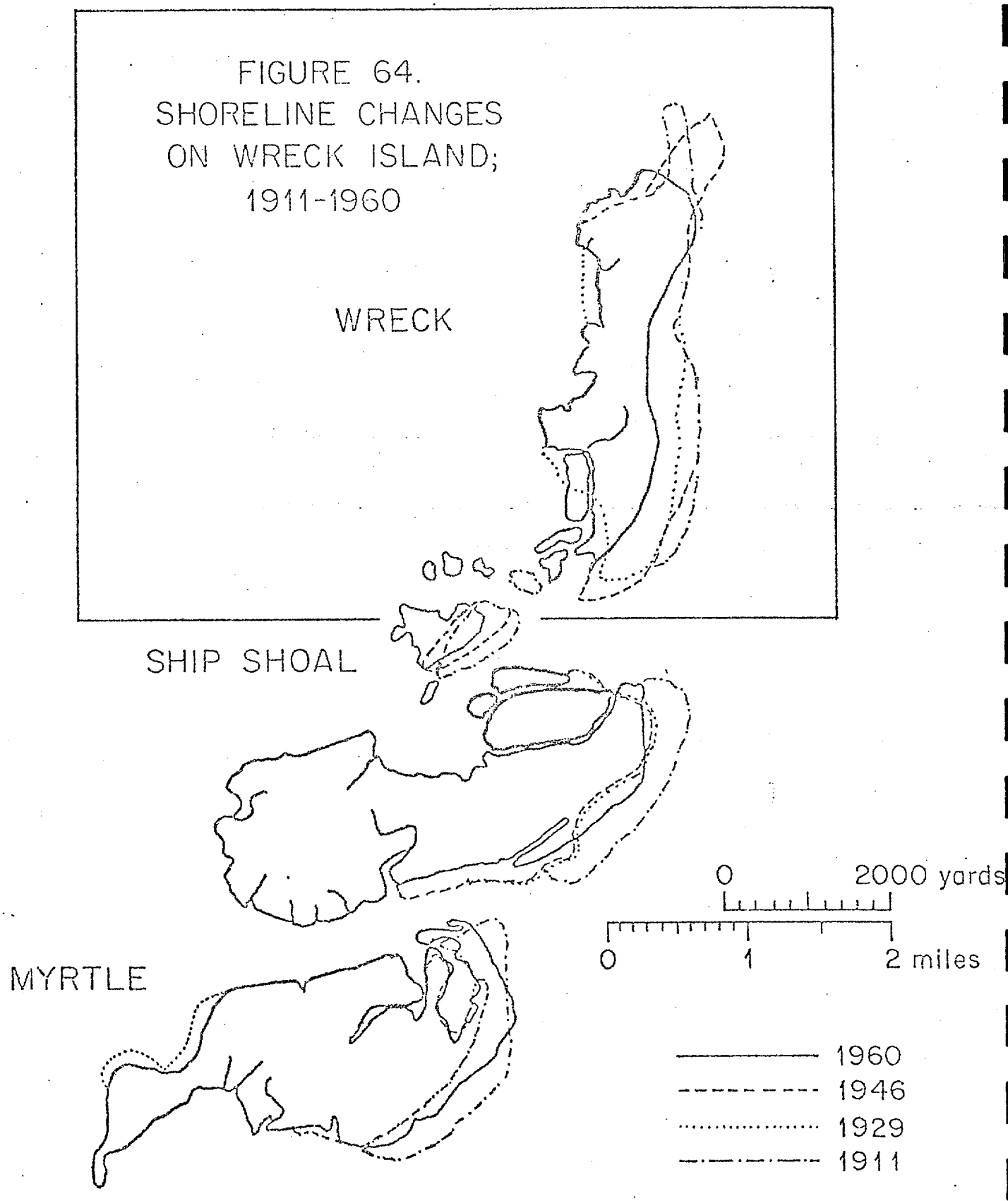


FIGURE 64.
SHORELINE CHANGES
ON WRECK ISLAND;
1911-1960

Island had decreased from 6000 feet to 4860 feet. The main channel inlet opening between Little Cobb Island and the tip of Wreck Island was only 2165 feet. New Inlet at the south end of Wreck Island had increased in width from 4320 feet to 4850 feet and turned to face nearly to the east. From sand spit to sand spit, the island was now 3.6 miles long, but discounting the dangling southern sand spit, which had rotated westward, the length was only 3.0 miles. Growth of the northern sand spit was mostly responsible for a 0.4 mile increase in the length of the island. The beach along Sand Shoal Inlet's seaward channel was continuous in a gentle curve. The earlier bulges in the beach were still apparent, but the hollow between them had partially filled in to make a smoother shoreline. The island's beach was beginning to assume a bend between that portion controlled by the inlet channels and that portion under the influence of waves and ebb tide delta processes. The length of the beach had increased to 3.7 miles.

The rebuilt northern sand spit had grown on the inlet side to reach a width of more than 875 feet. South of the sand spit, where the 1942 inlet had closed, the beach had advanced to line up with that further south on the island. South of the ephemeral inlet (.35 mile), the bulge had retreated more than 300 feet to reduce the prominence. At the beach "hollow" produced by erosion south of the location of the former Bone Island Inlet, the beach had advanced 570 feet to produce a straighter beach. However, the "hollow" continued to exist, having moved further south, where retreat of the beach reached 130 feet. Where the southern bulge had been on "old" Wreck Island, beach retreat reached 360 feet and the bulge was reduced. To the south, near the tip of the island, retreat declined to 200 feet. Averaged along this portion of the island, retreat was about 200 feet.

1949-1968. In the interval between 1949 and 1968, the sand spit at the north end of Wreck Island experienced great changes. Prior to 1955, an inlet had opened near the base of the sand spit at the north edge of the marsh behind the island, and this inlet remained open until sometime after March 1960. During this time there was no sand spit. An area of shoals and sand bars occupied the location of the sand spit. However, the sand spit reformed, and the ephemeral inlet closed during 1962, and by 1968 the sand spit occupied a position east of its location in 1949. The length of the sand spit in 1968 was also greater than the length in 1949, by 0.35 mile. In 1968 the sand spit averaged 980 feet in width, but reached a width of 1450 feet near the north end. Sand Shoal Inlet was again framed between the north end of the sand spit and the west end of Little Cobb Island. The inlet width was 2000 feet. The south tip of Cobb Island had retreated, and the opening between there and the north end of Wreck Island had increased from 4860 feet to 5140 feet.

By 1968, erosion of the south end of Wreck Island, had removed 1230 feet of the island. Comparable growth of Ship Shoal Island had allowed the opening of New Inlet to shift about 1200 feet in a northwesterly direction without altering either the facing or the width of the inlet since 1949. The loss of length at the south end of Wreck Island was more than made up by gains at the north end of the island, so that the 1968 island was 3.1 miles long from inlet to inlet. However, smoothing of the island's beach front reduced beach length by 0.5 mile to 3.2 miles. The island's beach curved smoothly from the south end into the inlet opening, and then recurved slightly beyond the opening to form a shallow depression in the beach line near the north end of the island.

Beach retreat was limited to the southern third of the island. In addition to the accretion of the sand spit at the north end of the island, the beach along the mid-portion of the island, facing the sea, grew seaward by up to 112 feet for a distance of 0.75 mile. Most of the beach between this area of accretion and the sand spit remained unchanged. This is the section of beach where the island bends toward the

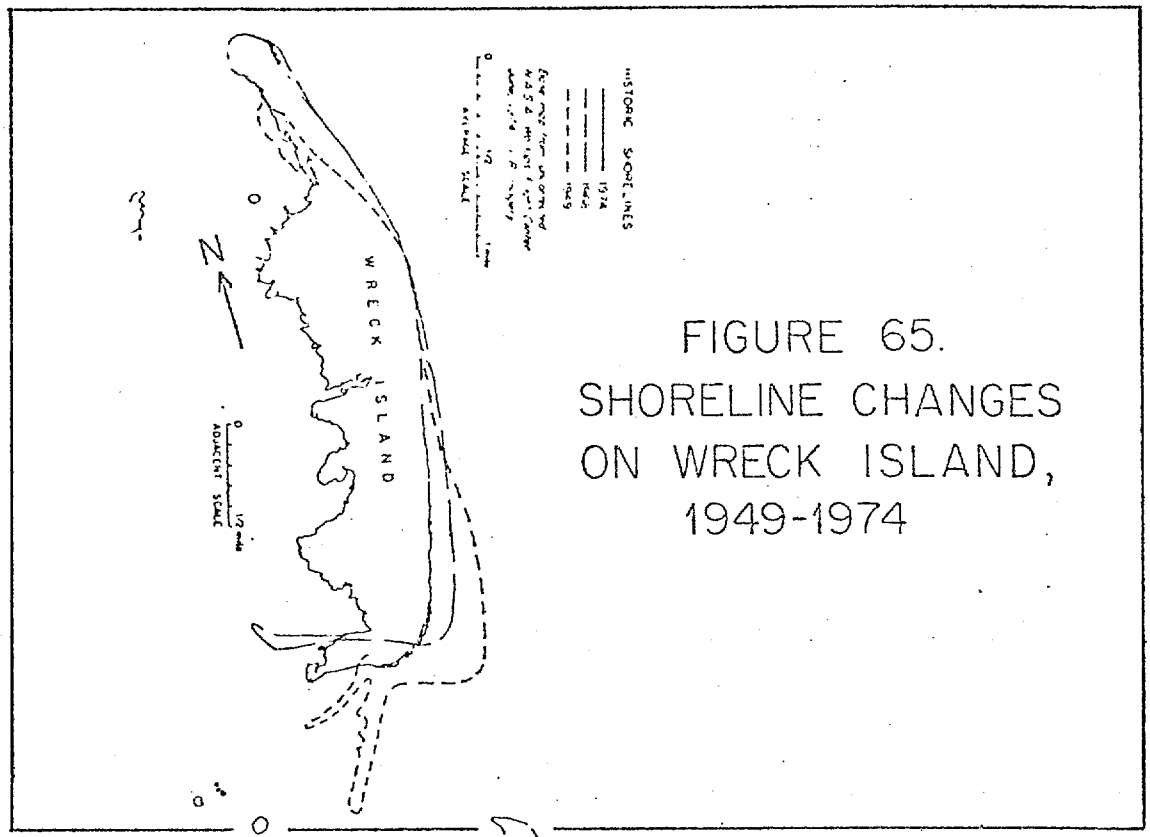
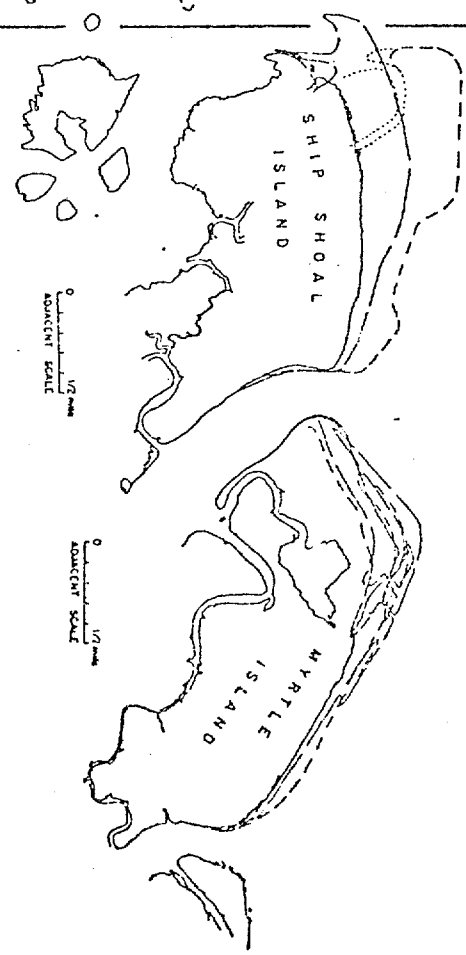


FIGURE 65.
SHORELINE CHANGES
ON WRECK ISLAND,
1949-1974



the inlet. Where retreat did occur along the southern half of the island, it increased quickly from nothing to more than 600 feet, and then more gradually to 955 feet at the south end of the island. Average retreat was about 675 feet.

1968-1974. Between 1968 and 1974 retreat of the seaward beach continued, and affected all of the beach from the bend at the inlet to the southern end of the island. Retreat reached a maximum of 660 feet at the south end of the island, and was between 500 and 600 feet along most of the southern half of the island. It fell off to nothing at the bend in the island. Averaged retreat was about 550 feet. The south end of the island increased in length by 800 feet to bring the length of the island up to 3.25 miles between the inlets, and about 3.5 miles along the beach. North of the bend in the island there was little change in the position of the beach, except for some beach adjustments near the inlet opening.

IV. SUMMARY

The most striking observation that can be made from this shoreline analysis is that the two halves of Wreck Island have behaved in very different fashions during the 121 year observation period. The northern portion of the island has moved around a lot but has not really gone anywhere. The sand spit which forms the northern quarter of the island has done most of the moving, even disappearing at times, but in 1974 the beach on the sand spit lay only 750 feet west of the beach near the tip of Bone Island in 1853. If this is expressed as an annual rate of change we find that the spit has shifted west at a rate of 6.2 ft./yr. near its tip, but at the base against the marsh, the 1974 shoreline is less than 200 feet west of the 1853 shoreline of Bone Island, and retreat here has been at a rate of 1.6 ft./yr. Changes have been minimal for a mile south of the base of the sand spit, to where Bone Island Inlet has been, and accretion has exceeded retreat so that the 1974 beach stands slightly east of the 1853 beach. This whole portion of the island is under the influence of inlet processes, and quite clearly the stability of the channel of Sand Shoal Inlet during this time period is reflected in the stability of this part of the island.

In sharp contrast, the southern half of the island has retreated at a rapid rate, and diminished in length as well. At the south end of the island the sea has steadily cut away 3900 feet of barrier island, and all of the marsh behind it. The 1974 beach curves around the cut-off marsh in a many fingered sand spit. The average annual loss of length has been 32.2 ft./yr. Along the island south of the former Bone Island Inlet, retreat has been rapid, and steady to the present. The northern two-thirds of this half of the island has retreated on average of 4800 feet east of the present end of the island, and even more to the south where the island is now gone. The average annual retreat at the present south end of the island has been 51.7 ft./yr. Wreck Island had a broad continuous marsh behind it in 1853. The marsh behind the southern half of Wreck Island is all that remains of that larger marsh area, and some of the present marsh is new.

V. DISCUSSION OF SHORELINE CHANGES

During this study occasional references have been encountered that have cited reportedly high rates of erosion during the stormy latter part of the 1800's. For islands previously described it has been seen that though erosion rates have varied through time, and with major storms, sites of rapid erosion could quite readily be traced to processes that were occurring in response to some change in the system, and were not literally assignable to a greater frequency of storm activity during some time period. Wreck Island is a case in point. It has experienced severe erosion throughout the time period. Table 1 compares retreat and rates of retreat

of the southern portion of Wreck Island for different time intervals. Clearly, the last quarter century has seen the highest erosion rate on Wreck Island, yet that period is not noted for its storminess. On other islands, both north and south of Wreck Island, the last quarter century has seen a general decline in the rates of beach erosion.

The explanation for the great and long lasting erosion of the southern end of Wreck Island is unknown, and could be the subject of further investigation. Unlike other reaches of this coastline, there have been no recent hydrographic surveys in this area. The hydrographic survey of 1921 was the latest survey found for use in this investigation. Without adequate bathymetric data, to know what has been happening offshore, or additional information from other sources, it would be difficult to substantiate any explanation.

TABLE I

Rates of Retreat for the Southern Part of Wreck Island in Various Time Intervals

Time Interval	Number Years	Retreat (ft.)	Rate (ft./yr.)	Events
1853-1871	18	650	36.1	Great Hurricane of 1865
1871-1911	40	1830	45.8	The "stormy" late 1800's
1911-1942	31	900	29.0	Great storm of 1933
1942-1949	7	200	28.6	The Great Atlantic Hurricane
1949-1974	25	1226	49.0	The 1962 Ash Wednesday Storm

However, some observation can be made, and a hypothesis drawn from them. The name New Inlet implies that this inlet has opened within the historical period of modern man's occupation of the islands. The date of that opening would be useful information. The idea that it is new, implies that Wreck and Ship Shoal Islands were formerly a single island. New Inlet has widened to more than 4800 feet and migrated a similar distance since 1853, as both Wreck and Ship Shoal Islands have retreated rapidly. Since 1853 New Inlet has not been a deep inlet (18 feet is the maximum channel depth shown on the hydrographic charts). The inlet channel has shifted over distances as great as the inlet opening. The 1949 aerial photos show the thalweg (the deepest threat of a channel) of the channel lying against the north end of Ship Shoal Island. The 1973 aerial photos show the thalweg lying against the south end of Wreck Island. That is a shift of more than a mile in 24 years. Comparison of those photos shows a large number of changes in channels and deposits within the bay and inlet area. There is a marked increase in flood tide deposits well back into the bay indicating that large volumes of sand are being trapped at this inlet, and thus removed from the longshore drift system. A system of bars has built off the north end of Ship Shoal Island, allowing flood tide deposition to occur in the inlet opening north of Ship Shoal Marsh. The pattern of the flood tide deposits in the 1973 photos indicates flood tide flow toward the south end of the bay, and the channel system that has developed agrees with that.

It can therefore be advanced as a hypothesis that New Inlet formed during retreat of a formerly longer barrier island, probably by tapping a large marsh canal or breaching into a former narrow bay. The new inlet disrupted tidal circulation in the marsh and to the bay behind it; particularly for the flood tide cycle when the shorter distance to the bay would allow the middle and late portion of the flood phase to flood the bay through this inlet faster than it could be flooded through Sand Shoal Inlet and Ship Shoal Inlet. This situation, combined with the continued shallow nature of the inlet, would enhance inlet trapping of sand on the flood tide, and discourage sand removal on the ebb tide. This situation, combined with the continuing erosion of the south end of Wreck Island, and the northern half of Ship Shoal Island. If this hypothesis is correct, the inlet should eventually choke itself with flood tide deposits, and close. But, the unknown element lies offshore in the configuration of the sea bottom. In 1921 the ebb tide delta of Sand Shoal Inlet lay seaward of Wreck Island and the northern portion of Ship Shoal Island. A small regular semi-circular ebb tide delta lay off New Inlet, with a depth of less than 10 feet of water above it. This delta was superimposed on the flank of the south lobe of the ebb tide delta from Sand Shoal Inlet. In the absence of knowledge of the changes in these two ebb tide deltas over the last 54 years, it is impossible to determine with any degree of certainty what the future holds for Wreck Island and New Inlet.

VI. GEOLOGIC DESCRIPTION AND INTERPRETATION

Discussion of the geology of the area west of Wreck Island will be deferred at this time, but will be included in the section of Smith Island. The descriptions and discussion of the geomorphology and geology given below are done in reference to the Geological Map of Wreck Island provided with this report.

The older geomorphic units of Wreck Island are found in the marsh west of the upland. At the very north end of the marsh, just south of the base of the sand spit there is a large vestigial tidal channel that is truncated by the barrier island sand deposits, but can be traced to the bay at the other end. This channel does not relate to any inlet or tidal canal shown on the maps and charts used for this study. About 1000 feet south of this channel there are two other vestigial tidal channels that merge about 500 feet west of the upland to form a larger channel that is truncated at the upland deposits. Inside the fork where this larger channel splits there is an ancient inlet island, and where the northern branch of the channel split again, farther to the west, another ancient inlet island is found within that fork. Between this ancient channel system and the large ancient channel previously described, there is a large ancient inlet island with numerous ponds that extends west to form the north end of the marsh. At the south edge of the southern of these two ancient channels there is a beach ridge extending westward into the marsh, and a vegetated sand flat extends southward from that between the marsh and the upland beach ridge unit. The sand flat and beach ridge are the north end of an ancient barrier island that extended off in a southeasterly direction, and the ancient channels are tidal channels inside of an ancient inlet.

About 0.4 mile north of the south end of Wreck Island there are a number of areas marked with the beach ridge symbol. These areas are shown near the western edge of the marsh area, but within the marsh. At the north end of these units there is a large vestigial tida canal about 500 feet wide. This canal is truncated by barrier island sand deposits at the southeast end but runs to the bay at the northwest end. The margins of the canal are easily recognized on the IR imagery, and they are visible, but not obvious, on the black and white aerial photos. There is no evidence of this channel on the maps and charts used for this study, and it is interpreted as an ancient feature of the marsh. Its size and orientation would indicate that it formerly drained a large marsh area to the southeast. The beach ridge units south of this ancient tidal canal are interpreted as being correlative in time, and therefore, also

ancient. The origin of the ridges, and what has been interpreted as a sand flat surrounding them, is unclear. The relationship of the ridges to the sand flat suggests that their origin might have been as a storm berm or low dunes behind a beach formed on the marsh by storm waves in the bay. The deep tidal channel offshore in the bay would have permitted larger waves to develop. Such a beach and dune ridge can be seen on Chimney Pole Marsh, and other modern marsh areas, where storm waves develop in the deep channel waters inside inlets. Similar, but smaller, features were photographed from the air in July and September 1975 along the margins of bays with deep channels near the northwest edge of the marsh. This does not rule out the possibility that the ridges may be of ancient barrier beach origin, but the explanation offered fits the existing evidence better. Much of the marsh area is interpreted as ancient, with younger areas readily discernable among the older features.

The remaining portions of Wreck Island are historical in origin. The remains of the southern half of Bone Island are the oldest of the modern features. The southern sand spit of Bone Island extends into the marsh in a southwesterly direction at the mid-point of Wreck Island.

The 1871 shoreline along the eastern and southern sides of Bone Island can be recognized in the beach ridges and is shown on the geologic map. This shoreline is truncated northward at the modern beach. Westward of where this shoreline is truncated, the 1871 shoreline of the western side of Bone Island can be recognized, and it too is shown on the map.

These two segments of the 1871 shoreline outline the base of the northern sand spit of Bone Island. Midway along the portion of the beach ridge unit that represents Bone Island will be found two short beach ridge lines that angle west from the trend of the Bone Island ridges. These ridges and the portion of the beach ridge unit associated with them are the recurved north end of the ancient barrier island that is truncated by the Bone Island deposits.

East of the 1871 shoreline a portion of the 1911 shoreline can be seen. The portion of the beach ridge unit between these shorelines accreted in that time interval. The north end of the Bone Island deposits are cut off by a 1942 shoreline, and at the south end of these deposits another segment of the 1942 shoreline scallops into deposits that were built onto Bone Island Inlet at the north side. Beginning with the narrow beach ridge and the active sand dune area behind the southern portion of this 1942 shoreline, and running south, the deposits of the barrier island all date from the time of that shoreline, or a later time. All of the active sand dune area shown has been overwashed and rebuilt one or more times.

At the middle of the island, in the hollow cut by the 1942 shoreline, there is a segment of the 1962 shoreline. On the island, at the south end of this 1962 shoreline there is a strange berm-like feature, three to four feet high and as wide as a roadway, that is composed mostly of oyster shells (McCaffrey, 1975, personal communication). This feature is about 900 feet long, and on the IR imagery it can be seen to splay out in spit-like extensions at the north end. Because the feature was not examined when the island was visited in September 1975, it is not possible to comment on its origin, but its presence and association with the 1962 shoreline should be included here.

At the north end of Wreck Island the present sand spit has grown since 1962 when an ephemeral inlet at its base was closed. The ephemeral inlet had opened in the early 1950's and first appeared on the 1955 hydrographic chart. Its position is indicated on the geologic map.

VII. GEOLOGIC HISTORY AND INTERPRETATION

Not much geologic history can be drawn from the scanty ancient geomorphology that remains on Wreck Island. There is evidence for an ancient inlet north of an ancient barrier island in the marsh at the north end of Wreck Island. In the marsh at the south end of the island there is evidence of an ancient marsh and canal system that extended far to the south and east. Together, these two sets of ancient features are related to a barrier island that ran southeastward from the position of the remnant near the north end of the marsh behind Wreck Island. It is most probably that this ancient barrier correspond in age with similar ones found on other islands, and represents the position of the barrier chain before a period of progradation. Certainly, the 1853 charts show that there was more than a mile of marsh seaward of the ancient tidal canal at the south end of Wreck Island, and that ancient tidal canal was not shown on those charts. The modern erosion of that marsh has destroyed any further evidence of the earlier history of Wreck Island.

SHIP SHOAL ISLAND AND GODWIN ISLAND

I. DESCRIPTIVE GEOGRAPHY

Ship Shoal Island is the ninth island from the north end of the Virginia Barrier Island Group, and the seventh island from the north in the area covered by this study. Godwin Island is the name given to the western portion of the marsh on the landward side of Ship Shoal Island. The tidal canal which clearly divided Godwin Island from Ship Shoal Island until the 1940's has since filled in, leaving no clear physical boundary between the two islands. Ship Shoal Island is separated from Wreck Island on the north by New Inlet, and from Myrtle Island to the south by Ship Shoal Inlet. Ship Shoal and Godwin Islands are located due east of the town of Cape Center on U.S. Interstate 13 on the mainland.

Access to the island is by boat, and except near high tide, should be made only by way of Main Ship Shoal Channel and Black Rock Channel because of the shallow depths in South Bay. Mockhorn Island, which lies west of Ship Shoal Island, blocks any direct route to the island by boat, and Main Ship Shoal Channel is the only deep channel that leads to the island. Main Ship Shoal Channel connects into Smith Island Bay, 2.5 miles from the mainland coast. At the mainland coast there are a number of landings and boat launch areas that can be reached from Virginia Route 600. East of the town of Townsend there are three private landings; Steelman's Landing, Bull's Landing, and Cushman's Landing. There are also two public landings on the Intracoastal Waterway southeast of Cape Charles Air Force Station; Dixon's Dock and another located on Raccoon Creek. Persons unfamiliar with this passage and the waters of Magothy Bay and Smith Island Bay would be well advised to hire the services of a local waterman to serve as guide.

Ship Shoal Island is the smallest island included in this study. It is 1.72 miles long, inlet to inlet, but along the curved beach the length is 1.85 miles. The width of the upland barrier island varies from a minimum of 500 ft. just south of the north end of the island to about 1500 ft. at the north end, and more than 2500 ft. at the south end. Including Godwin Island, the marsh area extends about 2.8 miles to the west southwest of the island with a north-south width that averages 1.15 miles. A small bay on the north side of the marsh breaks the regularity of the width of the marsh and serves to give an approximate division between Ship Shoal and Godwin Islands.

At the north inlet, Ship Shoal Island is 7.8 miles off the mainland coast, and at the south end the distance is 7.36 miles. At its farthest point from the mainland, the seaward beach is 8 miles out. The orientation of the island follows more closely that of the other islands to the south, and to the north of Cobb Island. However, the northern third of the island curves toward Sand Shoal Inlet and forms part of the indentation that Wreck and Cobb Islands make in the seaward face of the barrier chain. The trend of the southern shoreline of the island is more parallel to the main trend of the barrier chain.

In the area to the west of the island, between the island and the mainland, the mass of Mockhorn Island divides the bay area and isolates Ship Shoal Island from the mainland. South Bay occupies the area between Ship Shoal and Godwin Islands, and Mockhorn Island. No channels cross this shallow bay, which limits boat access to the island. Black Rock Channel connects from Main Ship Shoal Channel to New Inlet around the west edge of Godwin Island and the north side of Ship Shoal Island. This channel permits access to oyster houses on Godwin Island, to the marsh areas, and to the south end of Wreck Island. Near the north end of Ship Shoal Island there are also a number of small marsh islands established on flood tide deltas inside of New Inlet.

Along the western edge of South Bay, Mockhorn Island runs from north to south. Mockhorn Island varies from a mile, to more than two miles, in width in this area and consists almost entirely of marsh. There is a low, sandy, partially forested ridge following the axis of the island near the middle, and other low sandy ridges within the marsh. A point of interest to this section on Mockhorn Island is a man-made ditch, Stringer's Ditch, which has been dug through the main sandy ridge of the island to connect large tidal canals on either side of the ridge. This has obviously been done to provide small boat passage, across Mockhorn Island between Magothy Bay and South Bay. it has also connected two previously isolated tidal basins. The construction of the ditch is known to have occurred between 1942 and the beginning of 1949, but the exact date is not known.

The north end of Magothy Bay lies between Mockhorn Island and the mainland. The bay averages about 1.8 miles wide and is deeper than South Bay. Small tidal flats are shown around the margin of Magothy Bay. At the very north end of the bay, marsh areas from the mainland and from Mockhorn Island reach out to close the bay except for Mockhorn Channel which connects through to Mockhorn Bay to the north. The Inland Waterway passes through this channel into Magothy Bay. The mainland coast lies behind the narrow marsh on the west side of this bay.

II. PHYSIOGRAPHIC DESCRIPTION

In the western half of the area described with Ship Shoal and Godwin Islands, the physiographic units are the southward extensions of the units previously described with Wreck Island. Those descriptions are referred to in the following text where they are applicable, and significant changes are noted.

The mainland coast in this area still coincides with the Mappsburg Scarp and the beach at its base. However, the steepness of the Mappsburg Scarp diminishes rapidly along this 2.5 mile length of coastline, and west of Ship Shoal Inlet it begins to lose its identity as an escarpment. The former shoreline found a half mile off shore at Oyster, lies a quarter mile off the mainland shore west of Ship Shoal Inlet. The only evidence of it on the topographic map is indirect; in the form of influence on the pattern of thelarger tidal canals in the marsh between the mainland and Magothy Bay. However, on the black and white aerial photograph the linear pattern of this old shoreline can be readily followed through the marsh area. The ridges that run along the length of Mocknorn Island are most strongly developed in this section. The main ridge lies about a half mile east of Magothy Bay, and is clearly shown on the U.S.G.S. Topographic Map. This ridge is up to a quarter of a mile wide and forested on the higher elevations. The topographic map shows lesser ridges lying both east and west of the main ridge. East of the main ridge, these lesser ridges continue to the shoreline of South Bay, into the marsh that extends east around the southwest corner of the bay and on out to White Perch Channel.

Godwin Island displays no noticeable physiography. It is a marsh island. Along the northern shore there is some higher ground in the marsh, where elevations reach 24 to 30 inches above mean sea level. Large areas of Godwin Island are occupied by shallow ponded areas of mudflats, and most of the marsh contains smaller areas of pond or mudflat (characteristic of low, young, or drowned, marsh areas). Ship Shoal Island has two physiographic provinces, a marsh area that is continuous with Godwin Island, and the upland barrier island deposits. In the marsh area near the

north end of the island, there are four roughly circular ponded areas or depressions. These are interpreted as unfilled portions of former large tidal channels. Near the north end of the marsh, and near the middle of the island there are two broad, low, crescent shaped ridges with ponds in them. Near the west edge of the marsh, at the northeast end of the small bay, there is another short low ridge unit oriented nearly east-west. These ridge units are all interpreted as old inlet deposits. Near the middle of the island a remnant of an old beach ridge stands in the marsh. South and southwest of this, other remnants of that beach ridge occur.

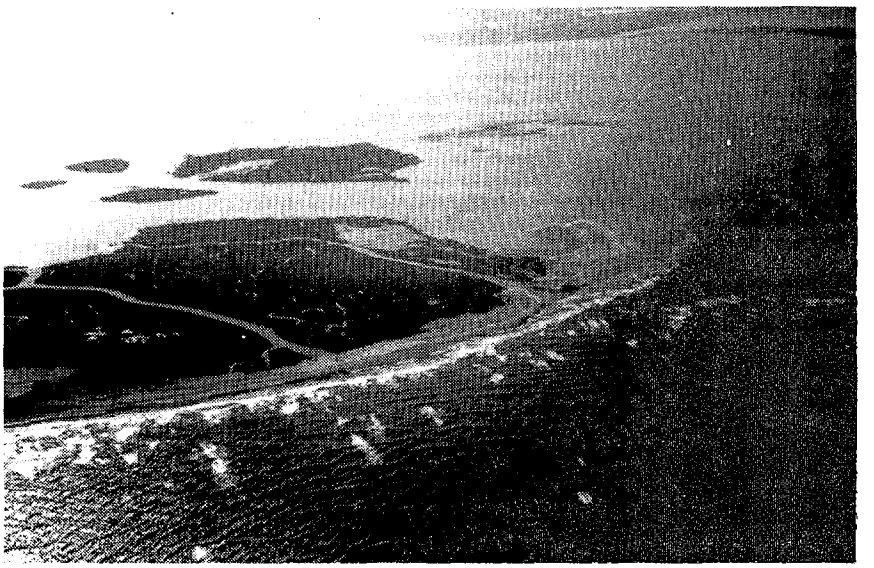
The upland barrier island deposits are nearly all found at the south end of the island. Here a large northeast trending beach ridge unit begins at the edge of the marsh and extends northeast to the shoreline. At the south end of the island a small dune field is established on a sequence of recently formed berms. The ridges in the beach ridge unit are all truncated where they meet the seaward facing beach, and they do not extend north of the midpoint of the island. Along the northern half of the island, the beach is being actively washed back and the upland barrier deposits consist of overwash fans, new dunes, and a recent berm (see Figure 66a). Two east-west marsh canals have been overrun by the retreating beach, and these canals are visible seaward of the beach where they run through extensive peat outcroppings. This is shown in Figure 66b. Ephemeral inlets open and close at the ends of these canals (one appears at the northernmost canal, Figure 66a). At the north end of the island, along New Inlet, the marsh has been overwashed and buried beneath a large overwash fan. Also, a former sand spit has been driven in over the north edge of the marsh to form a low beach ridge with a recurving sand spit at the west end of it. A new sand spit, which recurves west into the inlet, has formed at the north end of the island. Along the northern half of the island the active beach is narrow, and there are outcroppings of peat extending 125 to 200 ft. into the surf zone. Near the midpoint of the island the peat outcroppings end, and the active beach is a little wider. Only near the south end of the island the beach ridges also run back along the north shore of Ship Shoal Inlet for more than a mile, and accretion along the beach at the south end of the island carries well back into the inlet.

III. SHORELINE CHANGES

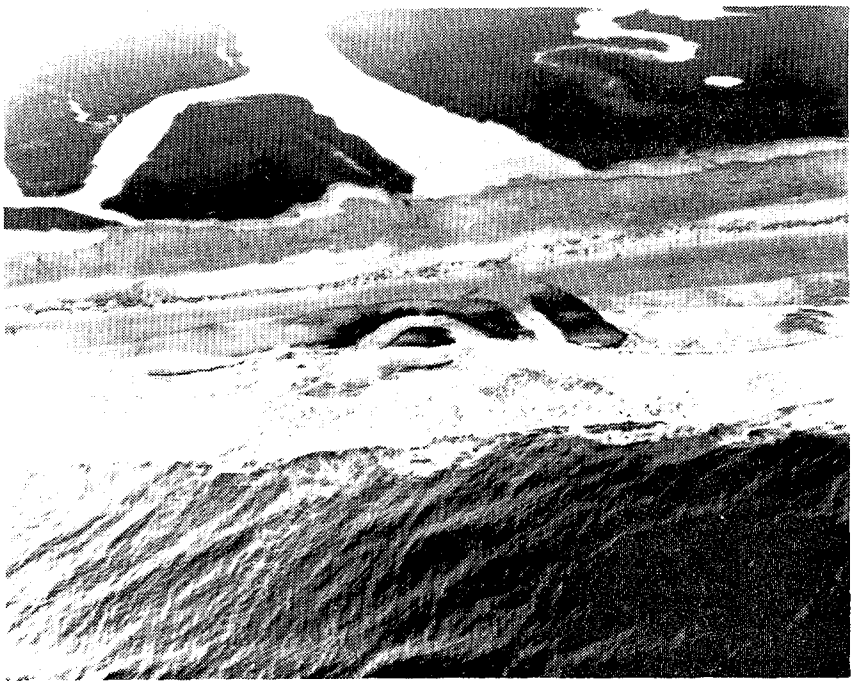
The effect of shoreline changes on Ship Shoal Island has been unlike that on any of the islands previously described in this study. The shape of the island has changed frequently and rapidly, whereas other islands have changed shape more gradually and more systematically.

The short length of this island contributes considerably to this pattern of rapid changes in the shape of the island. A change that affects only one portion of the island is immediately reflected as a change in the shape of the island. On longer islands, similar changes would have less effect on the overall shape. Another consequence of the short length of the island is the near absence of an ocean-front beach that is free of the effect of inlet processes. Almost the entire length of Ship Shoal Island is under the influence of the inlets at each end. Due to the absence of a reach of ocean beach, the role of a wave driven longshore transport system in shaping the island is reduced, which accentuates the role that is played by inlet processes.

However, something other than the short length of the island is also involved in the changes in shape of the island. If only retreat of the island and inlet processes were operating, then there should be some systematic character to the shape changes. There is no immediately apparent system for these changes as Figures 67



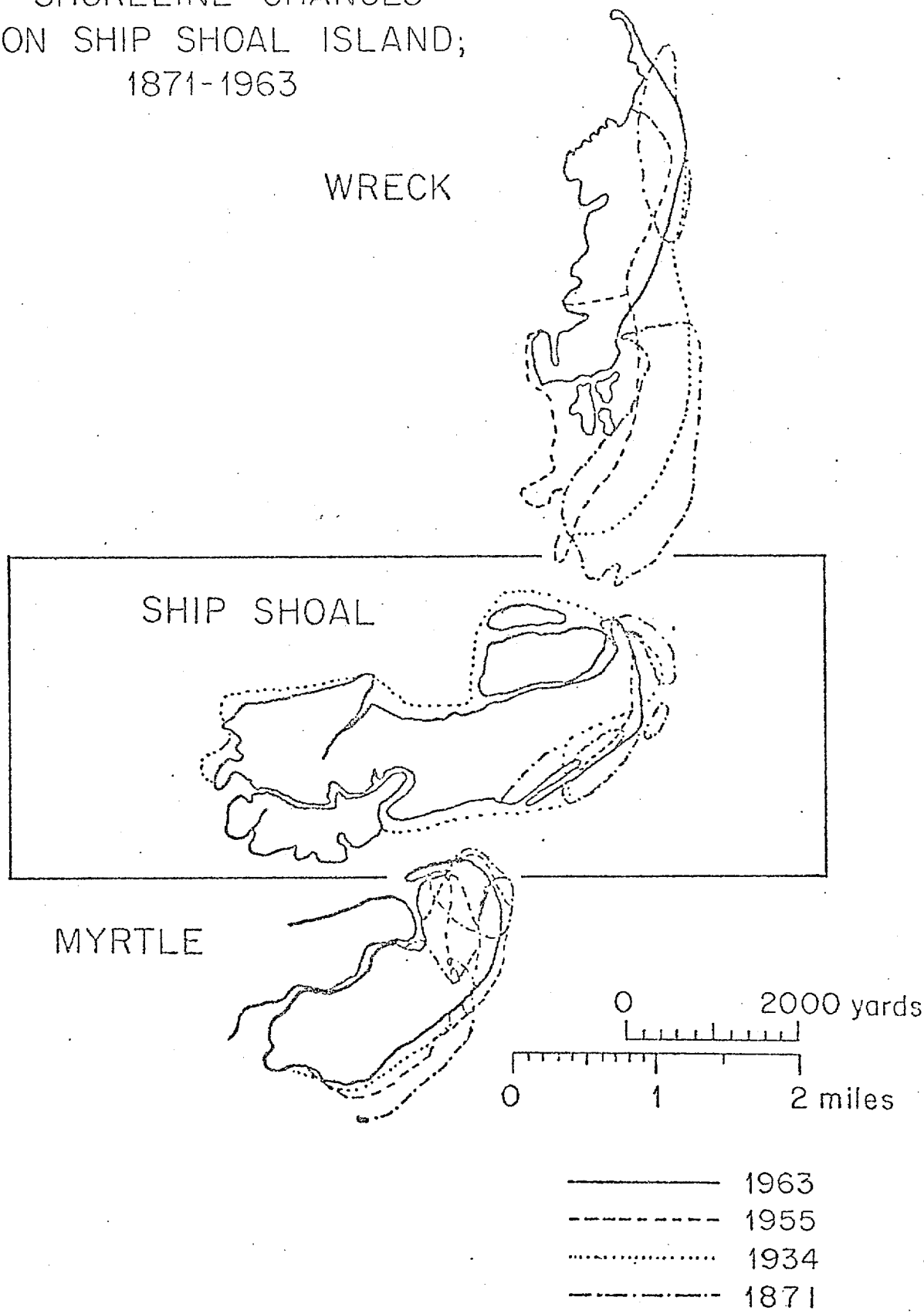
a. North end of Ship Shoal Island where beach retreat has been very rapid in recent years. Note peat outcrops in beach and truncated marsh canals. Flood tide deposits at New Inlet form line of small islands.



b. Close-up view of truncated marsh canal shown near center of photo (a). Retreat of the island at this location has exceeded 190 ft./yr. since 1963.

FIGURE 66: Northern Half of Ship Shoal Island

FIGURE 67.
SHORELINE CHANGES
ON SHIP SHOAL ISLAND;
1871-1963



and 68 illustrate. The pattern of shoreline positions is confusing and difficult to follow or interpret. Byrne's (1972) Historical Shoreline Positions Map shows seven shoreline positions on a single overlay that is even more difficult to follow. None of these presentations reveals any pattern for the movement of the shoreline. Only the shoreline changes of the last quarter century (figure 69) show any systematic shift, and that illustration is deceptive because the shoreline advanced and retreated again between 1949 and 1968. The additional factors involved in the shoreline changes are not revealed, or suggested by the standard presentation of data.

A. Tabular Presentation of Data

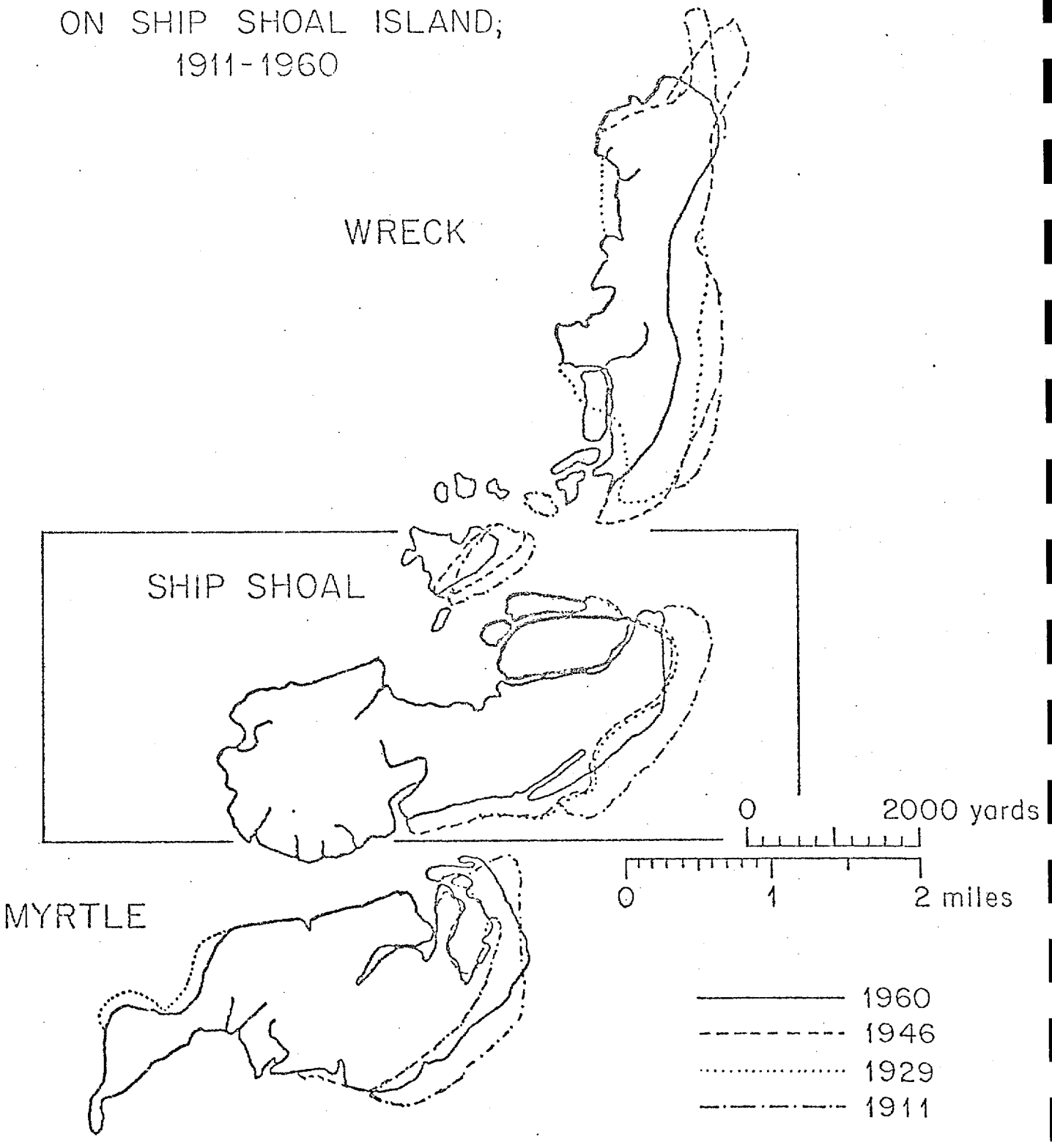
In the process of trying to understand the shoreline changes and to interpret them in terms of what was happening to the island, the data was organized in a different manner. Table II shows this data presented in a tabular form, or matrix arrangement. The table is arranged so that data for each observation period appears in a single column under the terminal date of the observation period. The columns are arranged with the oldest on the left hand column. Arrows and lines are used in the table to graphically present direction of movement of the shoreline, and the position or shape of features. The numbers shown in the table tell the magnitude of the change in feet. The changes given for any period are net changes during the period, and do not reflect reversals or variations that occurred during the period. Presented in this manner it is possible to scan any row in the table to determine what has happened at one location during the historical period of this study. Similarly, for any date, the changes down the length of the island appear in a single column that can be scanned easily.

A quick scan across any row in Table II reveals part of the difficulty with analyzing the changes. Retreat and advance have alternated along every section of the beach, but some sections have experienced two alternations, others three, or four. The north end of the island has lengthened, shortened, and sometimes shifted west. The facing and width of Ship Shoal Inlet have changed, but with no clear relationship to movements of the south end of Ship Shoal Island or the north end of Myrtle Island. Comparisons of one column to another indicates that in some time intervals one part of the island retreated, while another advanced. During other periods of time, the whole beach advanced or retreated as a unit, but not uniformly. Although Table II makes it easier to visualize the shoreline changes it, too, does not immediately reveal a pattern or explanation for the changes.

B. Bathymetric Data

It is only when Table I is used in conjunction with the offshore bathymetry that a pattern begins to emerge. Unfortunately, that bathymetry is not very complete. Hydrographic surveys (U.S.C. & G.S.) of the area were suspended after the 1921 survey. Earlier surveys were not always complete. The survey of 1852 defined the bathymertry of Ship Shoal Inlet and New Inlet. The 1870 survey redefined Ship Shoal Inlet, but only approached New Inlet. The 1911 survey did not include New Inlet, but did resurvey Ship Shoal Inlet. Lastly, the 1921 survey redefined the outer edge of the ebb tide delta at New Inlet, but it ignored the inlet channels. Altogether these surveys do provide enough data to verify that the shoreline changes on Ship Shoal Island are dominated by inlet processes. These surveys, together with the shoreline changes shown on the hydrographic charts, also provide strong evidence that the north end of Myrtle Island is part of the ebb tide delta at Ship Shoal Inlet.

FIGURE 68.
SHORELINE CHANGES
ON SHIP SHOAL ISLAND;
1911-1960



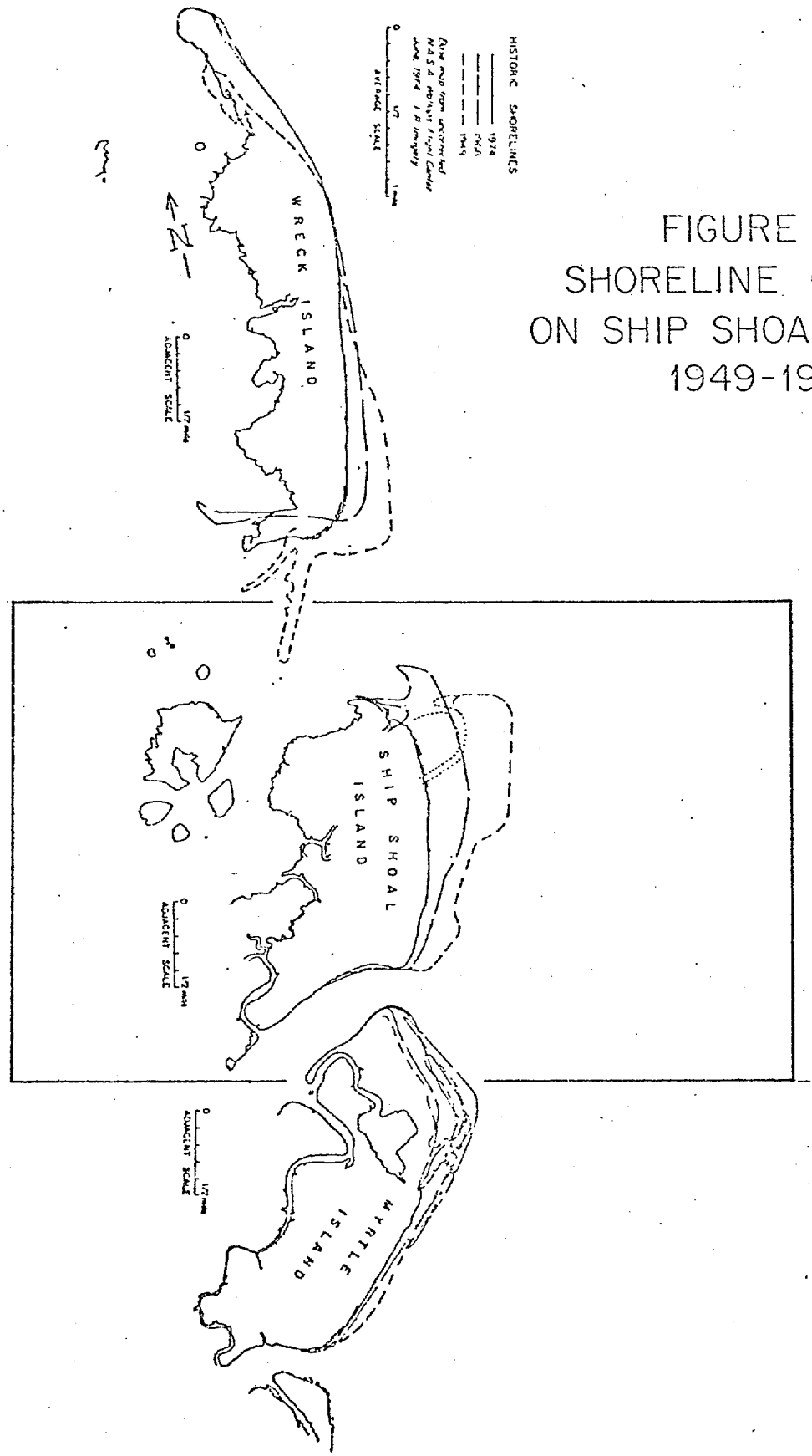


FIGURE 69.
SHORELINE CHANGES
ON SHIP SHOAL ISLAND;
1949-1974

ITEM OR POSITION ON ISLAND	1871	1911	1929	1955	1963	1968	1974	1975
NORTH END	↓ 1500	↑ 890	↓ 1450	↖ 1900	↓ 1330	↖ 1340	← 2000	←
SHAPE OF NORTH END								
NORTH END OCEAN BEACH		0	← 980	←	↗	↑ 8 3 0 → 530	↙ 1740 ← 1680	←
1/4 SOUTH	→ 1020	→ 450	← 980	→ 710	→ 444	← 800	←	←
1/2 SOUTH	0	→ 1100	← 1780	→ 533	→ 444	← 810	← 1160	← 350
3/4 SOUTH	← 870	→ 2133	← 1333	← 533	0	← 340	←	←
SOUTH END OCEAN BEACH	← 915	→ 25	← 1644	← 1200	0	→ 560	← 330	←
SOUTH INLET FACING & WIDTH	\ 2130	/ 3060	/ 1150	/ 2578	/ 2130	/ 1450	| 1214	|
NORTH END MYRTLE ISL.	0	← 1100	↗ 1650	0		↗	→	
PROCESS SUMMARY	BEGIN ACCRETION		RETREAT	O.S.BAR SOUTH 1/2	C.W. ROT.	C.C.W. ROT.	C.C.W. ROT.	C.C.W. ROT.

TABLE II

SHIP SHOAL ISLAND

Summary of shoreline changes; 1852–1975.

North is at top of page. Arrows indicate direction of movement. Lines show compass orientation.

Numbers are in feet.

1853-1871. The 1871 chart shows that the southern lobe of the ebb tide delta at Sand Shoal Inlet extended south past Wreck Island and curved landward to meet the beach of Ship Shoal Island about 1.0 mile south of the north end of the island. The chart also shows that New Inlet had a small, rectangular shaped ebb tide delta that was superimposed on the margin of the larger south lobe of the ebb tide delta at Sand Shoal Inlet. This smaller ebb tide delta only reached 0.6 mile seaward, but lay across New Inlet and the ends of the adjacent islands for 1.9 miles. The south end of this small ebb tide delta extended 0.5 mile south of the north end of Ship Shoal Island before it curved in toward the beach. At the south end of Ship Shoal Island, the ebb tide delta of Ship Shoal Inlet lay, fan-shaped, in front of the inlet. It had a radius of about two miles. At its northern limit, this ebb tide delta coalesced with the south lobe of Sand Shoal Inlet ebb tide delta. The two ebb tide deltas met about a mile south of the north end of Ship Shoal Island, and 0.5 mile off shore. Thus, in 1871, the entire shoreline of Ship Shoal Island had ebb tide delta deposits seaward of it, and was under the influence of those deposits and the processes that were building them.

The 1871 chart also shows a sand bar welded to the north end of Ship Shoal Island (Table II), and another short sand bar offshore just south of it. An offshore sand ridge (bar) began south of the short sand bar and paralleled the shore of Ship Shoal Island for its entire length, extending through the inlet opening to parallel the north shore of Ship Shoal Channel for 0.75 mile back into the marsh area. The sand bars and the long offshore sand ridge indicate that at the time of the 1871 survey, Ship Shoal Island was experiencing a period of accretion. Confirmation of this, and its extent, can be seen readily in the 1911 column of Table II. This period of accretion appears to have been initiated when the island's entire shoreline came under the influence of ebb tide delta processes. However, this gives no indication of what caused this to happen, nor does it explain the shoreline changes that occurred between 1853 and 1871.

To find an explanation for the shoreline changes prior to 1871, it is necessary to re-examine the charts for other evidence of changes in the area. Ship Shoal Channel follows a course of N70°E for 3.25 miles through the marsh before it reaches the inlet area. Depths vary from 30-47 feet along the channel. The channel maintains a fairly uniform width of over 1600 feet through the marsh. The 1871 chart (see Figure 67) shows the north end of Myrtle Island to be cut off from the rest of Myrtle Island by a broad curving channel a little over 1600 feet in width. The chart also shows that this channel was being closed by the northward growth of a sand spit at the seaward end. The 1888 shoreline (Bryne, 1972) shows that the ephemeral inlet was open still, but the 1911 chart indicates that it had closed prior to the 1911 survey. The shape, width, and position of this channel on the 1871 chart clearly indicates that, for a time prior to the 1871 survey, most of the tidal circulation at Ship Shoal Inlet must have passed through this channel.

In 1871 Ship Shoal Channel was oriented N73°E where it passed through the inlet opening, and it lay 0.25 to 0.5 mile off the shore of the southern third of Ship Shoal Island. This effectively made that whole end of Ship Shoal Island the shore of the inlet. Seaward, the channel turned to follow a course of N130°E and discharged to the southeast. This course had the channel lying 0.25 mile north of the northern tip of Myrtle Island, where it turned sharply to discharge to the southeast. That channel position placed the detached north end of Myrtle Island in a location where it was effectively a part of the south lobe of the ebb tide delta. The partially abandoned channel across the north end of Myrtle Island, when it was in use, would have allowed Ship Shoal Channel to discharge to the sea 1.1 miles farther south. The orientation of this channel (N155°E) is such that it would have kept inlet currents away from Ship Shoal Island and put Myrtle Island under their influence instead. Thus, while this channel was functioning, the southern two-thirds of Ship

Shoal Island would have been more under the influence of waves and a wave driven longshore transport system than under the influence of inlet currents. Table II shows that the southern half of Ship Shoal Island eroded severely in the 18 years between 1853 and 1871, but the northern half, which had remained under the influence of inlet processes, had built seaward by more than 1000 feet. (The retreat of the north end of the island was due to the loss of a sand spit at New Inlet.) The seaward beach at the very northern end of Myrtle Island retreated by a similar amount during the same span of time.

The temporary inlet across the north end of Myrtle Island developed after 1853. The 1853 shoreline (Byrne, 1972) shows an ephemeral inlet near the south end of the island that connected to Ship Shoal Channel, but that is not the inlet or channel shown on the 1871 chart. It is not known when the larger channel developed, but by 1871, it was already beginning to close, and Ship Shoal Channel was again lying off the shore of Ship Shoal Island. It would therefore seem that the erosion of the southern half of Ship Shoal Island had occurred rapidly during the shore lifetime of the wide ephemeral inlet across the north end of Myrtle Island.

1871-1911. Hydrographic surveys were carried out in 1911 for Sand Shoal Inlet and Ship Shoal Inlet. The bathmetry for Little Inlet that appears on the 1911 chart was determined during the hydrographic survey of 1888. New Inlet was not resurveyed. The 1911 chart shows that the shoreline of Ship Shoal Island had advanced seaward during the forty years following the 1871 survey, and Table II summarizes the shoreline changes. Accretion was greatest near the south end of the island, where the island had been brought back under the influence of Ship Shoal Inlet. Accretion diminished toward the north end of the island where the influence of Ship Shoal Inlet declined and the influence of New Inlet and Sand Shoal Inlet was greater.

The Bathymetry offshore of Ship Shoal Island shows that the south lobe of the ebb tide delta from Sand Shoal Inlet merged at the 2 fathom depth, with the north lobe of the ebb tide delta from Ship Shoal Inlet, midway along Ship Shoal Island. In shallower water, the ebb tide delta at New Inlet still influenced the northern 0.75 mile of the island, but because it was not resurveyed, its role over that of the Sand Shoal Inlet ebb tide delta is unknown. At Ship Shoal Inlet some significant changes had occurred. The north lobe of the ebb tide delta had been reduced in size at depths shallower than 12 feet, and the north edge of the shallow portion of the ebb tide delta ran southeast from the south end of Ship Shoal Island. The apex of the ebb tide delta (at 2 fathoms) had lain off the midpoint of Ship Shoal Island in 1871. By 1911 it lay off the midpoint of Myrtle Island, and the south lobe of the delta curved in to meet Myrtle Island near its south end. Along the apex, the delta had grown seaward by about 300 yards. The bend in Ship Shoal Channel, where it turned seaward from the course it followed through the marsh, had migrated southwest by 3900 feet. The turn had formerly occurred out on the ebb tide delta, seaward of Ship Shoal Island. In 1911 the channel turned at the inlet, at the south end of Ship Shoal Island. The channel across the ebb tide delta had become more defined and discharged southeast instead of nearly south. The north end of Myrtle Island had retreated 1100 feet to the west. The changes in the offshore bathymetry indicate a change in the manner by which the inlet processes affected Ship Shoal Island. The removal of most of the north lobe of the ebb tide delta at Ship Shoal Inlet indicates the onset of erosion, or scour, by currents along the lobe of the delta. This eventually would be accompanied by retreat of the beach along Ship Shoal Island, and by deposition on the south lobe of the ebb tide delta; with accompanying growth of Myrtle Island. The changes had probably already begun by 1911, but their effects weren't apparent until the 1921 hydrographic survey revealed them. Table II (1929) shows those changes.

1911-1921. The hydrographic survey of 1921 was the last survey conducted (by the U.S.C. & G.S.) in this area. Only the outer portion of Little Inlet and Ship Shoal Inlet was resurveyed, but the entire ebb tide delta at New Inlet was resurveyed. The ebb tide delta at New Inlet had grown somewhat from what was indicated by earlier bathymetry, but it was still small. Most of the growth was in an easterly direction, which made the ebb tide delta more radial and less rectangular in shape. The south lobe extended more than a mile south of the north end of Ship Shoal Island. At Ship Shoal Inlet the bathymetry indicates that the ebb tide delta had maintained its position at the apex, but that the channel across it had turned toward the south, and the outer part of the delta was growing southward. The south lobe had also grown until it merged with the ebb tide delta at Little Inlet at the south end of Myrtle Island. The north lobe of the Ship Shoal Inlet ebb tide delta, inshore, had grown in front of Ship Shoal Island to merge with the New Inlet ebb tide delta at the midpoint of the island. The lack of bathymetric data for most of the area around Ship Shoal Inlet makes it difficult to interpret other inshore changes in the ebb tide delta. The slight inshore growth of the north lobe of the ebb tide delta suggests that scour by inlet currents had been reduced along the southern half of Ship Shoal Island. A continued change in that direction could account for the lessened erosion in the subsequent time period. Similarly, the accretion of the northern half of the island subsequent to 1929 could be interpreted as indicating continued growth of the ebb tide delta at New Inlet. However, without additional bathymetry there is no way that subsequent shoreline changes can be related to inlet processes and changes in them. The existing bathymetry has been adequate to demonstrate that shoreline changes on Ship Shoal Island are controlled by inlet processes.

IV. SUMMARY

A. Ship Shoal

Shoreline changes to Ship Shoal Island have been erratic, frequently rapid, and therefore difficult to evaluate. Net changes during the historical period can be calculated, however, and they indicate that the island has retreated an average of 2200 feet over the past 122 years. That figure yields an averaged annual retreat of 18.1 ft./yr. The effect of the inlets can be seen when the figures at each of the observation points are examined. Most of the westward retreat of the north end of the island has occurred since the early 1960's. By 1975 that retreat had reached about 2600 feet. Averaged for the last 13 years (since 1962) the retreat of the north end of the island has been at a rate of 200 ft./yr. However, the retreat from 1974 to 1975 exceeded 350 feet. All of the southward retreat of the north end of the island took place prior to 1963. That retreat amounted to 1240 feet, and averaged 11.25 ft./yr. for the 110 year period. There has been no southward retreat of the north end of the island since 1963.

Away from New Inlet, one-quarter of the way down the island, the shoreline is still under the influence of the inlet. Retreat here was only 886 feet during the historical period, although fluctuations of over 1000 feet have occurred during that time span. Averaged for the 122 year period, this part of the island retreated at a rate of 7.25 ft./yr. At the midpoint of the island retreat occurred at a rate of 16.6 ft./yr., and three-quarters of the way south retreat was 15.9 ft./yr. The south end, like the north end, showed a greater retreat; more than 3700 feet at an averaged rate of 30.3 ft./yr.

It should be noted that erosion has been occurring rapidly since the mid-1960's. Retreat at the midpoint of the island has been at the rate of 193.3 ft./yr. since 1963 and at lesser, but still rapid, rates elsewhere on the island, except near the north end. This retreat has been affecting the entire length of the

island and is similar in nature to the retreat that occurred between 1911 and 1929. The 1973 aerial photographs show the reason for this. In 1973, the channel at New Inlet lay against the south end of Wreck Island nearly a mile away from the north end of Ship Shoal Island, and at Ship Shoal Inlet the main channel turned south along the beach of Myrtle Island. With the inlet channels turned away from Ship Shoal Island, the island is subject to scouring inlet currents during the flood tide cycle, and, as before, the beach is eroding rapidly. There is no way of predicting how long this condition will persist, but retreat of the island will continue until conditions change at the inlets.

B. Godwin Island

Before concluding this section on shoreline changes, a statement should be included regarding the marsh area of Godwin Island and the marsh at the southwest end of Ship Shoal Island. This marsh area is unlike that associated with nearby islands, because of the changes that have been occurring within the marsh. On the IR imagery much of the marsh appears to be drowned. Tidal canals have shifted position or disappeared entirely. The canal which separated Ship Shoal and Godwin Islands has disappeared, without a trace, as have other canals shown on the early charts. The large tidal canal which enters that marsh from the north end of Godwin Island is building natural levees and deltas into the marsh. A strip of marsh parallel to the north shore of Godwin Island has been broadly overwashed with sediment from the north, and a low ridge has built up above high tide level all along that shore. Within that strip of marsh former tidal canals have been blocked off, and partially filled. The sediment being deposited in the marsh is sand being swept in through New Inlet. These features make this part of the marsh very different from the portion of the marsh west of Ship Shoal Island, or the marsh on other nearby islands.

C. Geomorphic Description and Interpretation

This discussion of the geology of the area west of Ship Shoal and Godwin Islands will be deferred at this time, and included in the section on Smith Island. This was also done with the area west of Wreck Island. The descriptions of the geomorphic units and geologic history given below are made in reference to the Geologic Map of Ship Shoal Island included with this report.

The oldest geomorphic features are located in the marsh west of the seaward facing beach of Ship Shoal Island. Two crescent shaped areas are mapped as former inlet deposits or inlet islands. The southernmost of these is located west of the midpoint of the island and has two small beach ridge areas on it near the western edge. These beach ridge units align with two other beach ridge units about 0.2 mile south, and with other units further south which were too small to map. This line of beach ridge units is roughly parallel to the modern shoreline, but they are the oldest geomorphic units on the island. The area mapped as inlet deposits at the north end of the line of beach ridge units probably marks the north end of an old barrier island. At the north end, these recurve into the marsh and the sand spit trails off into a natural levee across the marsh. A modern tidal canal parallels the main levee, but it is believed that a large canal formerly occupied the site. The south end of this unit was cut off long ago, and the marsh behind it has not filled in. It is believed that this unit and the line of beach ridge units are related. The northern area, mapped as inlet deposits, is a separate unit of about the same age. These units are believed to be the only ancient deposits on the island.

In the marsh along Ship Shoal Channel at the south end of Ship Shoal Island, there are two parallel beach ridge units. The northernmost of these ridge units

predates the hsitorical part of this study by an unknown span of time. It is shown, in place, on the 1871 charts. It is old, but not ancient, and probably predates the historical period by a century or more. At the north end of this beach ridge unit there is another, broader, beach ridge unit which cuts across this unit with a more northerly trend. This latter unit is breached at two locations, and truncated at the south end by a pre-1871 shoreline. At the north end it is cut off by the modern shoreline. At the south end this unit consists of a single ridge, but midway a second ridge merges with it from the north. This beach ridge unit also predates 1853, but it is younger than the first unit.

At the south end of Ship Shoal Island, on Ship Shoal Channel, a beach ridge unit lies along the north edge of the channel. The main ridge on the northern side of this unit is the offshore ridge shown on the 1871 chart. This ridge line can be traced northeastward until it is cut off by the modern beach. The deposits south and east of this ridge are all post-1871 in their deposition. It is believed that the short east-west ridges relate to the period of rapid progradation of the island between 1871 and 1911. All other features along the shoreline are quite recent in origin because the very rapid retreat of the island during the past twelve years has removed most features formed during this century.

D. Geologic History and Interpretation

Even less geologic history can be learned from the geomorphic units of this island than could be learned on Wreck Island. The units that have been interpreted as ancient are so incomplete as to be of little certain value. The changing character of the marsh area has not helped in preserving ancient features. Erosion during the past century or more has destroyed any more complete ancient features that would have lain seaward of the modern beach. Therefore, it is only possible to establish that there are ancient beach features in the marsh area of Ship Shoal Island and that the island has, in the distant past, prograded eastward of these features. It is not possible to even estimate how far eastward progradation may have advanced the island.

The beach ridge unit that predates 1853 by a century or more, and the younger beach ridges that also predate 1853 all relate to the modern period of retreat of the island. The parallelism of these beach ridge units with similar features formed after 1853 is strong evidence that the changes in the inlet channels and ebb tide deltas (that were previously described) are cyclic in nature. Along Ship Shoal Channel the position of the 1871 beach ridge south of the older beach ridge indicates that Ship Shoal Channel had migrated south between the formation of the first ridge and the formation of the second. If the changes in the inlet channel and the ebb tide delta are somewhat cyclic in nature, and if Ship Shoal Channel continues to migrate south, then a third ridge unit might be expected to develop in the future.

MYRTLE ISLAND AND MINK ISLAND

I. DESCRIPTIVE GEOGRAPHY

Myrtle Island is the tenth island from the north end of the Virginia Barrier Island Group, and the eighth island from the north in the area covered by this study. It is also the third island from the southern end of the barrier island group. Mink Island is the name given to the contiguous marsh area immediately west of Myrtle Island. Mink Island is separated from Myrtle Island on the east by the tidal canal, Mink Creek, and from Big Creek Marsh to the west by other tidal canals (Big Creek and Black Rock Channel). Myrtle Island is separated from Ship Shoal Island on the north by Ship Shoal Inlet, and from Smith Island on the south by Little Inlet. Myrtle Island is located due east of the towns of Capeville and Townsend on the mainland.

Access to the island is made by boat. The north shore of both Mink and Myrtle Islands face on Ship Shoal Channel, and are accessible throughout the tidal cycle. The south shore of both islands fronts on Little Inlet and Mink Island Bay and again can be reached throughout the tidal cycle except for northern portions of Mink Island Bay which are tidal flats. Mockhorn Island lies west of Myrtle Island and blocks direct passage from the mainland, so that it is necessary to reach the island by way of Smith Island Bay and various tidal channels. Boat landings and boat launching ramps that may be used to get to Myrtle Island are the same as those cited in the discussion of Ship Shoal Island. Because of shallow waters and shifting channels, visitors to the island should be advised to hire the services of a local waterman who is familiar with these waters.

Myrtle Island is another small island, the second smallest in the Virginia Barrier Island Group. From inlet to inlet it measures 2.13 miles, but along its curved beach it measures 2.65 miles. The width of the upland barrier island varies from 400 ft. to more than 2000 ft., but the southern half of the island averages about 800 ft. in width, and the northern half about 1100 ft. The marsh area of Myrtle Island averages about 3000 ft. in width, and there is marsh behind the beach units for the entire length of the island. The irregularly shaped marsh area of Mink Island runs west southwest from Myrtle Island for a distance of 2.6 miles. The width of Mink Island Bay is located along the south edge of the island near the western end. The appearance of Mink and Myrtle Islands is remarkably like that of Godwin and Ship Shoal Islands in respect to size, shape, and orientation.

The north end of Myrtle Island, at the inlet, lies 7.2 miles off the mainland coast, while the south end of the island, at the inlet, is only 6.4 miles from the coast. At the point of maximum seaward curvature, the beach is 7.8 miles from the coast. The island lies with its axis parallel to, and coincident with, the seaward face of the barrier chain. The island is far enough removed from Sand Shoal Inlet so that it is not influenced by the processes that are responsible for the coastal indentation at that inlet.

The area between Mink Island, Myrtle Island, and the mainland is occupied by marsh which extends west to Magothy Bay. Magothy Bay is a long, narrow bay lying parallel to the mainland to the west of Ship Shoal, Myrtle, and Smith Islands. It averages about 1.7 miles in width and is more than 9.0 miles long, The bay is separated from the mainland by a narrow (1000-1500 ft.) strip of marsh. The Inland Waterway follows a channel through this bay. The marsh area falls into two distinct units, Big Creek Marsh lies immediately west of Mink Island and is separated from it by Big Creek tidal channel. This channel connects from Main Ship Shoal Channel to Mink Island Bay Channel. Main Ship Shoal Channel separates Big Creek Marsh from the broad marsh area of Mockhorn Island to the west. The three marsh areas, Mink, Big Creek, and Mockhorn, occupy about 70 percent of the area west of Myrtle Island.

II. PHYSIOGRAPHIC DESCRIPTION

The physiographic units in the western half of the area between Mink Island and the mainland, are the southward extension of units whose descriptions were begun previously in the section dealing with Wreck Island, and continued in the section on Ship Shoal Island. Those earlier descriptions are cited here for reference.

The mainland coast west of Myrtle Island is coincident with the base of Mappsburg Scarp, as it is to the northwest of Wreck and Ship Shoal Islands. However, the terrace riser slopes up more gently to the terrace surface in this area, and the feature is less dominant in the topography. The former beach at the base of the Mappsburg Scarp forms the mainland shore at the western edge of the tidal marsh. The eastern edge of the marsh along the western side of Magothy Bay near Townsend is an ancient shoreline that has been traced southward in the physiographic descriptions of Wreck and Ship Shoal Islands. On the 1949 black and white aerial photograph (ANP-2E-30), features of this ancient shoreline are clearly visible in the marsh along the mainland from Dunton Cove to south of Cushman's Landing. Northeast of Townsend, at Dunton Cove, the line of this beach is broken by the cove and a semicircular ribbon of marsh that encircles the cove on the north and east sides. The size and shape of the pattern formed by the ribbon of marsh and the edge of the tidal flat at the south side of Dunton Cove indicate that this feature is a drowned Carolina Bay. Similar bays are seen on the adjacent mainland. This drowned Carolina Bay is clearly visible on the 1949 and 1973 black and white aerial photographs. A larger and more distinct Carolina Bay is found on Mockhorn Island due east of Bull's Landing on the mainland. Both of these Carolina Bays clearly disrupt the ancient beach ridges where they are located, and are, therefore, younger than the ancient beach ridges. To the north, in the area west of Cobb Island, Hog Island, and the southern part of Parramore Island, the most ancient beach ridges are disrupted by other Carolina Bays. The very ancient beach ridges are apparently of early Wisconsin age, which would indicate that the time of formation of the Carolina Bays is more recent than the early Wisconsin.

East of Magothy Bay, in the marsh of Mockhorn Island, there are a number of drowned ancient beach ridges. The most strongly developed of these ancient ridges forms the eastern shore of Magothy Bay in the area west of Myrtle Island. At its north end this ridge can be traced northward into the marsh of Mockhorn Island, but at the south end it disappears beneath the waters of the bay. There are forested areas on higher ground along this ridge. The forested ridge described in the section on Ship Shoal Island has a gap over 2100 ft. in width in this area. It lies 1000 ft. or more east of the ridge that forms the shore of Magothy Bay. The portion of the ridge south of the gap is lower in elevation and only small areas of it are forested. At the south end this ridge declines in elevation and disappears in the marsh of Mockhorn Island. East of this ridge there are several other lesser ridges. The easternmost of these ridges merges to the south with the next ridge to the west. The angle between the ridges is 10°. The aerial photographs show that all of the ridges on Mockhorn Island diverge eastward in the northern part of the island, but none as strongly as the easternmost ridge. From west to east each successive ridge terminates further to the north. All of these ridges have less than five feet of relief, and most of them have only 2-3 ft. of relief. On the U.S.G.S. topographic map of the area they are indicated as sandy areas in the marsh.

The eastern portion of the marsh of Mockhorn Island, Big Creek Marsh, and Mink Island do not display any distinctive physiography. There are a few natural levees in the marsh that indicate former positions of tidal canals and one that indicates the westward migration of Main Ship Shoal Channel maintains depths of more than 20 ft. as it passes through this marsh area to Smith Island Bay. Channel depth rapidly decreases as the channel reaches the bay.

The marsh area of Myrtle Island does not contain any features that could be interpreted as relating to beach or inlet processes. At the north end of the marsh there are remnants of former tidal canals, both large and small, that have been partially filled in by overwash, and all along the seaward side of the marsh there are canals that have been cut off by beach retreat. At the very north end of Mink Island there are two short beach ridge units that face northeast and their ends are recurved towards the southwest. It is evident that initially these were a single beach ridge (about 0.4 miles long) that was breached near the middle.

The barrier island deposits of Myrtle Island consist of a beach ridge unit with several distinct beach ridges at the north end of the island and along the seaward side; and the active beach. There are peat outcrops in the beach and surf zone along the seaward facing beach. The beach ridges have been broken by ephemeral inlets in two locations. One of these, in the short northeast facing beach, at the inlet, has healed and ridges have grown across the opening. The other, at the north end of the seaward facing beach, has closed but is still susceptible to overwashing. A broad overwash fan has been built into an old channel in the marsh that still contains water. At both ends of the island the beach ridges curve back through the inlets and along the inlet channels.

The active beach is wide, with multiple berms and bars built in the surf zone. At the north end of the island, at the inlet, a ridge and runnel has been added to the island, and all along the seaward side of the island a bar lies 400-500 ft. off the beach. At the south end of the beach a sand spit has grown back into the inlet. All of these characteristics of the beach indicate that in 1974 Myrtle Island was, and had been, accreting.

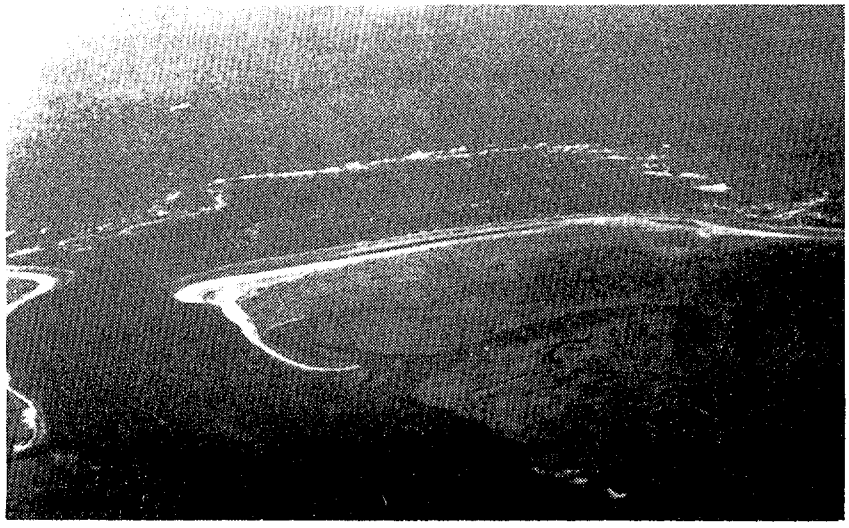
Figure 70a shows the north end of Myrtle Island at Ship Shoal Inlet as it appeared in July 1975. The northeast facing beach is at the right and the seaward facing beach is at the bottom. The beach ridges stand out sharply in the area behind the beach. The partially closed ephemeral inlet that is still subject to overwash can be seen behind the beach at the lower left of the picture. The older ephemeral inlet that has closed can be located at the center of the picture. A ridge and runnel has been added to the northeast facing beach sometime after June 1974. An older ridge and runnel appears as the whiter beach and dark area inshore from the newer runnel. The body of water at the left center is the unfilled portion of a large channel that was cut through the island between 1853 and 1871 when Ship Shoal Channel formed an ephemeral inlet south of the present inlet. Overwash fans have been built into this channel from the two smaller ephemeral inlets. Near the upper left two small beach ridges can be seen at the north end of Mink Island.

Figure 70b shows Ship Shoal Inlet and the north end of Myrtle Island. A surf line offshore outlines the shallower portions of the ebb tide delta, and illustrates the asymmetry to the right (south). The place where the south end of the surf line curves in toward the beach indicates the location on Myrtle Island that separates the section of beach under the influence of the inlet (to the left) from the section of beach under the influence of a wave driven longshore drift system (right). The abrupt change in the orientation of the beach just north of that location, and a scallop cut in the beach at the location, are characteristic features associates with this situation. The same features can be seen on Wreck, Cobb, Hog, and Parramore Islands. Another characteristic feature associated with this location on thin barrier islands, is that the scallop is a site for overwash or the development of ephemeral inlets. Both have occurred at this location on Myrtle Island. At a similar location on Hog Island, the beach ridge was broken through, and the island was badly overwashed about 1871.

III. SHORELINE CHANGES

Shoreline changes on Myrtle Island since 1853 have not been as complex or as spectacular as the changes on other islands to the north. The northern and southern portions of the island have behaved differently because they were influenced by different processes. The southern portion of the island has been dominated by a wave driven longshore drift system and has not been strongly influenced by Little Inlet. The northern portion of the island has been under the influence of Ship Shoal Inlet throughout the observation period. The island has retreated in a northwesterly direction, but retreat has not been uniform along the length of the island, and the shape of the island has changed somewhat.

a. North end of Myrtle Island at Ship Shoal Inlet. Note breach in beach ridge closest to the marsh at the center of the photograph.



b. Ship Shoal Inlet. Surf line shows position of shallow portions of the ebb tide delta.

FIGURE 70: Myrtle Island at Ship Shoal Inlet

Figures 71 and 72 portray shoreline positions for Myrtle Island for various years from 1871 to 1963. Figure 73 depicts shoreline positions for 1949, 1968, and 1974. All three figures show that the shoreline of the southern portion of the island maintained essentially the same orientation throughout the time period, even though retreat occurred. This is a reflection of the role of waves and longshore drift in shaping this portion of the island. Similarly, the figures show the more erratic behavior of the shoreline of the northern part of the island where changes in the channel and ebb tide delta at Ship Shoal Inlet have played the major role in controlling shoreline position.

IV. TABULAR PRESENTATION OF DATA

Table III presents measurements of shoreline changes at various locations on the island for seven different time periods. The changes shown for any given date are the net changes during the span of years since the preceding date. The observations begin with the 1853 shoreline (Bryne, 1972). Measurements shown are in feet, and the direction of movement is indicated by arrows. At the ends of the island where changes in both length and position have occurred, multiple arrows are used to aid in visualizing the changes. The facing and width of Little Inlet are shown near the bottom of the Table. The changes at the inlet are almost entirely due to the movements of the ends of Myrtle and Smith Islands, and not to changes in the inlet itself. A detailed discussion of the movements of Ship Shoal Inlet and its channel and ebb tide delta were included in the section on Ship Shoal Island and will not be repeated here.

1853-1871. The most significant period of retreat of the shoreline of Myrtle Island took place in the 18 years between 1853 and 1871. Sometime during those years, Ship Shoal Channel turned and broke through the north end of Myrtle Island and discharged south southeast. The partially abandoned 1600 ft. wide channel cut during this breakthrough is shown in the diagram of the north end of Myrtle Island in 1871 (Table III). The spit growing into the inlet from the southern beach indicates that the channel was already being abandoned when the 1871 survey was conducted. The northern beach and the southeast facing southern beach were still separated by an ephemeral inlet when the 1888 survey was done. The abrupt and short lived change in the position of Ship Shoal Channel, and the marked retreat of Myrtle Island are undoubtedly related events. The data used for this study are insufficient to determine what caused those changes, but the short time span involved, again suggests that a major damage producing storm may be responsible. Whatever the cause, the movements of Ship Shoal Channel, that began at this time, continued.

In 1871, Ship Shoal Channel passed through the inlet with an east-west orientation and extended seaward on this course before it turned south and broke up into three east-west distributaries. This position put the channel seaward of the southern portions of Ship Shoal Island and away from the north end of Myrtle Island. The ebb tide delta lay seaward of Ship Shoal Island and the south lobe extended down along the northern beach on Myrtle Island.

FIGURE 71.
SHORELINE CHANGES
ON MYRTLE ISLAND;
1871 – 1963

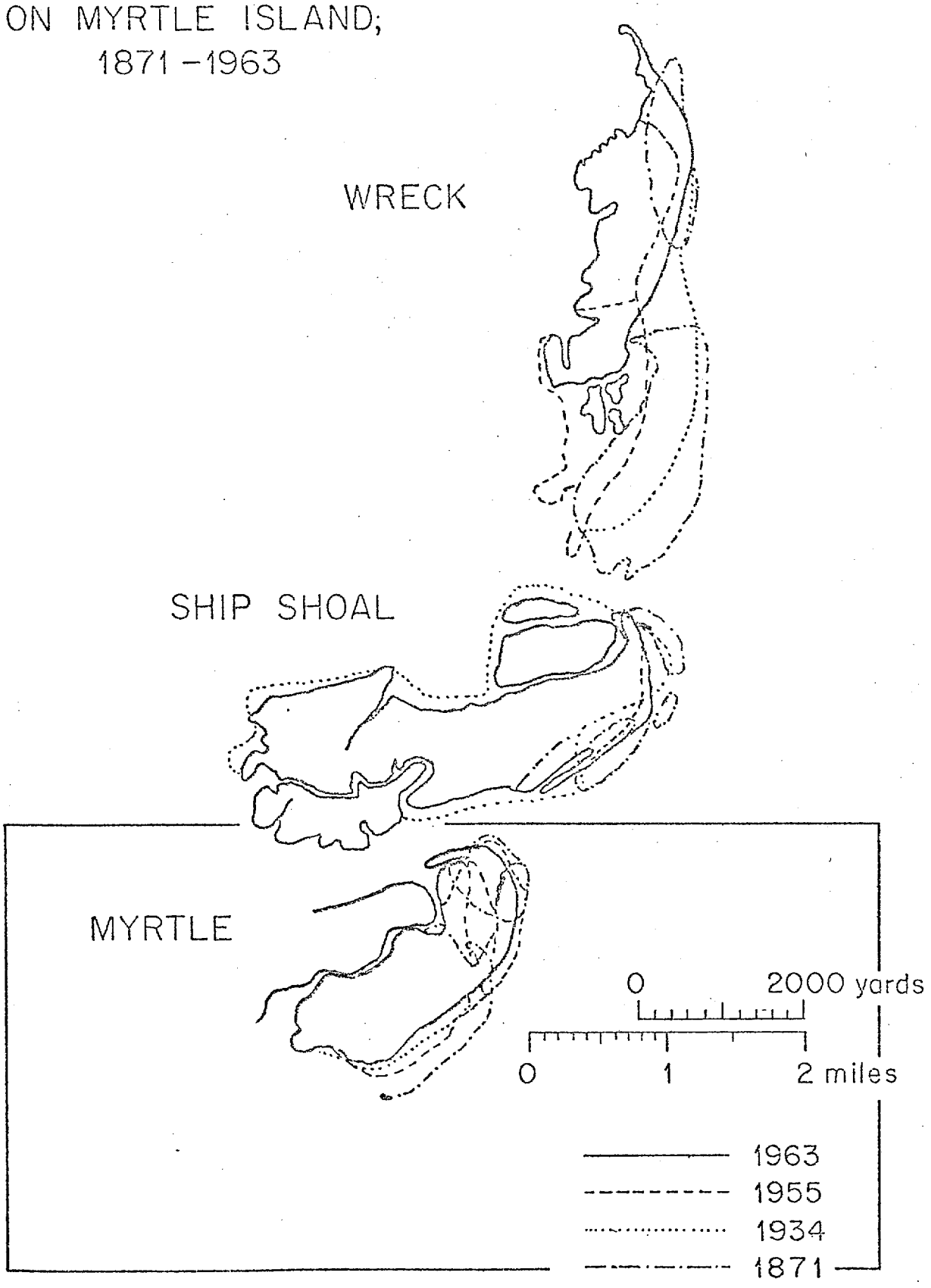
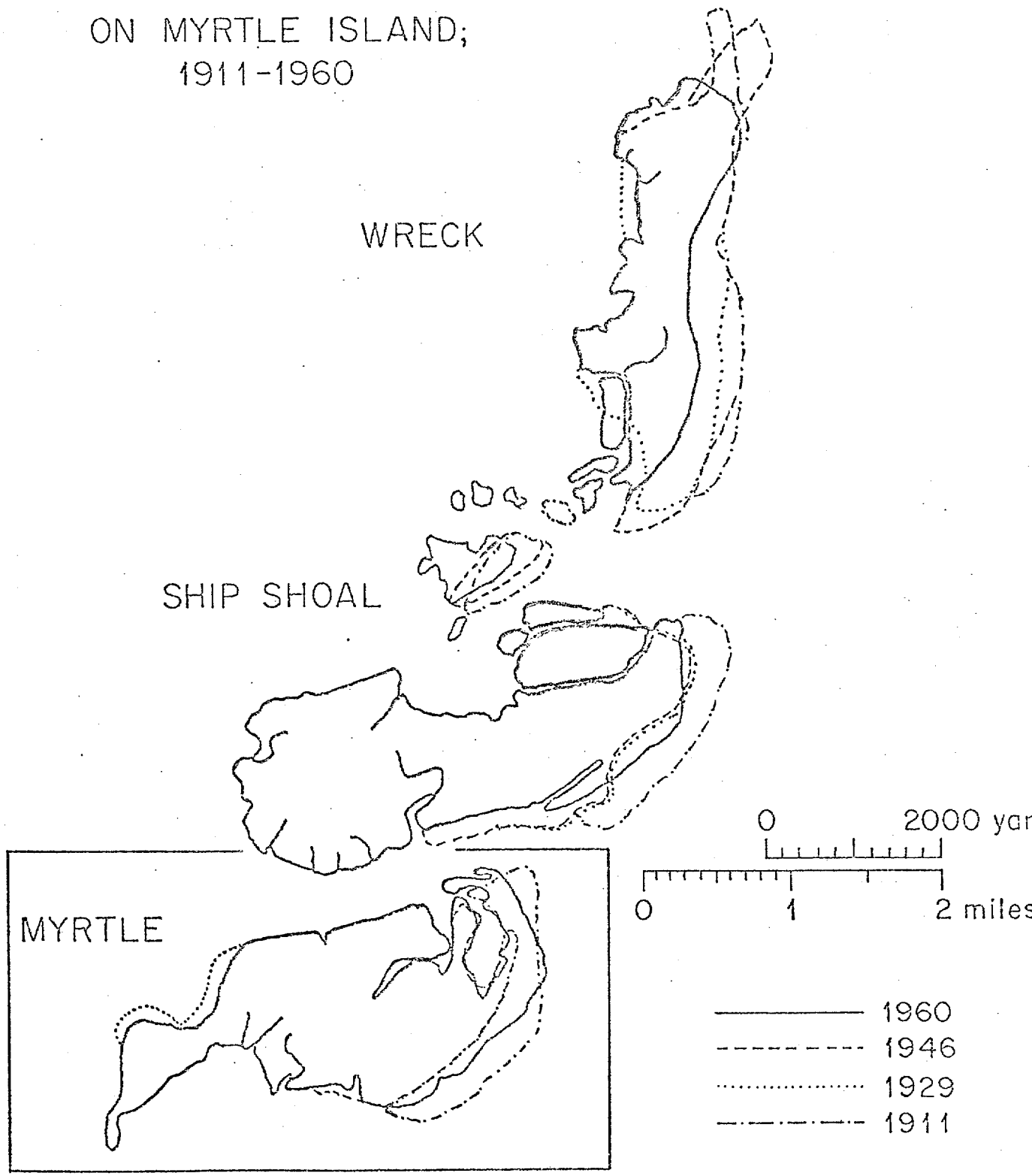


FIGURE 72.
SHORELINE CHANGES
ON MYRTLE ISLAND;
1911-1960



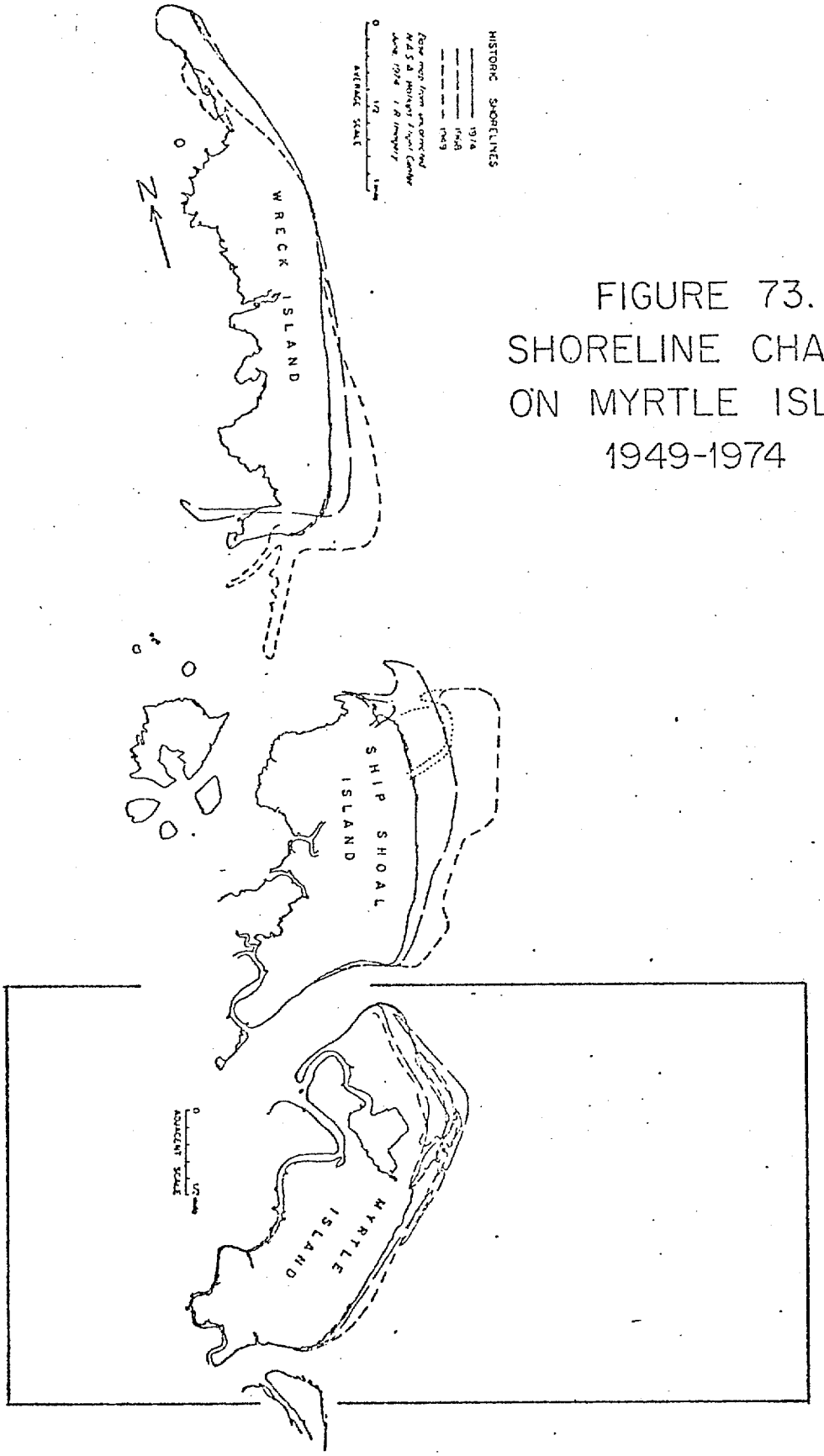


FIGURE 73.
SHORELINE CHANGES
ON MYRTLE ISLAND;
1949-1974

ITEM OR POSITION ON ISLAND	1871	1911	1929	1943	1955	1968	1974
SHAPE OF NORTH END							
MOVEMENT NORTH TIP	↑ 880 ↑ 1000 ←	↑ 300 ↑ 1500 ←	1200 ← ↓ 420	↓ 120	↑ 270	1425 ↗	260 →
NORTH END NORTHERN BEACH	830 ←	1300 ←	ephemeral inlet	—	0	↗ 1210	↗ 550
FACING OF NORTHERN BEACH	E	E	ENE	NE	NE	NE	NE
MIDWAY ON NORTHERN BEACH	← 1000	← 750	↙ 900	↗ 880	↗ 80	↗ 330	↗ 450
SOUTH END NORTHERN BEACH	inlet ← 1200	inlet closed 0	← 1400	↗ 1300	↗ 70	← 350	→ 525
NORTH END SOUTHERN BEACH	↖ 1200	0	↖ 1400	↘ 1300	↘ 170	↗ 2400	↖ 550
SOUTH END SOUTHERN BEACH	↖ 1200	↖ 300	↖ 900	400 → 140 ↓ TIP	↑ 140 TIP ↖ 120	1400 ↖ 400 ↓ 250 TIP	↑ ↖ 175 175 TIP
FACING AND WIDTH OF LITTLE INLET	/ 830	/ 1200	/ 1600	/ 1380	/ 1650	| 780	| 870
OBSERVATIONS	S. S. INLET → UNSTABLE CHANNEL	S. S. INLET → EBB TIDE DELTA					

TABLE III MYRTLE ISLAND.

Summary of shoreline changes; 1852-1975.

North is at top of page.
Arrows indicate direction of movement.
Lines show compass orientation.

Numbers are in feet.

1871-1911. By 1911, the turn in the channel from Ship Shoal Inlet had migrated 3900 ft. to the southwest, and the channel passed through the inlet to the southeast. The main channel lay 0.25 mile north of the tip of Myrtle Island, and the tip of the island had migrated west by 1500 ft. The ebb tide delta had shifted south so that the apex was southeast of the inlet and it was no longer radially distributed in front of the inlet. The north lobe which formerly lay seaward of Ship Shoal Island had been removed to depths of more than two fathoms. By 1911, the margin of the north lobe was more than 6000 ft. south of its former position, and followed a nearly straight course southeast from the south end of Ship Shoal Island. The south lobe had grown offshore and down the length of Myrtle Island, to the delta at Little Inlet. A minor flood tide channel lay between the northern beach of Myrtle Island and the south lobe of the delta.

The changes in the ebb tide delta at Ship Shoal Inlet are reflected in shoreline changes on Myrtle Island. The presence of the delta offshore changed the processes affecting the northern two-thirds of the island. The northern and southern beaches met near the middle of the island in 1911. Retreat of this part of the island had been arrested and the ephemeral inlet of 1871 was closed. Retreat had been sharply reduced along the southern beach except near the southern end of the island where the ebb tide delta thinned out. There, retreat reached 300 ft. North of the middle of the island, the beach retreated as the northern tip of the island adjusted to changes in the main inlet channel and to a minor flood tide channel that lay along the northern half of the northern beach. Retreat reached 1300 ft. along the northern half of this beach.

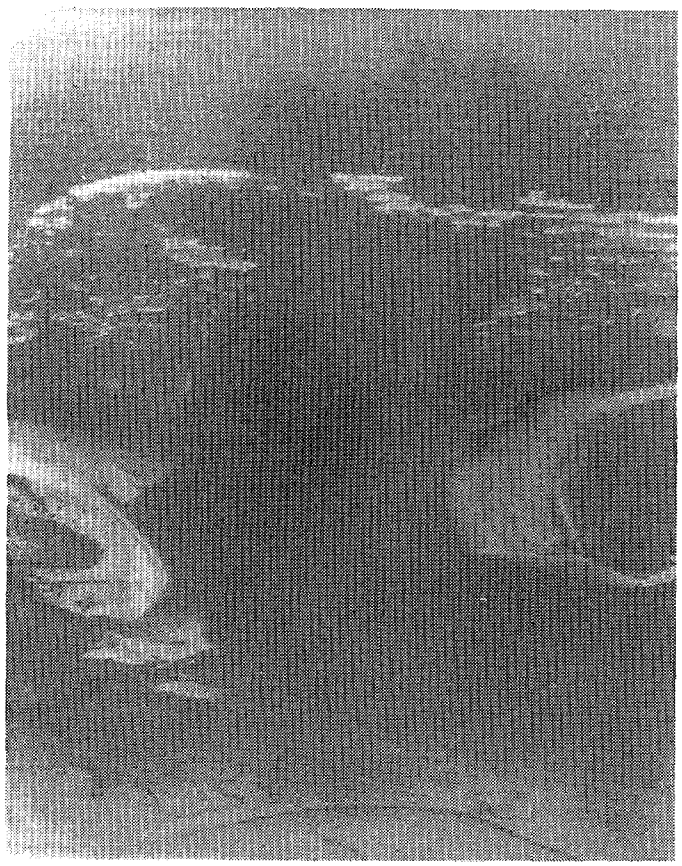
1911-1921. The last hydrographic survey of this area was conducted in 1921, and it did not provide details of the bathy-metry near either inlet, only shoreline changes and offshore bathymetry. However, both shoreline changes, and changes in the offshore bathymetry indicate that the Ship Shoal Inlet ebb tide delta had continued to change and adjust its shape. The continued westward retreat of the north end of Myrtle Island combined with a southward shortening of the north end indicates that the bend in Ship Shoal Channel had continued to migrate southwest. This continued retreat of the north end of the island had thinned the beach, and an ephemeral inlet had broken through into the abandoned 1600 ft. channel. Retreat had also turned this northern beach from facing east to facing east northeast. The offshore bathymetry shows that the north lobe of the ebb tide delta had grown northward by about 1500 ft. and indicates that the main channel over the delta was oriented more to the east southeast instead of southeast.

The northern beach was shorter, running only about one-third the length of the island. The junction between the two beaches had thus shifted northward, and the former midpoint of the island retreated about 500 ft. more than the rest of the island, which averaged about 900 ft. of retreat. The fact that the entire island was retreating suggests that inlet processes from Ship Shoal Inlet had ceased to affect it, except near the inlet. This would agree with the bathymetric evidence that the inlet channel over the ebb tide delta had rotated counterclockwise away from Myrtle Island. This shift in the channel, and the growth of the north lobe of the ebb tide delta had restored some radial symmetry to the delta.

1921-1960's. By 1943, the northern beach was rotated to face the northeast and was accreting seaward. The ephemeral inlet had closed, but was still functional as an overwash channel, and sand dune ridges had formed behind the beach. The length of this beach still accounted for about one-third of the island's beach length. Greater accretion near the south end of this beach produced a bulge in the shoreline. The southern beach also accreted, more at the northern end than along the southern reach. Accretion all along the length of the island indicates that the southern lobe of the ebb tide delta at Ship Shoal Inlet was again active. The 1949 aerial photographs indicate that discharge from Ship Shoal Inlet was definitely toward the southeast over the south lobe of the ebb tide delta. Continued accretion of most of the island into the early 1960's indicates that conditions around Ship Shoal Inlet remained relatively unchanged until that time.

Most Recent Shoreline Changes. The most recent shoreline changes have been different than earlier changes in that they have been less systematic. Without recent bathymetry to show what has happened offshore it is difficult to confirm observations. The nature of the shoreline changes indicates that conditions at Ship Shoal Inlet may have become more stable. Beginning in the mid-1950's, the southern portion of the southeast facing beach began to retreat slowly to the northwest. With time, retreat spread northward, until by 1968 it was affecting most of the southeast beach. Retreat has not been marked, and has been accompanied by alternate advance and retreat of different sections of the beach. The southern tip of the island, at Little Inlet, has advanced and retreated by 100-150 ft., and the beach at the inlet was advanced and retreated. In 1973 a sand spit had actually grown about 800 ft. directly seaward along the north edge of the Little Inlet Channel, and the south end of the beach curved sharply seaward with the sand spit. By 1974 all of this had been removed, and the beach curved gently into Little Inlet. These changes along the southeastern beach and at Little Inlet are the consequence of the southerly drift of sand along this beach and of the bypassing of that sand around Little Inlet ot the north end of Smith Island. The path of this bypass can be visualized from Figure 74 which shows the pattern of surf activity on the shallow part of the ebb tide delta at Little Inlet. The pattern of sandbars at the south end of the beach on Myrtle Island shows where sand is entering the bypass around the ebb tide delta.

Discussion of Shoreline Changes. The northern part of the island had begun to accrete in the period between 1921 and 1943. Accretion had taken two forms: gradual accretion, with steady advance of the beach; and growth of sand dune ridges which had occurred near the north end of the island. North of the mid-point of the island, where the two beaches met, accretion occurred as offshore bars came ashore and welded to the beach. This process has maintained a ridge and runnel character for this part of the island since the late 1940's. However, since the early 1960's the offshore bars have increased in length to the extent that they have influenced the entire northeast beach, and this beach has accreted rapidly. Figure 70a shows the extensive ridge and runnel system extending from the north end of the southeast beach northward to the inlet. This increased rate of accretion, and the size of the sand ridges that coming ashore indicates an increased supply of sand to the north end of the island. The immediate source of this sand is difficult to determine without recent bathymetric data.



LITTLE Inlet. The inlet is located between Myrtle Island (left) and Smith Island. Mink Island is the marsh area at the bottom of the picture. The surf pattern outlines the shallow part of the ebb tide delta and the main inlet channel.

FIGURE 74

Ebb Tide Delta at Little Inlet

Two types of shoreline changes have affected Myrtle Island during the past 121 years; normal retreat, and adjustments caused by changes in Ship Shoal Inlet and its ebb tide delta. The preceding paragraphs have attempted to explain the nature of the adjustments that have been made in the shoreline, and to indicate that they are still taking place along the northern portion of the Island. Table III permits an examination of the more regular retreat of the island by providing figures on net change over the time period. The southern half of the island has displayed the more uniform advance and retreat. Retreat near Little Inlet has averaged 22.1 ft./yr. since 1853, but the beach has been retreating at more than double that rate since the early 1960's. Near the middle of the island retreat has varied from 8.6 ft./yr. to 13.8 ft./yr. since 1853. This part of the island has been retreating during the last decade, but has changed little since the late 1940's. The northeast beach has been accreting recently, and average net retreat figures vary from 370 ft. just south of the inlet to an average along the beach yields a retreat rate of 7.5 ft./yr. since 1853. The retreat of the tip of the island at Ship Shoal Inlet has been just over 2000 ft., and this yields a retreat rate of 16.5 ft./yr. This is probably a more representative retreat figure for the northern portion of the island because it avoids that portion of the beach that responds quickly to changes in the inlet currents and the ebb tide delta.

Mink Island. Although it is not a shoreline change, there has been a significant change in the eastern boundary of Mink Island during the historical period of this study. Mink Creek is taken as the boundary between Myrtle Island and Mink Island because it is the first tidal canal west of the beach of Myrtle Island that connects through from Ship Shoal Channel to Little Inlet. At present, Mink Creek divides into multiple canals midway between the two inlet channels. It formerly continued almost due south from that point as a broad canal. The southern half of the original creek was blocked and filled-in between the 1921 survey, and that made in 1943. Through drainage had been taken over by another canal that entered the channel to Little Inlet about 2800 ft. west of the original canal. This change in the tidal canals added more than 0.25 sq. mile of Mink Island to Myrtle Island. By 1974 the beach ridge at the southern tip of Myrtle Island was built onto the southeast corner of the original Mink Island, and the beach at the tip of the island lay only a few hundred feet east of the original Mink Creek.

V. GEOMORPHIC DESCRIPTION AND INTERPRETATION

There are no ancient geomorphic units that can be identified on Myrtle Island (in the marsh or in the beach ridge units). On the Geologic Map of Myrtle Island, the large pond at the north end of the island is the remaining portion of the 1600 ft. wide channel, which cut across the island between 1853 and 1871. The straight shorelines at the northeast and southwest edges of the pond, where it is widest, are the approximate shorelines of the old channel. The old inlet opening shown on the geologic map near the north end of the southeast beach is the opening where the channel connnected to the sea. The beach ridge curving into this opening from the south side is the sand spit that grew northward to close the opening. Other beach ridge units that completed the closing of this inlet have been eroded in recent years, and at present there are several overwash channels that cut through this part of the island.

The old inlet symbols through the middle of the beach ridges behind the northeast beach indicate the location of an ephemeral inlet that broke through into the old channel between 1911 and 1921. The position of the inlet can be seen in Figure 70a where the beach ridge farthest from the beach is broken at the middle. The portions of the beach ridge unit closest to the marsh on either side of this inlet represent the oldest beach ridge remnants on the island. During the time that this inlet was open the north end of Myrtle Island was severely eroded, and it is believed that the low, breached, beach ridge unit on Mink Island was formed by storms during this time span. This inlet closed between 1929 and 1943 when this end of the island began to accrete. The strand line shown northeast of this inlet is believed to be a shoreline of the 1950's. In Figure 70a, the ridge inshore of this strand line is the ridge that closed the gap of the older ephemeral inlet. It was formed after overwashing of the partially closed inlet had ceased, and overwashing was still occurring in April 1949. That strand line marks the limit of retreat before the most modern period of accretion began. All of the other geomorphic units along the island date from the past quarter century and record accretion of the northern half of the island and retreat of the southern half of the island.

VI. GEOLOGIC HISTORY

No geologic history can be advanced for Mink and Myrtle Islands beyond that which has already been outlines in the analysis of shoreline changes since 1853. Except for the marsh area and two small sections of beach ridge on either side of the ephemeral inlet at the north end of the island, no part of the upland island has a history greater than 122 years. The orientation of the ancient geomorphic units on Wreck and Ship Shoal Islands indicates that any ancient portion of Myrtle Island would have lain east of the present position of the island.

SMITH ISLAND

I. DESCRIPTIVE GEOGRAPHY

Smith Island is the eleventh island from the north end of the Virginia Barrier Island Group and the ninth island from the north in the area covered by this study. It is also the second island from the south end of the group at Chesapeake Bay. Little Inlet marks the north end of the island and separates it from Myrtle Island. The southern end of Smith Island is about equidistant from both Fisherman's Island and the southern tip of the mainland peninsula. The broad Smith Island Inlet lies between Smith Island and both adjacent land masses.

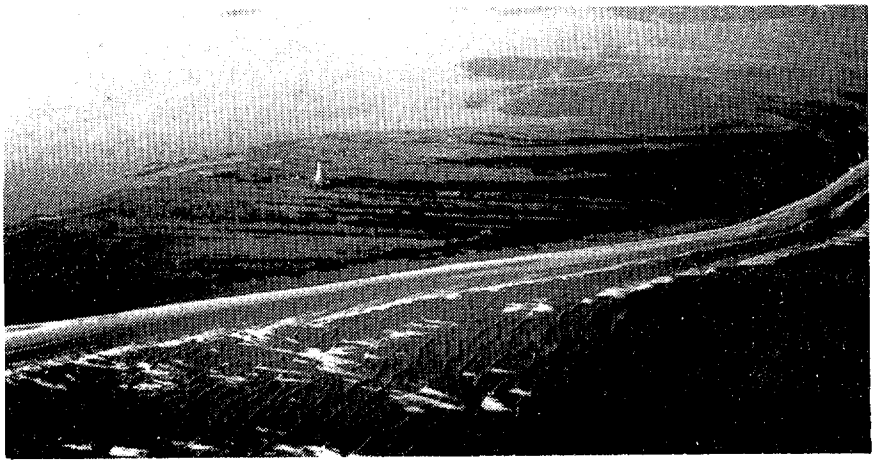
The village of Townsend lies west of the north end of Smith Island, and Magotha and Cedar Grove are just south of Townsend. Otherwise there are no other settlements of consequence on the mainland west of Smith Island. Access to the island is by boat from the mainland. Bull's, Cushman's, and Steelman's Landings on the mainland are all located near Townsend. Dixon's Dock and Raccoon Creek are landings near the Cape Charles Air Force Station west of the south end of Smith Island. The waters of Magothy Bay and Smith Island Bay are very shallow and there are many tidal flat areas within the bays. Passage to the north end of Smith Island should only be attempted by way of Main Ship Shoal Channel, Pudding Creek, and Little Inlet Channel. Smith Island Bay Channel should be avoided because of shallow water and shifting shoals. Persons unfamiliar with the waters and the channel markings of local watermen would be advised to engage the services of a waterman to guide them to the islands.

Smith Island is a longer barrier island than the islands immediately north of it. Its length along its axis is 7.1 miles but it has almost eight miles of seaward beach. The southern 25 percent of the island (Figure 75b) is a broad beach ridge area without any important marsh area on the bay side. This part of the island reaches a maximum of 0.85 mile in width, and averages 0.5 mile in width. The relief of this portion of the island is not great; ranging from 5 to 7 ft. in the beach ridge areas and 0 to 3 ft. over the rest of the area. There are numerous marshy swales between the beach ridge units and along the bay side of the island. The remaining 75 percent of the island extends northeast as a thin upland barrier island that averages 500 ft. in width. The associated marsh varies in width from 500 to 4200 ft., but the marsh behind the northern third of the island averages about 3500 ft. in width.

Smith Island is oriented at a sharp angle to the mainland coastline. The beach at the north end of the island is 6.6 miles east of the mainland, but the beach at the south end of the island is only 1.9 miles from the Intracoastal Waterway at the mainland. The mainland coast west of Smith Island trends N5°E, but the shoreline of the island lies at N45°E. This sharp angle can be attributed to the position that Smith Island occupies, between the tip of the mainland peninsula and the offshore trend of the Virginia Barrier Island Group. The seaward beach at the rounded north end of the island coincides with the seaward face of the barrier island chain to the north.

The area west of the northern half of Smith Island is proportioned about 2:1 between marsh and bay area. Much of the bay area is part of the long, narrow Magothy Bay

a. Smith Island Inlet. Smith Island is at the top of the picture and Fishermans Island is at the lower left. Surf pattern outlines shape of ebb tide delta, and reveals locations of channels that cross it. Note shallow bar at bottom center to the right of the sand spit.



b. Beach ridge provinces at the south end of Smith Island. Tower near center of picture is Cape Charles Light. Many of the beach ridges are forested, but others are only grass covered.

FIGURE 75: South End of Smith Island

which lies adjacent to the mainland. The marsh area is about equally divided between marsh and tidal flats and canals. Main Ship Shoal Channel runs north-south through the middle of the marsh area dividing the marsh of Mockhorn Island on the west from other marsh areas to the east. The southern end of Mockhorn Island lies west of the midpoint of Smith Island. The area west of the southern half of Smith Island is made up of Smith Island Bay, and westward, Magothy Bay. Smith Island Bay has numerous small marsh islands in it and many tidal flat areas. Magothy Bay is deeper, and has a deep channel running most of the length except at Smith Island Inlet where it is not well-defined because of shoals and multiple channels. Smith Island Inlet and the shoals in the inlet are shown in Figure 75a. Skidmore Island lies in Magothy Bay about a mile northwest of the southern part of Smith Island. There is a narrow fringe of marsh between Magothy Bay and the mainland.

II. PHYSIOGRAPHIC DESCRIPTION AND DISCUSSION

Most of the physiographic units in the area west of Smith Island can be identified as the southward continuation of units previously recognized and identified to the north. The Mappsburg Scarp is not present, because it died out several miles to the north. The ancient beach at the base of the Mappsburg Scarp continues southward into this area and can be recognized in the mainland terrain about 800 ft. inland of the edge of the tidal marsh. Near the south end of the mainland peninsula, the beach is closer to the edge of the marsh, and there are gaps in it where younger stream valleys cut across it. At the south end of the peninsula, near Dixon's Dock, the beach turns abruptly westward toward Chesapeake Bay.

The next physiographic feature to the east in this group of continuing features is a drowned beach ridge that lies offshore at Oyster, and forms the edge of the marsh at Townsend. This ancient beach ridge can be traced as a series of linear ridges lying in the marsh between Magothy Bay and the mainland, from Dunton Cove (northeast of Townsend) southward through this area to Dixon's Dock. Between this ridge and the mainland there are older drowned beach ridges in this area which were not observed in the areas to the north. These ridges are most strongly developed in the vicinity of Jones Cove, but can also be seen south of Cushman's Landing. North of Cushman's Landing they merge to a single ridge that continues north until it disappears along the west edge of Dunton Cove. South of Jones Cove the ridges are less distinct and have been destroyed in places by stream erosion when sea level was lower during the Wisconsin glaciation. But, they can be followed to Dixon's Dock.

Raccoon Island, Holly Bluff Island, and Skidmore Island are all ancient drowned beach ridge deposits. A beach ridge unit in Holly Bluff Island can be traced through the marsh to the mainland where it truncates the beach ridge units described in the preceding paragraph. The same ridge unit may also correlate with one of the beach ridges on Skidmore Island. Similarly, a younger beach ridge unit on Raccoon Island can be traced through the marsh to the mainland and in the other direction, toward Holly Bluff Island. All three islands contain drowned beach ridges of different ages and islands. These islands were not included for detailed analysis in this study, but should be investigated at a later time because there is good evidence that they correlate with the beach ridges on Mockhorn Island. Some of the deposits on these islands, and in the marsh at the south end of the mainland peninsula probably correlate with the ancient barrier island deposits found on the landward side of some of the modern barrier islands.

Mockhorn Island, located east of Magothy Bay, extends south to about the midpoint of Smith Island before it thins to a narrow peninsula and ends. The drowned beach ridges on Mockhorn Island were discussed at length in the section on Myrtle Island, and their

successive terminations record the eastward migration of the seaward face of the beach during the early Wisconsin recession of sea level. The southward convergence of those drowned beach ridges near the south end of Mockhorn Island, and the orientations of the seaward faces of the ancient beaches, conforms with an extension of that trend through Skidmore Island to Holly Bluff and Raccoon Islands, and finally to the southern end of the mainland peninsula.

In the marsh and bay areas between Mockhorn Island and Smith Island, there is no noteworthy physiography. Main Ship Shoal Channel runs through the marsh, maintaining depths in excess of 15 ft. for its entire length. Pudding Creek and Little Inlet Channel also cross this marsh with deep channels, but their depths have not been charted recently.

On Smith Island, itself, there are two provinces, the marsh area, and the upland barrier island area. The marsh area, which is primarily confined to the northern three-quarters of the island, can be considered in two parts: the northern and western portion; and the portion immediately west of the barrier beach deposits. The former is older, more typical, marshland. It is composed of silt, finer sediments, and organics to a considerable depth below the surface. In this older marsh near the north end of the island, there is a portion of a large ancient tidal canal and several areas of higher ground that resemble low mounds. There is no recognizable pattern to either feature so no interpretation was attempted beyond recognizing that they are ancient features of the marsh. The remainder of the marsh is a sandy marsh formed upon recently overwashed fine sand, on sand deltas and on inlet deposits from ephemeral inlet openings. This latter marsh unit is therefore younger, and relates to the past century or more in time. This marsh unit varies in width from several hundred feet at the north end of the island to as much as 3000 ft. near the middle of the island, and lies immediately west of the upland barrier beach deposits. Much of this marsh area is shallow in depth and rests upon a sandy stratum below.

The barrier beach deposits of Smith Island are more varied. The northern three-quarters of the island consists of an active beach area, a foredune ridge, discontinuous areas of dunes, and overwash channels and deposits. Mud Hole Creek at the north end is a formerly deep tidal canal that has been overwashed and cut off by retreat of the island. The modern beach and foredune ridge cut across this canal, but on the marsh side, the canal is deep and provides a safe anchorage for small boats at the north end of the island. Wind breaks and other shelters near this location indicate the frequent use of this anchorage by fishermen and others using the northern beach of Smith Island. To the south, for nearly three-quarters of the length of the island, the upland barrier island deposits consist of little more than an active beach and a low (4-8 ft.) dune line that is frequently cut through by overwash channels. North of the Bungalow Inlet area there are two recent broad overwash channels that each break the dune line for more than 0.3 mile. The nature of these overwash channels and of the overwash fans associated with them can be seen in Figure 76. Large volumes of sand have been carried through these overwash channels and spread over the margin of the marsh where the sand buries the Spartina alterniflora marsh grass. If the volume of sand is large enough, as it is with these two channels, it raises the elevation of the surface of the fan above mean high tide level and prevents the recovery of the marsh grass. When this happens, other plants (Figure 77a) move in to colonize the overwash fan, and new dunes (Figure 76b) begin to form as vegetation and dampness trap wind-blown sand. These processes widen the barrier island and help to maintain

and reinforce it. There are many locations along this part of Smith Island where this has happened in the past. Figure 77b shows a drift matt of Spartina alterniflora that has been driven onto one of the older overwash fans; one that had not built above the mean high tide, and still supported marsh grass. After the drift matt has decomposed, areas such as this frequently stand exposed as sand flats through several seasons until the marsh grass becomes re-established.

During this century, ephemeral inlets have broken through this portion of Smith Island at two general locations, often remaining open for years. Sand swept through those inlets by the flood tide has built sand deltas and inlet islands in the bay area behind the middle portion of the island. This influx of sand has also partially filled Smith Island Bay near the island and created extensive areas of tidal flats. The sand, moving with currents and waves in the bay, is also responsible for shoaling and shifting of tidal channels in the bay. Wherever these sand deposits built up enough to support Spartina alterniflora, they have been colonized by the plant, and new marsh has formed. Much of the marsh from the southern beach ridge province north to Mud Hole Inlet has grown upon this sandy base. At several places in this marsh area, long low sand spits reach back through the marsh to mark the location of former inlets. The most prominent of these marks the south margin of the former Bungalow Inlet. In many areas of the marsh bordering Smith Island Bay, sand is being carried up the tidal canals with the flood tide. This sand is building levees along the distributary canals, and is beginning to fill tidal flat areas within the marsh.

Near the north end of the island where the older marsh is located, retreat of the island has driven the beach back into large well-established tidal canals. Just north of Mud Hole one of these large canals is rapidly filling with sand being overwashed from the beach and redistributed by tidal currents. Other overwash channels are supplying sand to fill Mud Hole Inlet and a large embayed area just south of it.

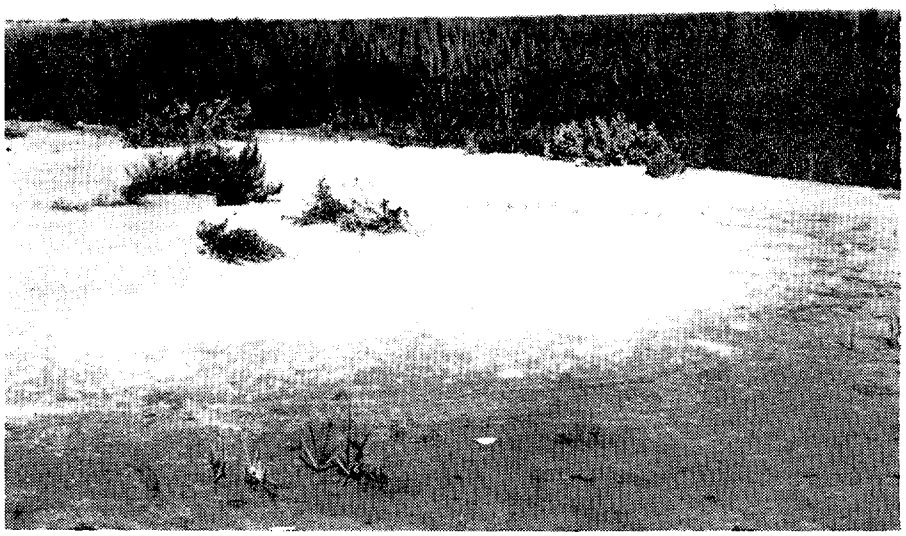
Retreat of Smith Island has moved the beach and dune lines back over older established marsh along most of the length of the island. Outcroppings of peat can be found in the beach and surf zone at many locations. The peat has a high organic content, is dense and compact, and is very resilient. It is also much thicker than any peat encountered while augering in any of the modern marsh areas. No attempt was made to auger through this tough peat with the split spoon hand auger used for sampling. However, the exposed thickness exceeded 5 ft., and the actual thickness is undoubtedly greater.

Figure 78b shows one extensive outcropping of peat that was located east of Mud Hole Inlet. A similar outcropping nearly a half mile long is located south of Bungalow Inlet. Sawed boards and small post clusters were found driven into the peat near the location shown in 78b. The post clusters were of the type that watermen drive in the marsh for securing boats. Both occurrences indicate that this peat outcropping was located on the bay side of the island within historical times. One of the posts was removed from the peat (with considerable difficulty because of the tenacious nature of the peat) in the hope that it might yield a date for the time when the location was still on the marsh side of the island. At this time no date (by tree ring dating) has been determined. Figure 78a shows a large and deep tidal canal in a peat outcropping north of Mud Hole Creek at the north end of the island. The canal has been partially filled with sand to the plane of the beach, but the peat walls of the canal stand several feet higher, and above mean high water.

a. Large overwash channel on Smith Island. Wind blown sand has been trapped by vegetation to form low oval mounds.

b. Large oval mound of sand in an overwash channel. Near to the beach, such incipient dunes grow and help to close the overwash channel.

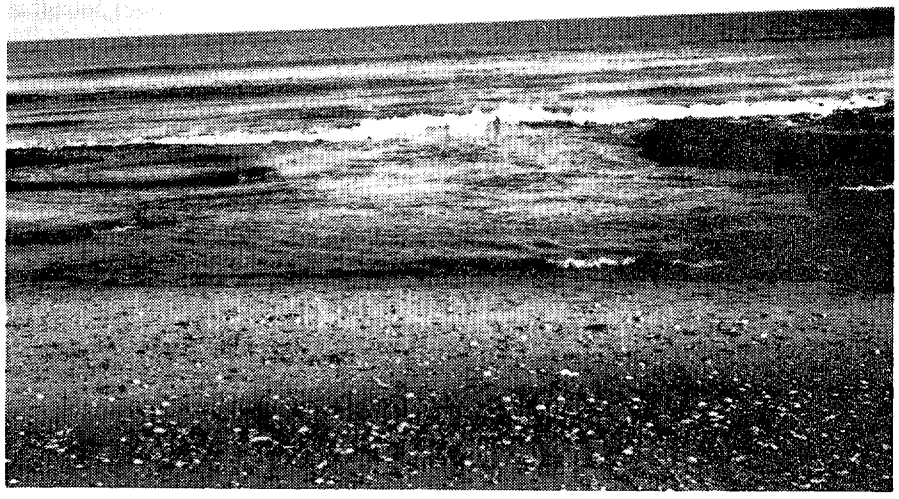
FIGURE 76: Large Overwash Channels on Smith Island



a. Overwash fan built into marsh near middle of Smith Island. Light area is wind blown sand that has begun to build up on the damp surface of the fan.

b. Drift matt on an overwash fan in the marsh behind the beach ridge near Bungalow Inlet.

FIGURE 77: Overwash Fans on Smith Island



a. Abandoned tidal channel through peat outcrop on the beach north of Mud Hole.

b. Continuous outcropping of peat on the beach between Bungalow Inlet and Mud Hole.

FIGURE 78: Peat Exposures on Beach at Smith Island

The southern quarter of Smith Island is very different from the northern three-quarters. This part of the island is an older beach ridge province made up of many beach ridges. The ridges occur in sets, with the ridges in each set being parallel to each other. Most adjacent sets of beach ridges meet at angles indicating a different direction of progradation for each set. The sets of ridges extend all the way to the southern tip of the island. The orientation of the sets varies but is generally east-west across the island. All of the ridges are low, rising to average elevations of 5-7 ft., and many of them are forested. The low areas between the ridges control a drainage system that connects ponds and small marsh areas with creeks that drain west to the bay. To the west, and south, these low areas become wider and take on the appearance of broad meadows or swales. All of the older ridges are truncated at their seaward end, and most of those lying south of Cape Charles Light are also truncated on the bay side. Younger beach ridges, roughly parallel to the shoreline, have been built against the truncated ends of the older ridges along the seaward side of the island. A younger sand dune field lies seaward of those ridges, and this sand dune field still is actively growing. All along the bay side of the island a very narrow fringing marsh lies between the truncated ends of the ridges and the bay. An old beach is found at the back of this marsh, against the truncated ridges, and across the lowland areas between the ridges.

The active beach along Smith Island varies from 150-250 ft. in width. The presence of many bars, both offshore and welded to the beach, indicates an active longshore drift system that is transporting sand southward along the beach. Along the southern half of the island, in particular, accretion is occurring along the beach in the form of broad back beach sand flats and actively growing sand dunes. At the south end of the island a recurved sand spit has grown in length and breadth during the past quarter century, even as it retreated.

III. SHORELINE CHANGES

The shoreline changes on Smith Island have been quite straightforward in comparison to what has happened to other islands in the Virginia Barrier Island Group. Smith Island has retreated, more or less steadily, to the northwest, since 1853. Two ephemeral inlets have opened, and closed, in the mid-portion of the island. The length of the island has diminished by a little less than a half mile, mostly due to losses at the south end. Smith Island Bay has been partially filled, and tidal circulation within the bay and behind Smith Island has been altered substantially. These latter changes are as important to the situation as the changes in the seaward beach, for they affect the future for Smith Island.

The changing appearance and position of Smith Island is portrayed in Figures 79, 80, and 81, which show the position of the shoreline at various dates during the historical period of this study. The two ephemeral inlets appear in all three figures and the changing shape and location of these inlets readily can be seen. Figure 81 also shows the extent of new marsh area that was built up inside both inlets between the opening of those inlets and their closings during the 1960's.

A. Tabular Presentation of Data

Table IV presents a summary of shoreline changes on Smith Island from 1853 to the present. Table V summarizes the shoreline changes that occurred on Myrtle Island

FIGURE 79.
SHORELINE CHANGES
ON SMITH ISLAND;
1871-1963

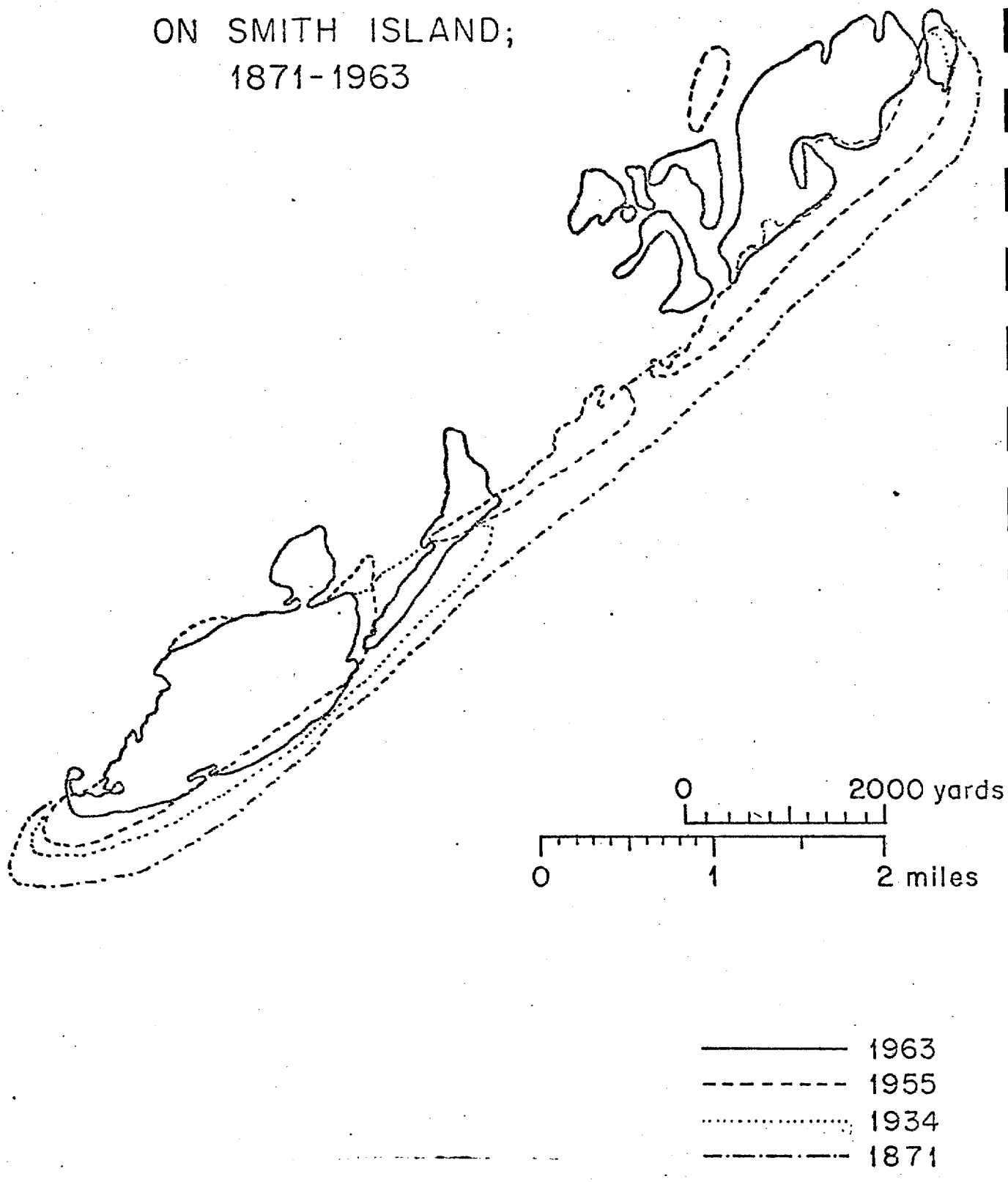


FIGURE 80.
SHORELINE CHANGES
ON SMITH ISLAND;
1911-1960

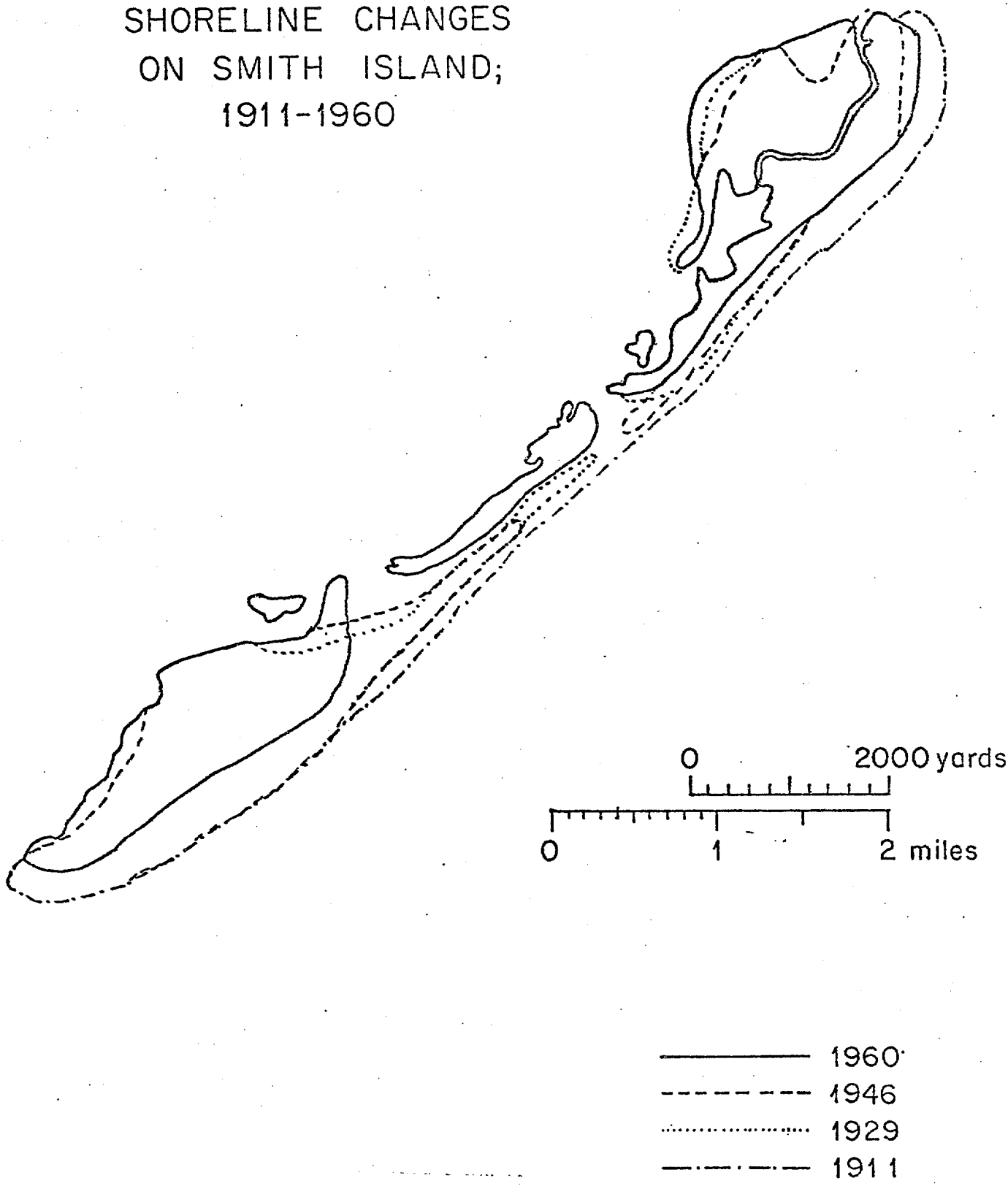
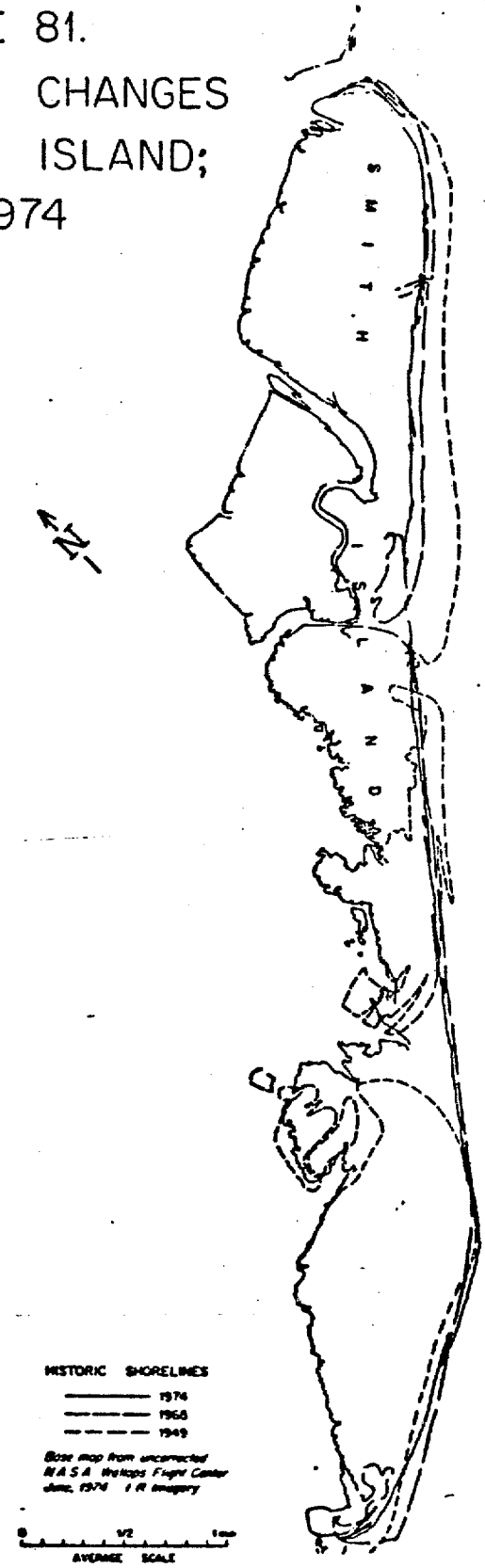


FIGURE 81.
SHORELINE CHANGES
ON SMITH ISLAND;
1949-1974



ITEM OR POSITION ON ISLAND	1888	1911	1929	1942	1955	1968	1974
SHAPE OF NORTH END	53 '28						
SHAPE OF INLET OR SPIT	—	—	B.I.	B.I. 2nd I.	B.I. 2nd I.	B.I. 64 64 2nd I	SPIT 74 68
MOVEMENT NORTH TIP	1170	670	1560	480	190	200	400
BEACH NORTH END	1000	680	1200	650	220	575	400
BEACH 0.5 MILES SOUTH	300	830	980	380	100	580	200
BEACH 1.0 MILE SOUTH	—	—	—	380	150	700	300
BEACH AT MUD HOLE	770	800	600	520	0	650	560
BEACH AT BUNGALOW INLET	770	330	Inlet open Beach trend 600	Inlet open Beach trend 500	Inlet open Beach trend 200	Inlet open Beach trend 1400	Inlet closed 200
BEACH 4.75 MILES	920	330	300	Inlet open Beach trend 600	Inlet open Beach trend 500	Inlet closed 200	180
BEACH AT OLD LIGHTHOUSE	830	230-0	0	450	150	75	180
BEACH SOUTH OF S.I. LIGHT	0-300	670	0	950	125	175	180
BEACH SOUTH END	400	670	0	450	250	900	700
SOUTHERN TIP	400	720	0	800	850	900	250
SOUTHERN SAND SPIT	—	—	—	—	300	800 1200	700 250

TABLE IV. SMITH ISLAND

Summary of shoreline changes; 1853-1974.

North is at top of page. Arrows indicate direction of movement. Lines show compass orientation. Numbers are in feet.

ITEM OR POSITION ON ISLAND	1871	1911	1929	1943	1955	1968	1974
SHAPE OF NORTH END							
MOVEMENT NORTH TIP	880 1000	300 1500	1200 420	120	270	1425	260
NORTH END NORTHERN BEACH	830	1300	ephemeral inlet	—	0	1210	550
FACING OF NORTHERN BEACH	E	E	ENE	NE	NE	NE	NE
MIDWAY ON NORTHERN BEACH	1000	750	900	880	80	330	450
SOUTH END NORTHERN BEACH	inlet 1200	inlet closed 0	1400	1300	70	350	525
NORTH END SOUTHERN BEACH	1200	0	1400	1300	170	2400	550
SOUTH END SOUTHERN BEACH	1200	300	900	400 140 TIP	140 TIP 120	400 400 250 TIP	175 175 TIP
FACING AND WIDTH OF LITTLE INLET	830	1200	1600	1380	1650	780	870
OBSERVATIONS	S. S. INLET → UNSTABLE CHANNEL		S. S. INLET → EBB TIDE DELTA				

TABLE V. MYRTLE ISLAND.

Summary of shoreline changes; 1852-1975.

North is at top of page.
Arrows indicate direction of movement.
Lines show compass orientation.

Numbers are in feet.

during the same period of time. The dates given at the head of each column are the dates of the maps and charts utilized in making the measurements of shoreline changes. Information for the initial interval (1853-1888) was derived from Byrne's (1972) Historical Shoreline Positions maps. The movement indicated in any column box is the net movement during the observation period. The tables clearly show the northwestward migration of the main body of Smith Island, and that, except for the period from 1942 to 1955, retreat was uninterrupted. The tables also show that both ends of the island experienced changes that were independent of the retreat, but were related to the inlets found there.

B. Summary of Retreat

As one would expect (after examining Figures 79, 80, and 81), the rate of shoreline retreat along the island's beach has not been uniform, even though it has been more or less steady. The net retreat of the north end of the island has been a little less than 3000 ft., and the averaged rate of retreat has been 24.7 ft./yr. However, it should be noted that retreat during the 1900's when it has occurred, has occurred at a more rapid rate than during the latter half of the 1800's. Retreat since 1955 has been at the rate of 51.3 ft./yr. whereas prior to 1911, it occurred at an average of 29.0 ft./yr.

The maximum retreat has occurred opposite Mud Hole where net retreat has reached 3900 ft. since 1853. This yields an averaged retreat rate of 32.2 ft./yr. Retreat increased steadily between the north end of the island and Mud Hole. To the south, past Bungalow Inlet, retreat remains almost as high before it begins to diminish steadily further south. At Bungalow Inlet the retreat rate has averaged 29.8 ft./yr., but further south, at the second ephemeral inlet, the averaged retreat rate has only been 23.0 ft./yr. which is about the same as the retreat rate at the north end of the island. To the south the retreat rate falls off sharply. Thus, the greatest retreat is centered between Bungalow Inlet and Mud Hole, and retreat diminishes away from that area. Retreat of the southern quarter of the island, where the beach ridges are found, has been very much less. At the site of the old lighthouse and life saving station, retreat since 1853 has been slightly more than 1900 ft., and more than 1000 ft. of that retreat occurred prior to 1911. The averaged rate of retreat at this location has been only 15.8 ft./yr. South of Cape Charles Light the beach has had an averaged retreat rate of 14 ft./yr. since 1853, but has actually been accreting for the past 20 years. The south end of the island has retreated north a net distance of about 2070 ft. since 1853, or at a rate of 17.1 ft./yr. It should be emphasized that this is a net rate because the island has grown southward on two occasions.

C. Discussion of Retreat

While the shoreline changes on Smith Island are more straightforward than on other islands, the explanation of them is not. As with other islands, it is necessary to look to the time period 1853 to 1911 to find the beginning of an explanation. Prior to that time period, a previous cycle of retreat had been operating under a different set of conditions. Not long after 1853 the channel at Ship Shoal Inlet (several miles north of Smith Island) abruptly changed its course and began a series of changes that have continued into the present century. The changes of the inlet channel led to changes in the ebb tide delta that lay offshore, and thus changes in the longshore sediment transport system. Although Ship Shoal Inlet is north of Myrtle Island the effect of changes at that inlet were reflected down the coast to affect Little Inlet and Smith Island. In the mid-1800's, when these changes started, Little Inlet was an established,

if lesser, inlet with a deep (up to 35 ft.) channel. The tidal circulation pattern of Little Inlet passed through extensive marsh areas to connect with channels in Smith Island Bay. The 1921 hydrographic survey showed that the ebb tide delta at this inlet had increased in size since the previous (1911) survey, and that the channel back into the marsh had changed little.

D. (1853-1911)

Smith Island had been retreating steadily, more or less uniformly, until sometime after the hydrographic survey of 1911. The northern quarter of the island was backed up by broad marsh areas, and the southern quarter of the island was a broad beach ridge province. But the middle half of the island formed the southeastern boundary of Smith Island Bay. Retreat of Smith Island before 1911 had gradually driven the beach and dune line back over the narrow marsh area on the southeast edge of Smith Island Bay, until by 1911, there was little marsh left to be overridden. The mid-portion of Smith Island had been reduced to a thin (as little as 300 ft.) ribbon of beach, dunes, and overwash channels between the open sea and the bay. The situation was very similar to that on Metomkin Island just prior to the time when that island broke through into Metomkin Bay. In Smith Island Bay water depths of 2-8 ft. were charted for the entire area of the bay. There were very few tidal flats shown, and those that were shown were small. There was a well-established network of tidal channels in the bay that drained to Ship Shoal Inlet, New Inlet, and Smith Island Inlet. Depths of 15-22 ft. were found in the main stems of these drainage networks and there was sufficient water depth in the bay for boats to navigate directly across the bay to New Inlet and Ship Shoal Inlet. A channel from Little Inlet passed through the marsh and entered Smith Island Bay with depths of 14-16 ft. near the north end of the thin middle portion of the island. Tidal channels of the bay that connected into this channel also lay close behind the beach of the middle of the island, so that deep water, instead of marsh, lay behind much of this part of the island. Conditions by 1911 were ideal for Smith Island to breach into Smith Island Bay.

E. (1911-1929)

The hydrographic surveys of 1911 and 1921 provide enough evidence to show that changes were in progress. The ebb tide delta of Ship Shoal Inlet had begun to grow south in front (seaward) of Myrtle Island and toward the ebb tide delta at Little Inlet. In a gross sense, it may be stated that this started a pulse (volume) of sand moving southward, the effects of which would be seen for many years. In the same interval of time, Smith Island breached into Smith Island Bay. The breach shown by the 1921 hydrographic survey was 4980 ft. wide. However, the shape and pattern of the sand spits at the ends of the breach would indicate that the initial breach may have been more than a mile wide. By 1929, the tidal channels leading to Little Inlet had already been partially filled with sand being drawn in through the breach, and through Little Inlet. The trapping of sand at Little Inlet indicates that tidal circulation through this inlet had changed during this time span. In the northern part of Smith Island Bay, channels leading to Main Ship Shoal Channel had shoaled and water depths in the bay had decreased markedly, along with an increase in the number and size of tidal flats. The similarity to more recent changes in Metomkin Bay should be noted here.

F. (1929-1942)

In the interval after 1929, the effects of the changes in the ebb tide delta at Ship Shoal Inlet began to be more visible. The beach along the southern part of Myrtle Island

grew seaward. Little Inlet narrowed as Myrtle Island grew south, and the north end of Smith Island retreated south to maintain Little Inlet. Sand drawn into Little Inlet accreted on the north bank of the inlet channel. The ebb tide delta at Little Inlet merged with the south lobe of the Ship Shoal Inlet ebb tide delta. The ebb tide delta at Little Inlet also became larger, shallower, and more clearly defined. The very north end of Smith Island grew seaward about 650 ft. as the ebb tide delta at Little Inlet expanded. Reduced beach erosion along the northern mile of beach would indicate that some sand was being bypassed around Little Inlet. The "pulse" of sand was moving south, but some of it was being drawn into Little Inlet where it was helping to change the pattern of tidal canals and tidal circulation.

At the breach in Smith Island, which was now called Bungalow Inlet, the effects of additional sand were obvious. The breach had narrowed to an inlet that was 650 ft. wide. Beach retreat near the inlet was diminished. The beach and dune line had been rebuilt, and the recurved sand spits at the inlet were long and broad. Large amounts of sand were being trapped at Bungalow Inlet. Sand deltas were being built into Smith Island Bay and tidal circulation in the bay was redistributing sand to fill the bay. A significant portion of the new sand was also being drawn into marsh areas by tidal canals, and the nature of the marsh began to change. The changes in the marsh and bay also signify that tidal circulation was still undergoing a change.

Trapping of sand at Bungalow Inlet resulted in accelerated retreat south of the inlet. A second breach (more than 1500 ft. wide) had opened at the north end of the beach ridge province. This new inlet connected to a deep channel (15-22 ft.) in Smith Island Bay that led to Smith Island Inlet. A deep channel in Magothy Bay that led to Smith Island Inlet lay just to the west of the first channel. This new inlet became dominated by the flood tide and served to draw large volumes of sand into Smith Island Bay. Inlet Islands and tidal flats grew rapidly in the bay, and gradually reduced total circulation through the inlet as they ringed the inlet opening, and excess sand filled the bay.

G. (1942-1950's)

The channel at Ship Shoal Inlet began to turn northward after 1942 and in the period between then and the mid-1950's, the effects of this change began to be visible on Myrtle and Smith Islands. The rate of accretion of Myrtle Island decreased markedly. The southern end of Myrtle Island retreated, allowing Little Inlet to increase in width. Sand accreted inside the inlet on both Myrtle Island and Smith Island, where it served to build up and broaden the ends of both islands. A shoaling bar lay along Little Inlet Channel on the north lobe of the ebb tide delta in 1949, and shoals and bars lay off the north end and northern beach of Smith Island. These features indicate a reduction in sand trapping at Little Inlet, and an increase in the amount of sand bypassing the inlet. The whole northern three-quarters of Smith Island advanced seaward during this time interval in spite of there being two ephemeral inlets, each of which was trapping sand from the longshore drift system. The "pulse" of sand had reached Smith Island. Large volumes of this sand were drawn into Smith Island Bay through the two ephemeral inlets, but enough of it continued southward along the southern quarter of the island to dramatically reduce the retreat of the beach. The beach at the south end of the island accreted 250 ft. and a sand spit grew into Smith Island Inlet.

Sand drawn in through Bungalow Inlet filled the north end of Smith Island Bay and created extensive tidal flats. The tidal canal named Mud Hole Inlet had been cut off from circulation with Smith Island Bay by the Bungalow Inlet deposits and it was filling in. Big Creek was also choked with sand from the inlet as were other nameless canals that formerly made up the channel network that tied Little Inlet to Smith Island Bay and South Bay. These changes are all clearly visible in the 1949 black and white aerial photographs of the area. It is obvious that in this time period the changes at Little Inlet, and to Smith Island and Smith Island Bay were forcing an adjustment in the tidal circulation to the marsh areas west of Myrtle Island and at the north end of Smith Island. These changes all involved tidal circulation through Little Inlet and to a lesser degree tidal circulation through Main Ship Shoal Channel.

H. (Mid-1950's-1968)

By the mid-1950's the "pulse" of sand had passed and the area of coastline discussed in the previous paragraphs gradually returned to more normal conditions. Further changes had occurred in the marsh and along the shoreline by 1968. The inlet channel across the ebb tide delta at Ship Shoal Inlet had shifted further to the north, and a secondary flood tide channel had begun to form off the northern beach of Myrtle Island. This beach was clearly under the influence of inlet processes and had accreted rapidly. Sand was again bypassing the ebb tide delta at Ship Shoal Inlet, and accretion was occurring along the southeast beach of Myrtle Island. A more usual longshore drift system was again functioning along this section of shoreline.

At Little Inlet other changes were apparent. The inlet had narrowed to less than half of the former width, indicating a sharp reduction in the volume of water moving through the inlet on the tidal cycle. The reasons for the reduced volume of water are found in the marsh areas adjacent to Little Inlet. Mink Creek had been blocked by deposition of sand in its network of tidal canals. A new network of lesser tidal canals had developed further west to assume the reduced function of Mink Creek. Big Creek had partially filled with sand, and its functions were taken over by Black Rock Channel further to the west. The channel called Mud Hole Inlet had continued to shrink as it filled in, and furthermore, Mud Hole Creek had been cut off by beach retreat. Mink Island Bay had become a tidal flat, and so had most of the north end of Smith Island Bay. Most of the deeper canals that had interconnected Little Inlet, Smith Island Bay, and Main Ship Shoal Channel were filled in or severely reduced in size. In effect, the drainage area of Little Inlet had been reduced in size, and the inlet became smaller as it adjusted to the change.

Some sand was being trapped at Little Inlet. Sand spits and dune fields had grown along the north side of the inlet channel and spread from Myrtle Island onto the former southeastern corner of Mink Island. Similar accretion was occurring along the south side of the channel, and the beach ridge at the north end of Smith Island had grown in size and elevation (maximum elevation, 9.0 ft.). An island had formed in the mouth of Mud Hole Creek, just inside the inlet, and a sandy beach had accreted along the edge of the marsh west of this canal.

Outside Little Inlet, sand was being bypassed around the inlet on the ebb tide delta. Bars and shoals curved seaward at the south end of Myrtle Island, and lay off the north shore of Smith Island. A sand ridge had grown offshore and welded to the north end of

Smith Island. The beach ridge along the north end of Smith Island at Little Inlet continued seaward and curved south behind the beach for about 0.7 mile before it was cut off by the overwash channel that had cut off and blocked Mud Hole Creek. Small sand bars lay off shore and in the surf zone along the northern beach of Smith Island from the inlet south to Mud Hole, where they died out. All of these features are accretional, and indicate that longshore transport of sand from Ship Shoal Inlet (or farther north) was reaching the northern end of Smith Island.

However, it is obvious that the volume of sand reaching the north end of Smith Island during this interval of time was inadequate to offset losses of sand along the beach of Smith Island. Retreat of the beach continued between the north end of the island and Bungalow Inlet, and the north end of the island retreated south by 200 ft. Retreat on this reach of beach averaged 600 ft. A large overwash channel had developed at Mud Hole Creek, and a new ephemeral inlet was open nearby. The inlet was connected by the southern part of Mud Hole Creek to Mud Hole, and thus to a large marsh area behind the north end of Smith Island. A large volume of sand had been removed from the drift system by these two features. The overwash channel had filled a portion of Mud Hole Creek and spread into the marsh west of it. The ephemeral inlet was trapping sand, and this sand was filling the southern part of Mud Hole Creek and apparently carrying farther through the canals to reach Mud Hole.

Bungalow Inlet was still open but had narrowed to 200 ft. A long sand spit had grown 2000 ft. into Smith Island Bay along the southern shore of the inlet channel. The north side of the inlet did not have a corresponding sand spit. The beach of Smith Island curved gently at the north side of the inlet to form the inlet opening. Sand eroded from the beach north of the inlet was trapped at the inlet and deposited in the north end of Smith Island Bay. Where there had been open bay behind the middle half of Smith Island in 1911, there was now an area of marsh and tidal flat at least 2000 ft. wide, and more than half of the area was in marsh.

Beach retreat was dramatically less along the beach south of Bungalow Inlet. Retreat had averaged 600 ft. north of the inlet. South of the inlet, to the north end of the beach ridge unit, retreat was only 200 ft. The southern (second ephemeral) inlet at the north end of the beach ridge unit had closed, the beach line had straightened. A line of low dunes had formed where the inlet had been. From this inlet location south to the old lighthouse, retreat declined rapidly to 75 ft. at the location of the former light and to zero just south of that location. From there south to near the end of the island, the beach accreted by as much as 175 ft. However, the south end of the island retreated northward by about 900 ft. The sand spit that recurved into Smith Island Inlet, although also shifted northward, had grown in length and breadth and developed a sand dune field.

The dramatic changes in the rates of beach retreat along Smith Island during this time span clearly demonstrate the role played by the ephemeral inlets in controlling retreat along the beach. Along the northern third of the island the longshore drift system was inadequate to supply the demand imposed by sand trapping at Bungalow Inlet. Sand was therefore removed from storage in the beach prism of the northern third of Smith Island, and the beach retreated at a rapid rate. South of Bungalow Inlet the second inlet closed and stopped trapping sand. The demand for sand was reduced to that which was needed to close the inlet, straighten the beach, and reconstruct a dune

line. Therefore, less sand was taken from storage in the beach prism of the middle third of the island, and the retreat of the beach was only about 30 percent as great as that on the northern third of the island. With the second inlet closed, the shoreline changes along the southern third of the island were occurring as adjustments of the beach to the single influence of a wave-driven longshore drift system. This system requires a straighter beach, and the shoreline changes that occurred served to produce a straighter beach.

The changes to the southern end of Smith Island seem to be a return to a retreating situation that had persisted throughout the 1900's, except during the time interval from 1942-1955, when the "pulse" of sand was passing. Events between 1955 and 1968 are certain to have influenced this return to a condition of retreat. The second ephemeral inlet closed which served to increase the volume of water moving through Smith Island Inlet on the tidal cycle. The closing also changed the current pattern offshore of the southern quarter of Smith Island by removing the effect of that inlet's currents along that part of the beach. The inlet channel past the end of Smith Island had begun to shift westward in the early part of this century, and that shift would also have led to a change in inlet currents near the south end of the island. The sand spit at the south end of the island began to grow north northwestward in the 1930's, and by 1942 it had reached a length of about 1100 ft. and a width of about 150 ft. Erosion of the west side of Smith Island was halted during this same interval of time, and a fringing marsh began to develop. By 1968, this sand spit had grown to a length of over 1700 ft. and a width of about 550 ft. Tidal flats had grown in front of the fringing marsh all along the west side of Smith Island. All of these changes are a response to changing inlet currents along the southern part of the island.

I. (1968-1974)

All of the ephemeral inlets on Smith Island had closed by the spring of 1973. Although some overwashing was still taking place in the vicinity of Bungalow Inlet and Mud Hole Creek, the episode of breaching into Smith Island Bay had drawn to a close. Overwashing would continue at various locations as part of the normal process of retreat and build up of the barrier island. Little Inlet had begun to increase in width and by 1974 was more than 900 ft. wide. The reason for the increase in width was an increase in tidal circulation through the inlet. Drainage to Little Inlet was becoming re-established. The tidal canal named Pudding Creek had deepened, providing a better connection to Main Ship Shoal Channel. The channel from Little Inlet to Pudding Creek (not named) had extended into the tidal flats at the north end of Smith Island Bay. A broad and deep channel extended a mile south of the southern sand spit from Bungalow Inlet before it branched into a dendritic network of minor channels. The north end of Smith Island Bay was again directly connected to Little Inlet. The drainage in the marsh of Mink Island had also changed. Mink Island Creek no longer provided a meaningful connection with Ship Shoal Inlet. Big Creek had filled in, adding a section of marsh to the west end of Mink Island. Black Rock Creek had diminished in size and was clearly closing off near the southwest end of Mink Island. Mink Island Bay had filled and become part of the marsh of Mink Island. Two large tidal flats west of Mink Island Bay were also beginning to fill and become marsh. For all practical purposes, Mink Island no longer existed, except in name. The marsh area behind Myrtle Island extended west to Main Ship Shoal Channel and Pudding Creek. The northern half of the marsh was draining to Main Ship Shoal Channel, and the southern half drained

to the channel from Little Inlet. The marsh behind the northern third of Smith Island drained to Little Inlet, and a new network of tidal canals was becoming established. Trapping of sand at Little Inlet has contributed to the change in tidal drainage at Mink Island Bay and at the eastern end of Mink Island.

By 1974 the changes to the shoreline of Smith Island had produced a very much straighter beach, which curved inward slightly along the middle portion of the island. Retreat of the northern part of the island was still rapid, occurring at rates of 50-65 ft./yr. Much of this retreat can be attributed to straightening of the beach and continuing overwash which is transferring large volumes of sand to the marsh area. The area of most rapid beach retreat is located between Bungalow Inlet and the north side of Mud Hole. This is also where overwash is still occurring. South of Bungalow Inlet the beach has not been overwashed in recent years, and a dune ridge runs the length of this beach. This portion of the beach has been retreating, but the rate has been only about half as great as in the section near Mud Hole and about equal to the rate at the north end of the island, south of Little Inlet. Retreat diminished southward to zero at the bend in the beach southeast of Cape Charles Light. South of the bend, the beach accreted as much as it had retreated just north of the bend. Retreat at the tip slowed, and the sand spit continued to grow in area. These changes all indicate that shoreline processes are adjusting to a wave-driven system. The shoreline is straightening, and will continue to retreat, but the rate of retreat can be expected to diminish in the near future.

IV. GEOMORPHIC DESCRIPTION AND INTERPRETATION

A. Area West of Barrier Islands

The geology of the marsh and bay area between the mainland coast and the barrier islands south of Sand Shoal Inlet includes some geomorphic features that extend north and south for distances greater than the length of an individual barrier island. Therefore, discussion of these features was omitted from the sections dealing with Wreck Island, Ship Shoal Island, and Myrtle Island. Many of those geomorphic features terminate west of Smith Island, and the discussion of all of them is included in this section.

An erosional feature known as the Mappsburg Scarp lies at, or very near, the mainland coast at the western limit of the area covered by this discussion. The scarp is a wave-cut cliff that averages about 25 ft. in relief. It has been eroded into barrier island deposits of late Sangamon age that have been dated at 65,000 years BP (Mixon, et al., 1974). North of Oyster the west shoreline of Brockenberry Bay coincides with the base of the scarp. The scarp can be traced northward for miles but it passes inland from the modern shoreline north of Indian Town Neck. Southward from Brockenberry Bay to Dixon's Dock near the south end of Magothy Bay, the coastline is straight. The Mappsburg Scarp lies within a few hundred feet of the coastline as far south as the north end of Magothy Bay where the sea cliff begins to fade away to more gently sloping topography. There is an ancient beach at the base of the scarp, and where the modern shoreline is not governed by the base of the scarp, it follows this ancient beach. From the north end of Magothy Bay southward to Dixon's Dock this ancient beach lies at the landward side of the thin strip

of marsh along the west side of Magothy Bay. West of Dixon's Dock this ancient beach turns sharply west and follows a west southwest course across Cape Charles to Chesapeake Bay. Near Chesapeake Bay a 20-ft. sea cliff lies behind the beach.

In the physiographic descriptions of each of the four barrier islands included in this discussion, there were descriptions of two groups of beach ridges that were found in the marsh and bay area. One group of beach ridges is found west of (or in) Magothy Bay and Mockhorn Bay. The second group of beach ridges is east of those bays in the marsh area between them and South Bay and Smith Island Bay. All of these beach ridges diverge eastward away from the line of the Mappsburg Scarp as they are traced northward. This same divergent pattern can be seen in the ancient beach ridges west of Hog Island Bay.

In the first group of beach ridges, one can be traced easily on the U.S.G.S. topographic maps for this area. The other beach ridges in this group are more easily located and traced on the black and white and IR imagery. The ridge that can be traced on the topographic maps begins at the strip of marsh between Brockenberry Bay and Ramshorn Channel, runs southward as a string of marsh islands in Mockhorn Bay, and on through the middle of the marsh that separates Mockhorn Bay from Magothy Bay west of Mockhorn Channel. Further south it passes west of the small cove at the south end of Dunton Cove and along the edge of the marsh to Cushman's Landing, then across Jones Cove to merge with an older beach ridge to the west. The merged beach ridges can be traced southward to Dixon's Dock where they join the deposits associated with the ancient beach that cuts across the south end of the peninsula to Chesapeake Bay. The beach ridges in this nearshore group must predate the major fall of sea level during the Wisconsin glaciation, because they are all cut through by valleys of streams draining from the mainland. The group of beach ridges records the beginning of a drop in sea level, following the time when the Mappsburg Scarp and beach were produced.

Most of the beach ridges in the second group are contained in the marsh area identified as Mockhorn Island, but there are beach ridges in New Marsh at the north end of Mockhorn Island and in the marsh east of the southern portion of Mockhorn Island. Other beach ridges are found in Elkins Marsh. The larger of these beach ridges rise far enough above the level of the marsh to be forested, but not enough to be contoured on the topographic maps. Some of them are shown on the topographic maps as sandy and forested areas in the marsh of Mockhorn Island. The pattern of eastward divergence to the north can also be seen in the beach ridge pattern on the topographic map, although it is much easier to see in aerial photographs. The long southward tapering shape of Mockhorn Island is a consequence of the merging of these beach ridges to the south. The relief of the beach ridges also declines progressively to the east in respect to modern sea level, which is a reasonable indication that they had each formed at progressively lower sea level stands.

The merged beach ridges at the southern end of Mockhorn Island curve gently southwest toward Skidmore Island at the south end of Magothy Bay. There are ancient beach ridge units on Skidmore Island that trend generally east northeast. They are truncated on both ends by the modern shoreline of the island. The northernmost of these beach ridge remnants line up with a similar beach ridge remnant on Holly Bluff Island to the southwest of Skidmore Island. The trend continues to the ancient beach deposits at Dixon's Dock, and these in turn continue west southwest across the south end of the mainland

peninsula. It is believed that these features on the west side of Magothy Bay correlate with the merged beach ridges at the south end of Mockhorn Island. Together they define an ancient coastline north of Chesapeake Bay. The pattern of these ancient beach ridges (diverging to the north; merging to the south) provides a record of changing shoreline positions during the initial withdrawal of the sea caused by the onset of Wisconsin glaciation. The pattern fades out to the east and is lost at about the position of the western half of South Bay. East of there the elevation of the tops of the beach ridges would be below modern sea level.

In the area between these beach ridges and the modern barrier islands, there is little other ancient geomorphology. There are inlet island deposits and abandoned natural levees at places in the marsh areas that may be ancient, but they are so scattered that there is no discernable patterns from which they might be interpreted. The antiquity of those features is thus unknown. It would appear that marsh and bay sediments in this area are young and simply cover older features. A considerable portion of the marsh in this area has formed during historical times, and much of that within the past sixty years. This area thus isolates pre-Wisconsin beach ridge features from post-Wisconsin barrier island features.

B. Smith Island: Ancient Beach Ridge Province

On Smith Island, the oldest geomorphic features are found in the beach ridge province of the southern quarter of the island. There are no significant older geomorphic features on the northern three-quarters of the island. The northernmost beach ridge in the southern beach ridge province is the oldest unit, and each beach ridge to the south is younger. The northern beach ridges are also higher than those farther south. The northernmost beach ridge is a short ridge that reaches seven feet in elevation. It can be seen on the topographic map northeast of Cape Charles Light, and midway in the width of the island. On the Geologic Map of Smith Island this beach ridge is located in the northwesterly prominence on the north edge of the beach ridge unit shown on the map. Detailed examination of the ridge in the vicinity of its highest point reveals that the high area is the remnant of a northwest trending sand spit. Two lower and thinner sand spits that also trend northwest lie on its west side. A low narrow beach ridge runs nearly due east from the highest point, for a distance of 1800 ft., before it disappears under a younger ridge. Just south of the highest point, but not connected to it, a second low narrow beach ridge parallels the first to the east. Westward, this second beach ridge starts to recurve to the northwest, but is truncated at the modern beach of Smith Island. The northern of these two narrow beach ridges was obviously a sand spit with a well developed sand dune ridge where it hooked into the inlet. This could only be the western end of an ancient barrier island.

It is equally obvious that that ancient island was being driven back into Smith Island Bay when something stopped the retreat, and left the remnant found today. The second narrow beach ridge that parallels the first is younger, and was formed shortly after retreat of the ancient island had been halted. Both of these ridges terminate to the east where a third low beach ridge cuts across them at a small (13°) angle. This third beach ridge trends more nearly east northeast, and is cut off by the modern beach deposits at its east end. At the west end a sand spit recurves to the northwest before it is truncated at the modern shoreline of Smith Island.

This third low beach ridge is rotated counterclockwise with respect to the first two, reflecting beach erosion on Smith Island in an easterly direction, and sand spit

extension in a westerly direction. It is believed that this third beach ridge was produced as a result of shoreline adjustments that took place along the seaward (SE) facing beach of Smith Island as retreat of the island was halted. These first three beach ridges are treated together as the first beach ridge unit; one that records the end of an ancient retreat of Smith Island.

To the south of the three ridges previously described, there is a group of five ridges that make up a second beach ridge unit. The first, second, and fifth of the beach ridges in this second unit are prominent and continuous; the third and fourth are lower and discontinuous. The beach ridges in this group are nearly parallel to the third ridge in the previous group, but they are oriented a little more to the east. All five ridges in this group are truncated at their eastern end at the 1949 shoreline and thus terminate against younger deposits. The first ridge in this group has two sand spits at the western end, each of which recurves to the northwest. The older of these two sand spits terminates on the island, but the larger, younger one is truncated at the modern beach. The second ridge in this group extends further west than the first and ends with several sand spits which recurve northwest to west northwest and terminate at the shore of the island. The third prominent beach ridge in this group is about 400 ft. south of the second and separated from it by a broad sand flat on which the lower, discontinuous third and fourth beach ridges are located. This last prominent beach ridge merges with a younger beach ridge midway across the island and the merged ridge continues west across the island until it ends in a broad overwashed recurved sand spit that terminates on Smith Island. This second group of beach ridges records a period of rapid progradation of the ancient barrier island, during which time the island grew westward more than 3100 ft. and southward by 900 ft.

The third beach ridge unit to the south is oriented more to the east than the second one was, and its northernmost ridge meets the second beach ridge unit at an angle of 5°. This unit is truncated by an old strand line along its southern margin so that ridges that are present on the eastern side of the island end when they encounter this strand line. At the eastern end this unit is more than 1350 ft. wide, but at the western end of the island, it is only about 750 ft. wide because of erosional losses along the old strand line. There are nine parallel beach ridges of fairly uniform height and size in the unit, and a number of smaller, discontinuous beach ridges. The northernmost beach ridge merges with the southernmost ridge of the second beach ridge unit and the two continue west as a single but larger beach ridge. The second ridge in this unit merges with the first near the middle of the island, but just west of that, one of the discontinuous ridges takes up the position of the second ridge and continues west until it ends on the island as an overwashed sand spit that recurves northwest. Further south near the middle of this beach ridge unit, there is a cluster of ridges spaced very closely together. At the east side of the island there are three distinct ridges in this cluster, but across the middle of the island the number varies from three to five. At the western end of these closely spaced beach ridges, the two northernmost ridges recurve to the northwest and merge with a younger, composite, northwest trending sand spit, but at least three younger and smaller ridges die out before they reach the western part of the island. The next beach ridge south, reaches the middle of the island before it is truncated by the old strand line that marks the south boundary of this beach ridge unit. Each successively younger beach ridge is truncated further to the east along this strand line. There is a beach ridge along

the north side of this old strand line, and all of the truncated beach ridges merge into this one beach ridge. At the western side of the island the strand line turns sharply to the northwest and the beach ridge associated with it recurves northwest and ends abruptly on Smith Island. Farther to the northwest, the strand line has reworked older sand spits (of this beach ridge unit) to make a large broad composite sand spit that is truncated at the modern beach line. This third beach ridge unit represents a second phase in a continuing period of rapid progradation of this end of Smith Island. The old strand line clearly indicates that this second phase of progradation was followed by a period of reshaping of this south end of the island to establish a nearly east-west shoreline. The recurving of the shoreline to the northwest along a sand spit indicates the continued presence of an inlet channel near the west end of the beach ridge unit.

The fourth beach ridge unit to the south is a narrow unit, bounded north and south by old strand lines. It is about 650 ft. wide near the east end but narrows to a width of about 165 ft. at Cape Charles Light and maintains that width as it recurves northwest to the modern shoreline. On the U.S.G.S. Topographic Map it appears as the thin triangular forested area that lies due east of Cape Charles Light. It contains seven to ten closely spaced beach ridges and no noticeable depressions or swales. The southern boundary is a low (3-4 ft.) wave-cut scarp east of the lighthouse, but it is only a break in the topography along the northwest sand spit west of the lighthouse. The trend of the beach ridges is turned about 4° clockwise of the older strand line, which places them almost eastward in orientation. The beach ridges come in to the older strand line, where they are successively welded onto the old beach. The younger strand line is oriented 3° clockwise of the trend of the beach ridges, so that it does not truncate many of the ridges. This beach ridge unit represents a third phase of progradation of this part of the island that was, in turn, ended by a return to conditions of reshaping of the shoreline by erosion. The southward rotation of both the beach ridges and the second strand line indicate that to the east of the modern island, the ancient Smith Island continued to prograde toward the south and east.

The fifth beach ridge unit to the south is a double ridged unit about 250 ft. wide. It parallels the older strand line east of the lighthouse, but west of the lighthouse it does not recurve to the northwest. It continues straight west until it is truncated by a modern beach. Both of the ridges in this unit have south-facing wave cut scarps from the lighthouse eastward to where the unit is truncated against modern deposits. West of the lighthouse, there is a series of low sand spits that progressively curve from the north side of this ridge unit to the northwest, but the two beach ridges of the unit continue through as partially overwashed lower beach ridges. The series of sand spits along the northern of these two beach ridges record the progressive westward growth of the sand spit and beach ridge that built upon it. The southern boundary of this unit is another strand line that is oriented 3° clockwise of the one at the northern margin of the unit.

This fifth beach ridge unit is interpreted as an intermediate (fourth) stage in a changing history of progradation. The straight through pattern of the ridges indicates that the southern tip of island had begun to grow to the west. This in turn implies that changes in the inlet channel had occurred that would allow this westward growth. The wave-cut scarps on both ridges probably reflect the oscillations of the beach that normally accompany changes in inlet processes.

The character of the beach ridge province changes south of the fifth beach ridge unit. The beach ridges to the south are lower, generally less defined, and there are more discontinuous ridges and short ridges that don't follow the trend of the longer beach ridges.

The area to the south of the first five beach ridge units is designated as the southern beach ridge area, and the numbering of beach ridge units is resumed at one (i.e., there is a northern area in the beach ridge province that contains five units, wherein the beach ridges are of a different character than those in the southern beach ridge area). The spacing of the beach ridges in the southern area is more variable. (Overall, the ridges are farther apart, and separated by broader sand flats; particularly on the west side of the island where many of the beach ridges have been overwashed. Few of these southern beach ridges exceed three feet in elevation, and they nearly all diminish in elevation at their western end. Strand lines can be traced between many of the beach ridges, but most of them are parallel to adjacent ones. Only when a strand line was prominently developed, or changed orientation was it mapped. The beach ridge units are defined between those mapped strand lines.

The character of all of these southern beach ridges (particularly the discontinuous ridges and the short ones that lie at a slight angle to the trend of the others), the presence of numerous linear ponds at the north edge of the sand flats, and the frequently obvious strand line positions, all suggest that accretion was rapid. These features also suggest that accretion was pulse-like, with a period of time when sand ridges came ashore rapidly after a prior period when a well-defined strand line had developed. Each period of rapid accretion was then followed by a time when accretion slowed enough to allow another strand line to form, or a higher, more continuous beach ridge to build. The northern two beach ridge units in this southern section have a combined width of more than 1400 ft., and the ridges are essentially parallel throughout that width. This, too, suggests a period of very rapid accretion. The beach ridges in these two units also extend entirely across the island, and are truncated at both ends. None of them shows any recurvature to the north near their western ends. It is obvious that Smith Island continued to grow westward by 1000 ft. or more, because that is about the minimum width of the island occupied by the recurved portions of other beach ridges. (The westward bulge in the island produced by this period of accretion was removed by erosion prior to 1853).

The third ridge unit in this southern area of the beach ridge province is wider than either of the first two, varying in width from 800-900 ft. It is a beach ridge unit, but it resembles a broad sand flat, and most of it has been mapped as such. It can be divided into northern and southern halves on the basis of physical differences. The northern half is quite low and has a large number of small ponds strung out in lines that mark former runnels seaward of strand line positions. Between the rows of small ponds, the ground is slightly higher with scattered linear hummocks and Parramore Pimples. At the west end of this half of the unit there are fully developed beach ridges that line up with the high ground between the rows of ponds. But, these are cut off, or cut through, before they reach the western shore of the island. At the eastern end of this half of the unit the high ground between the rows of ponds runs gradually into low beach ridges that are truncated at modern beach deposits. Many features in this area indicate that although accretion was rapid, the beach ridges were low and subject to frequent overwash.

The southern half of this third section begins with a through-running beach ridge that has been breached by overwash channels at many places along the western half. This is followed by other beach ridges, each less frequently breached. The southernmost beach ridge is the most continuous, but it recurves to the northwest at the western end. The recurving of the beach ridge and strand line indicates that the southern tip of the island had been migrating to the south southeast.

The beach ridges in this third southern unit are not sub-parallel as are those in all of the preceding beach ridge units. The changing orientation of the beach ridges shows first a counterclockwise turning from the orientation of the first ridge and then a clockwise rotation of the later ridges. This changing beach ridge orientation, and the migration of the tip of the island toward the south southeast, while accretion was taking place, suggests that these changes are adjustments in response to other changes; at the inlet, on the island to the north and east, and, perhaps, in sea level. The fifth phase of accretion of the island began with the first of these three southern beach ridge units, continued through the second, and into the northern part of this third unit, without much change or abatement. Then, although accretion continued to widen this third unit, the beach ridges become smaller and farther apart, and then larger and closer together, but disoriented. This phase of accretion then ended with a reshaping and slight retreat of the shoreline.

The next beach ridge unit to the south is the fourth unit in the southern part of the island. It is a narrow unit that added only 330 ft. to the island. It is separated from the previous unit by a broad pond (runnel) along the middle part of its length where it consists of a single broad beach ridge that is higher (1.0-1.5 ft.) than the beach ridges to the north. To the east the width of the unit increases and the single beach ridge leads into three divergent beach ridges. The western end of the unit splays out into a pattern of sharply recurved beach ridges, some of which have built across the old strand line and onto the deposits of the third beach ridge unit. The younger of these recurved beach ridges are cut off at the modern shoreline. The strand line at the south edge of this unit is a wave-cut scarp that extends all the way across the island. The orientation of this strand line has been rotated slightly clockwise from the next one to the north, so that this unit gradually widened to the east of the present shoreline. The part of this unit that remains on the island is interpreted as a sand spit that grew in front of the older beach as the island accreted more to the east of the present island. The recurved beach ridges at the west end define the southern tip of the island, and show that it had moved back toward the south southwest.

The fifth beach ridge unit in this southern section is almost a duplicate of the fourth, except that it is narrower and visibly narrows to the west as it crosses the island. There is a broad pond (runnel) between it and the previous unit, except at the west end where the beach ridge has built against the older unit. The unit does not recurve, but runs straight across the island to where it merges with a larger northwest trending beach ridge that recurves from a younger unit to the south. The pattern of this fifth beach ridge unit shows that like the previous one it grew westward in front of the older beach as accretion increased farther to the east along the island. Because this unit does not recurve to the northwest it is clear that the southern tip of the island had continued to move toward the southwest as this unit was added. The strand line at the south edge of this unit is rotated clockwise from the previous strand line, indicating that this unit rapidly increased in width, east of the present island.

To the south of the fifth southern beach ridge unit there is less of the island remaining, and what is left of the ancient beach ridges has been reworked by man to some

extent. Enough data are on hand, however, to show that another narrow beach ridge unit (sixth) was the next portion added to the island. This unit is about 250 ft. wide and is truncated near the western end at the shore of an oval pond that is believed to be man-made. The three ridges in the unit are rotated clockwise from the older strand line and they trend east southeast. The next (seventh) beach ridge lies 950 ft. south of this unit, and it recurves from a west northwest trend at the east shore of the island to north along the western shore of the island. On the west side of the island it merges with the western ends of the previous two beach ridge units. Between this recurving beach ridge and the prior beach ridge, there was a broad expanse of ponded water which eventually filled in enough to allow some marsh to develop. Most recently, retreat of the island has caused sand to build into most of this area, reducing the marsh area and partially filling the remaining ponds. The portion of this beach ridge on the remaining piece of the island was part of a well-developed sand spit that grew westward after the island to the east had advanced south by more than 1000 ft. East of the present island, the beach ridge ran east-west, indicating that the shoreline at the south end of the island was still oriented in that general direction and that accretion had been continuing east of the present island. The beach ridge on this sand spit was well developed and is shown on the 1871 charts as a distinct ridge. South of this ridge, the 1949 aerial photography show three other ridges, the first of which is oriented northwest and the other two progressively more to the north. Reconstruction of the shoreline positions back to 1853 shows that this end of the island had continued to accrete, and the tip of the island had migrated southwest. The tip of the island has retreated about 2000 ft. in this century, but it had advanced about 400 ft. in the latter half of the previous century. It is not known how much of the 1600 ft. of pre-1853 island that has been lost was made up of ancient beach deposits, but it would not be unreasonable to assume that all of it had been.

The modern shoreline of the southern quarter of Smith Island on the bay side is (today) a straight shoreline, and many of the ancient beach ridges terminate at that shoreline. However, south of the present tip of the island, the part of the island lost since 1853 curved more southwesterly into the bay. The large ancient sand spit, mentioned in the preceding paragraph, had grown northward across the ends of two older beach ridge units. It would then seem most likely that the erosion of the older beach ridge units north of the end of this sand spit had occurred in the time interval just preceding the building of that sand spit; a time when this part of the island was not accreting. Growth of the island on the east side and erosion and lack of southerly growth on the west side suggests that some change in inlet circulation had occurred, and that the shape of the south end of the island changed to accommodate it.

C. Modern Features

The remaining geomorphic units of Smith Island are all very much younger than the units just described. The oldest among them are less than a half-century old. The retreat of Smith Island has been such that all of the island except the ancient beach ridge province has been reworked by the sea in recent years. The oldest of those modern units are found near the north end of the ancient beach ridge unit. An inlet opened at this location in the 1930's and closed in the early 1960's. While the inlet was open a sand spit grew northwest into Smith Island Bay along the south side of the inlet, and numerous beach ridges formed on the sand spit. It is shown on the geologic map as a northwest trending beach ridge unit at the very north end of the ancient beach ridge unit. Another series of beach ridges formed and grew southward from

the northern side of this inlet opening, narrowing the inlet as they grew. Just north of the inlet there is a remnant of a beach ridge that curves toward the bay along the north shore of the inlet. This is the remnant of the beach ridge that formed after the island breached and while the inlet was open at its maximum width. This is the oldest of the three beach ridge units, the other two are somewhat younger in age.

Two large marsh areas and many smaller ones grew in Smith Island Bay just inside of this ephemeral inlet while it remained open. There had previously been no marsh in this part of the bay except immediately behind the beach that breached, and a narrow fringe along the southern quarter of the island. After the inlet opened, a flood tide delta formed an inlet island just inside the inlet which served to divide the inlet channel. As the inlet closed, this island grew rapidly into the inlet to form a broad sand flat where the inlet had been. Sand dunes then built across the sand flat near the beach as the island accreted to erase the scallop in the beach where the inlet had been.

The marsh area behind the middle third of the island is about the same age as the marsh areas near the southern ephemeral inlet. This marsh has grown upon sand deltas that were deposited in Smith Island Bay when this part of the island was breached between 1911 and 1921. The closing of that breach to form Bungalow Inlet and the growth of the marsh area has been discussed under shoreline changes. In the years before Bungalow Inlet closed, a flood tide delta formed as an inlet island in the channel southwest of the inlet. A sand spit grew gradually along the southern edge of the inlet. Eventually it reached the north end of the inlet island and grew past it into the bay before it recurved to the southwest and ended. Bungalow Inlet has only been closed for a few years, and the inlet position still serves as an overwash channel.

Near the south end of the island an old strand line cuts across the eastern ends of the ancient beach ridges, and several beach ridges and a sand dune area lie between it and the modern beach. The strand line dates from the period of closing of the southern ephemeral inlet, when this part of the island stopped retreating and began to accrete. A reasonable data for the strand line would lie between 1960 and 1962, and the first beach ridge was in place by March 1963. Accretion since that time has added other beach ridges and allowed the sand dunes to build as the shoreline advanced. The remaining geomorphology of the island is comprised of the modern beach, berms, sand dunes, and overwash channels, fans, and aprons. Retreat of the island north of the old lighthouse has been so rapid in recent years that all of those features should be considered ephemeral, and will continue to be for the remaining time that it takes for the shoreline of the island to finish adjusting after the closing of the ephemeral inlets.

V. GEOLOGIC HISTORY AND INTERPRETATION

The deposits contained within the area covered by this section on geology yield a better picture of geologic history than those in areas previously described. The first part of this section discussed the units found in the marsh and bay areas. Those units provide the basis for understanding the older geologic history of the southern end of the barrier island chain. The Mappsburg Scarp and the beach at the base were formed in the very late Sangamon Interglacial Stage or at the very beginning of the Wisconsin Stage of glaciation (Mixon, et al., 1974). The scarp is a transgressive feature representing retreat of the shoreline, and could have been formed during a

still stand of sea level or with a rising sea level. The drowned beach ridges that parallel the Mappsburg Scarp lie east of the beach at the base of the scarp, and could only have been formed under conditions of a falling sea level. The first two or three of these ridges remain roughly parallel to the beach at the base of the scarp, but later ridges formed at a low angle to the scarp, diverging from it in a northerly direction. These earliest ridges all lie within about a half mile of the beach at the base of the scarp. The first ridges formed were apparently mainland beaches with sand dune ridges, but the youngest one was probably part mainland beach and part barrier island beach. It is much straighter, and more continuous than the earlier beaches. Also, this beach diverges from the mainland trend and lies farther offshore with a lowland between it and the mainland. North of Indiantown Neck and west of Cobb Island and Hog Island, another set of beach ridges begins at the mainland and diverges from it to become offshore barrier beach ridges with broad low areas between them and the mainland. These are more clearly barrier type islands. The divergence from the shoreline was probably caused by the configuration of the continental shelf at that time, but it would also have been influenced by longshore currents which would have been moving the sediment needed to build the beach ridges.

This early stage of beach ridge building as sea level began to fall was followed by the appearance of barrier islands about 1.7 miles east of the beaches previously discussed. The intervening area is occupied by Magothy and Mockhorn Bays and there is no clear evidence of any drowned beach ridges within the main part of the bays. It is not clear whether or not this development should be interpreted as being caused by a change in the rate of sea level decline. The barrier island that formed ran easterly from Cape Charles through Skidmore Island and then curved north to parallel the youngest ridge in the older group of ridges on the west side of the bays. The beach ridge of this barrier island forms the western shoreline on the southern half of Mockhorn Island but it runs into the marsh north of the midpoint on the island. Presumably there was an inlet at the south end of Magothy Bay and probably others along the length of the barrier island. This barrier island can be traced as far north as Oyster, but not beyond, and it is possible that it ended at an offset inlet at that location. After the establishment of this initial barrier island system, other beach ridges formed east of it. Each of these succeeding beach ridges diverged from the preceding at the north end and merged with it at the south end. This pattern gradually rotated the advancing shoreline in a clockwise sense while the south end remained essentially unchanged through the southern end of Mockhorn Island, and on through to Cape Charles. It is possible that this southern part was mainland coastline, and the point of divergence simply marked the location where a sand spit started offshore into the barrier island system. There are breaks in the beach ridges to the north, and the beach ridges all end in the vicinity of Sand Shoal Channel. There are beach ridges in Elkins Marsh on the north side of Sand Shoal Channel but they are not extensions of the beach ridges on Mockhorn Island. It seems that an inlet was maintained in the position of Sand Shoal Channel as the barrier islands advanced seaward, and that the coastline from there to an inlet near the south end of Magothy Bay acted as a separate section of coastline.

The succession of beach ridges on Mockhorn Island becomes lower in elevation until the ridges finally disappear beneath marsh and bay sediments in the vicinity of White Perch Channel. Similar features are doubtlessly found beneath those sediments, at least as far east as the modern barrier islands, because the decline of sea level during Wisconsin time caused the shoreline to advance many miles out onto the continental shelf. The sediments beneath which those features are buried are post Wisconsin in age, presumably late Holocene.

In summarizing this section, several characteristics of these very ancient features should be brought out. Magothy Bay and Mockhorn Bay were framed by beach ridge deposits very early in the Wisconsin recession of sea level, and have now been reflooded by the post glacial rise of sea level. The north edge of the inlet at Chesapeake Bay remained very close to the wave-cut scarp across the end of the peninsula at Cape Charles throughout all of the early stages of sea level retreat, and successive shoreline positions curve northward from that inlet opening. An inlet was maintained at Sand Shoal Channel throughout this early period of retreat, and probably was maintained as a mainland valley throughout the Wisconsin period of time. Each successive shoreline curved smoothly from this inlet to the mouth of Chesapeake Bay.

The remaining ancient features of Smith Island are the beach ridge units at the very south end of the island. These are post Wisconsin in age, but still old in comparison to other features on the island. To understand the meaning of these beach ridges, and the geologic history that they yield, it is necessary to draw upon features not located on Smith Island. Raccoon Island is located in the marsh area at the southeast end of the mainland peninsula. On this island there is a pattern of beach ridges that correlate very well in size and spacing with the northernmost ridges at the south end of Smith Island. The orientation of the Raccoon Island ridges is different, but they were on the opposite side of the inlet to Magothy Bay and Smith Island Bay. The other information needed comes from Wreck Island, far to the north. The analysis of the geology and shoreline changes for Wreck Island had shown that Wreck Island formerly extended a long distance to the southeast of the present position and that Ship Shoal Island had most likely been a part of Wreck Island. The geologic evidence from Wreck Island also showed the remains of an ancient barrier island that formerly extended to the southeast, and of large marsh canals draining from that general direction. Lastly, there were no truly ancient features on Ship Shoal Island, Myrtle Island, or on the northern three-quarters of Smith Island. Using this information and the description of the northernmost of the ancient beach ridges on Smith Island, it is possible to reconstruct the shoreline of the southern part of the Virginia Barrier Island Chain at some time in the distant past. This has been done schematically in Figure 82, which shows the configuration of the islands as they were at that ancient time in relation to the way they are today. The shore of the inlet at Chesapeake Bay was across the end of the peninsula. The shoreline trend for the barrier island system then ran eastward to the sand spit at the south end of Smith Island, curved northward along Smith Island and then curved landward again to an indentation in the barrier island chain at Sand Shoal Inlet.

Prior to the time of the ancient shoreline shown in Figure 82, the barrier islands had been retreating in response to a rising sea level. After that time the rise in sea level stopped, and, as noted on other islands, a period of sea level retreat set in and Smith Island began to prograde seaward. The beach ridge units that have previously been described provide the means of interpreting sea level changes and the history of progradation on Smith Island. The phases of progradation that were described have been shown on Figure 82, where they have been projected seaward to reconstruct Smith Island for various stages during this history of progradation. The amount of progradation of the northern three-quarters of Smith Island is unknown but for the purposes of reconstruction, it was assumed that it was less along the long seaward face

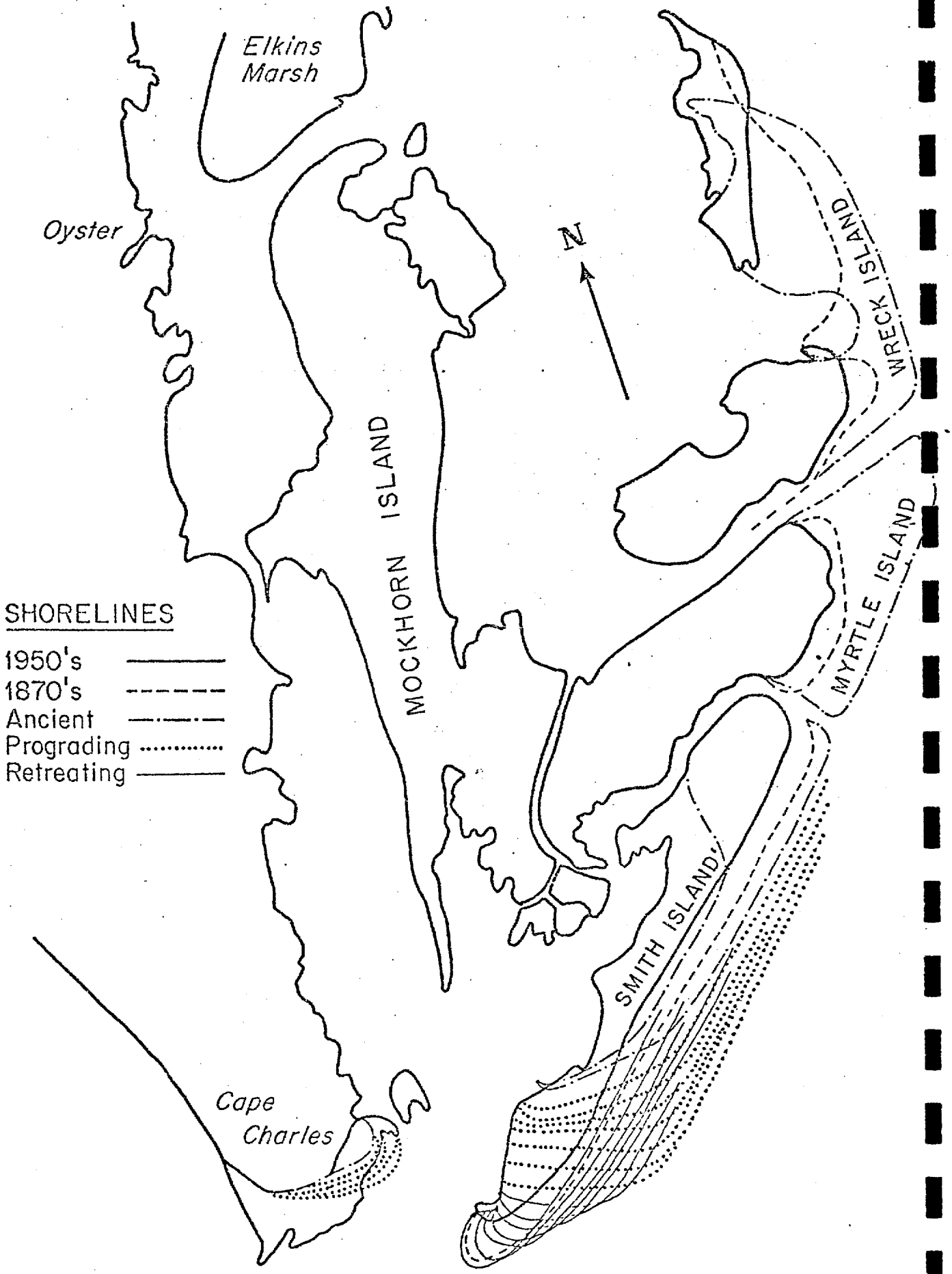


FIGURE 82. SOUTHERN GROUP, VIRGINIA BARRIER ISLANDS
Ancient Configuration and Shoreline Position

of the island than at the southern end where longshore drift would facilitate greater accretion.

The three northernmost beach ridges on the island comprise the first beach ridge unit and provide the record of the halting of the rise in sea level and a brief stillstand before sea level began to retreat. The second beach ridge unit built in front of the old sand spit, and parallel to it after the sea level had stopped rising. The third beach ridge cuts across both of the older ridges, indicating that the island had retreated, somewhere to the east of the present island, probably on the curved southern end of the ancient island. Longshore drift had moved the sediment south and allowed this ridge to build and grow to the west of the older beach ridges before it recurved to the inlet. This is interpreted as an adjustment in the shape of the island during the brief stillstand of sea level, before it began to recede.

The second beach ridge unit previously described records the onset of rapid progradation of the island and decline in sea level. The island grew westward by more than 3100 ft. and southward by 900 ft. during this first phase of progradation. As shown in Figure 82, the growth of the ridge unit was attended by southward and eastward progradation of the ancient Smith Island. In the description of the beach ridge units a differentiation was made on the basis of appearance between a group of northern units and the southern units. There were five units in the northern group and more than seven units in the southern group. Progradation of the island on a falling sea level continued through all of the remaining ridge units in the northern group and into the third unit in the southern group. Figure 82 shows these units and the amount of growth that had to have occurred on the ancient Smith Island in order to accommodate these units.

The nature of the beach ridges in the third beach ridge unit of the southern group is very much different than those in other units. Those differences have been discussed earlier in this section. Here it should be noted that in addition to those differences, this ridge unit shows the most severe effects of drowning by the recent rise in sea level. It is believed that the decline of sea level ended during the time it took to deposit the northern half of this unit and was either rising or at the end of its falling cycle during the deposition of the southern half of the unit. South of this unit the island continued to prograde for a long period of time, but the nature of the ridge units had changed abruptly, and they are interpreted to represent progradation with a rising condition of sea level.

The next three beach ridge units to the south all show the same characteristics. They are separated from the previous unit by a broad depression (runnel) and are composed of closely spaced or crowded beach ridges, and have occasional sand spits that recurve into the runnel on their north side. They are all interpreted as sand spits that grew westward in front of the older beach. Their orientation and interpretation require that the ancient Smith Island had continued to prograde south at a location east of the present island. Figure 82 shows how this could occur despite the implied return to a condition of rising sea level.

Near the south end of the island there is a gap of 950 ft. before the next beach ridge unit is encountered. This beach ridge unit, like the previous three, represents a sand spit that grew westward 950 ft. in front of the old beach. The sand spit recurved strongly at the western end and grew north until it welded to the western side of Smith

Island. In the time interval before this sand spit built westward, the western part of the island has experienced some erosion and a straight shoreline had been formed. This truncated many of the older beach ridges at the edge of the bay. It is believed that the channel to Smith Island Bay had shifted against the west edge of the island and remained there until after the sand spit grew westward and welded on to the island at the bay side. The growth of this sand spit enclosed a shallow body of water that had gradually filled and become partly marsh over the intervening years. The marsh and open ponds can be seen on the 1949 aerial photographs and are also shown on the 1968 U.S.G.S. topographic map. By 1974, beach erosion had partially destroyed this area and dunes had built over the eastern part of it.

The growth of this ancient sand spit so far to the south of the old beach shows that ancient Smith Island had continued to prograde south and other sand spits had doubtlessly grown westward, even though their growth was insufficient to reach the former western shoreline. South of this sand spit other beach ridges follow in succession, each recurving to weld to the bay shoreline. The study of recent shoreline changes shows that these ridges also built progressively west because the part of the island that has been lost since the 1850's extended southwest from the present tip of the island. Remnants of some of those ridges are visible in the 1949 aerial photographs. Figure 82 shows that at this stage of accretion of the south end of Smith Island, retreat of the seaward beach was well underway.

How far progradation extended the south end of Smith Island is unknown, but it is probable that it was not much beyond the position of the tip of the island in 1853 because the shoreline study shows that the southern tip of the island continued to grow until the late 1800's. It is possible that the island had prograded farther south before 1853 and that the growth after 1853 was unrelated to the earlier progradation. But it is not necessary that it had, and it is believed that it had not. If it had not, then the model presented in Figure 82 portrays the geologic history of Smith Island from the onset of progradation until it is picked up by the description of shoreline changes after 1853. The recent geologic history of the island has been adequately covered in preceding sections and need not be included here for the history of the island to be complete.

FISHERMAN'S ISLAND

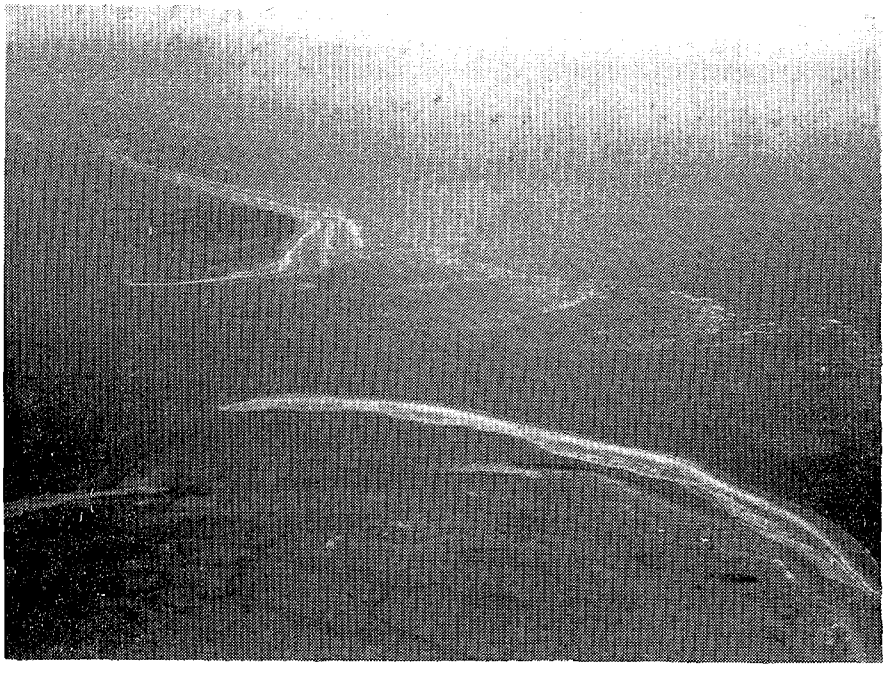
I. DESCRIPTIVE GEOGRAPHY

Fisherman's Island is the twelfth island from the north end, and the southernmost island, in the Virginia Barrier Island Group. It is the tenth, and last, island covered in this study. The island lies south of Cape Charles at the very southern end of the mainland peninsula. Fisherman's Inlet lies between the island and the mainland, and Smith Island Inlet separates it from Smith Island which lies to the northeast. The nearest mainland communities are Cedar Grove and Townsend which lie five to six miles north of the island along Virginia Route 600.

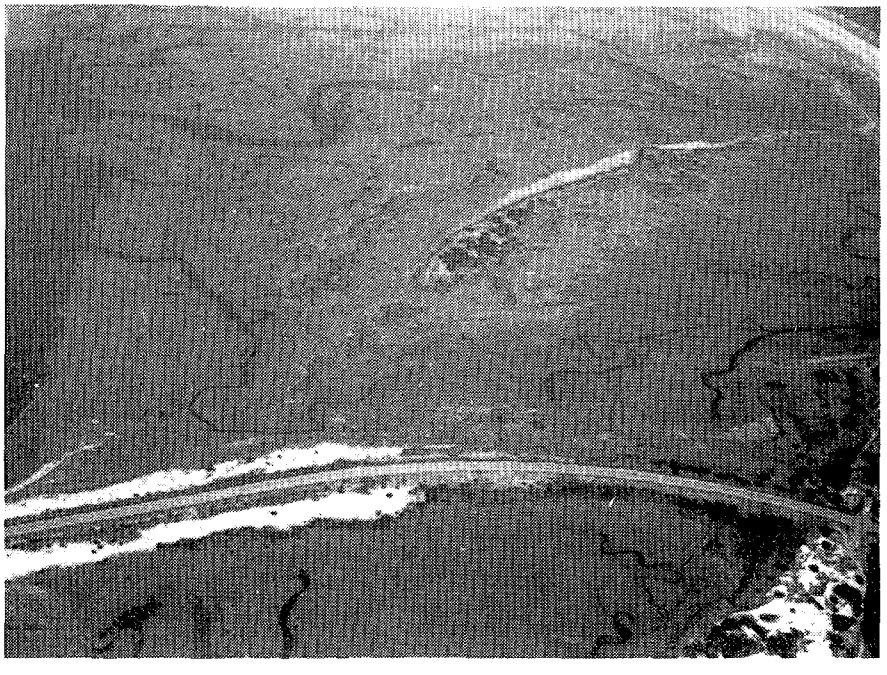
Fisherman's Island is managed as The Fisherman's Island National Wildlife Refuge. Access to the island is therefore restricted, and should not be attempted without prior approval by the manager of the refuge. United States Highway I-13, which crosses Chesapeake Bay by way of the Chesapeake Bay Bridge-Tunnel, connects Fisherman's Island to the mainland by means of a bridge and causeway. Access to the island may be acquired from this highway if arrangements have been made with the proper authorities. There is also a serviceable pier on the west side of the island and the remains of two other piers which could be employed for landing by boat. Landing by boat along the northern shoreline should not be attempted because of the lack of adequate water depth at most locations. There are boat launch areas at Dixon's Dock at the south end of Magothy Bay and at Raccoon Island on the Intracoastal Waterway. Both launching areas can be reached from the south end of Virginia Highway 600 at Kiptopeke.

Fisherman's Island is nearly rectangular in shape, with the longer dimension oriented nearly east-west. The maximum length of the island is 2.13 miles, but it averages about 1.9 miles long. The island is uniformly about 0.9 mile wide, except at the east and west ends where recurving beach deposits increase the width slightly. The minimum distance between the island and the mainland is near the west end where the distance from the north end of the beach to Wise Point on the mainland is less than 1.1 miles. The average distance to the mainland is a little more than 1.25 miles. The marsh area of the island is encompassed on three sides by barrier beach deposits, and lies on the north side of the island. About 50% of the area of the island is marsh and the remaining area is upland, above the range of the tide.

The orientation of the island does not relate simply to any single geographic feature. The axis of the island lies about 9° south of east (N99°E) and this relates best to the orientation of the south beach which is determined by coastal processes. It does not relate well to the mainland shore or the trend of the barrier island chain. The orientation of the south beach is primarily determined by inlet currents passing through the mouth of Chesapeake Bay, principally related to North Channel and Beach Channel just inside the bay. The west beach and the south beach are very nearly perpendicular as they are shown on the 1968 U.S.G.S. topographic map, but shoreline changes since that time have muted that sharp angular relationship. The orientation of the western beach, which is essentially north-south, relates best to the shoreline of Chesapeake Bay, with which it is in reasonable close alignment. The orientation of the eastern end of the island is approximately northeast-southwest, discounting the recurving end of the sand spit. This agrees very well with the curving trend of the seaward face of the barrier island chain. The 1974 shoreline is in better agreement with this trend than the 1968 shoreline. Figure 83a shows the eastern beach in relation to the beach of Smith Island, across Smith Island Inlet. Each of the three distinct beaches on the island has its own orientation owing to the unique situation of this island.



a. Smith Island Inlet. The picture shows the trend of Fishermans Island beach in relation to the trend of the barrier island chain at Smith Island. (View NE)



b. Central portion of Fishermans Island. Picture shows beach ridges and artificial fill along Interstate Highway, I-13. (View ESE)

FIGURE 83: Views of Fishermans Island

II. PHYSIOGRAPHIC DESCRIPTION

The area between Fisherman's Island and the mainland at the south end of the peninsula is occupied by Fisherman's Inlet. There was only one land unit in the area in 1974, and that was a small unnamed crescent shaped island. It was located north northeast of the middle of Fisherman's Island and about 0.5 mile off the northern edge of the island. This small island is near the west end of a very large sand bar, and represents the emergent portion of that bar. By July of 1975, the small island had increased in size and a second small island had appeared on the concave side of the first island. The second island, like the first, is the emergent west end of a large bar. These bars are but two in a complex series of concentric bars that are building far to the northwest, from the eastern end of Fisherman's Island. This, and other areas of complex bars across the north side of Fisherman's Island, are partially outlined on the Geologic Map of Fisherman's Island that accompanies this report. The accretion of this bar complex has occurred rapidly since the mid-1960's, and other islands can be expected to appear in this area. However, the islands can be expected to move or disappear as the bar system shifts with currents. This phenomenon has been a frequent occurrence along the western margin of Smith Island Inlet for more than a century. At that location, the ephemeral sand bars proved to be precursors of steady accretion of the east end of Fisherman's Island. It is believed that this new bar complex north of Fisherman's Island heralds the beginning of rapid accretion to that side of the island.

For discussion, the physiography of Fisherman's Island is best divided into that of the marshy half of the island, and that of the higher, sandier portion of the island. The marshy portion of the island is divided into two areas by the artificial fill upon which Interstate Highway No. 13 is contructed; a small western area, and a larger eastern area. Figure 83b shows how the highway crosses the marsh area. West is at the bottom of the picture. The artificial fill in the marsh appears as white areas along the highway in the left half of the picture, and as narrower light areas along the rest of the highway. The smaller marsh area west of the highway does not include any noteworthy physiographic features, except a low, short sandy ridge that emerges from under the highway fill midway along the eastern edge of this marsh. This is the western end of a tiny island that lay north of Fisherman's Island in 1869 (see Figure 85, p. 328). This marsh area is bounded on the east by the highway, and on the south and west sides by the western beach ridge unit of the island. North of the marsh there is a small enclosed lagoon about equal to the marsh in area. The lagoon was created when a sand spit grew southwest from the north end of the artificial fill, toward the north end of the western beach. A narrow inlet separates the two features. A flood tide delta is building inside the inlet on the floor of the lagoon. A complex pattern of sand bars lies just off the inlet opening and the northern sand spit. The oldest marsh area on Fisherman's Island is found in this western marsh area, in the southern and southwestern portions.

The larger marsh area lies east of the Interstate Highway. It is bounded on the west by the artificial fill area, and on the southwest, south, and east by barrier beach units of higher elevation. Figures 83a and b and 84a, show this marsh area. The north side of the marsh faces Fisherman's Inlet. This marsh area is built upon a complex array of coalescing accretionary sand deposits: most of which occurred as sand bars, sand spits, and shoaling sand deltas. Many of these features were barely emergent, or slightly awash at the time they welded onto Fisherman's Island. The emergent features appear in the marsh as short, linear or curving, discontinuous upland sand ridges that form patterns through the marsh (see Figures 83b and 84a). The patterns partially reveal the accretionary sequence on the island. The development and migration of tidal canals, as drainage became established, and adjusted, has modified these low ridge features making it more difficult to trace patterns.

a. View north across Fishermans Island. Beach ridge in marsh near center of the picture was one of the Isaacs of the 1890's.

b. View east along the southern beach on Fishermans Island. Note the diagonal stubs of former sand ridges that welded to the island.

FIGURE 84: Southern Beach of Fishermans Island

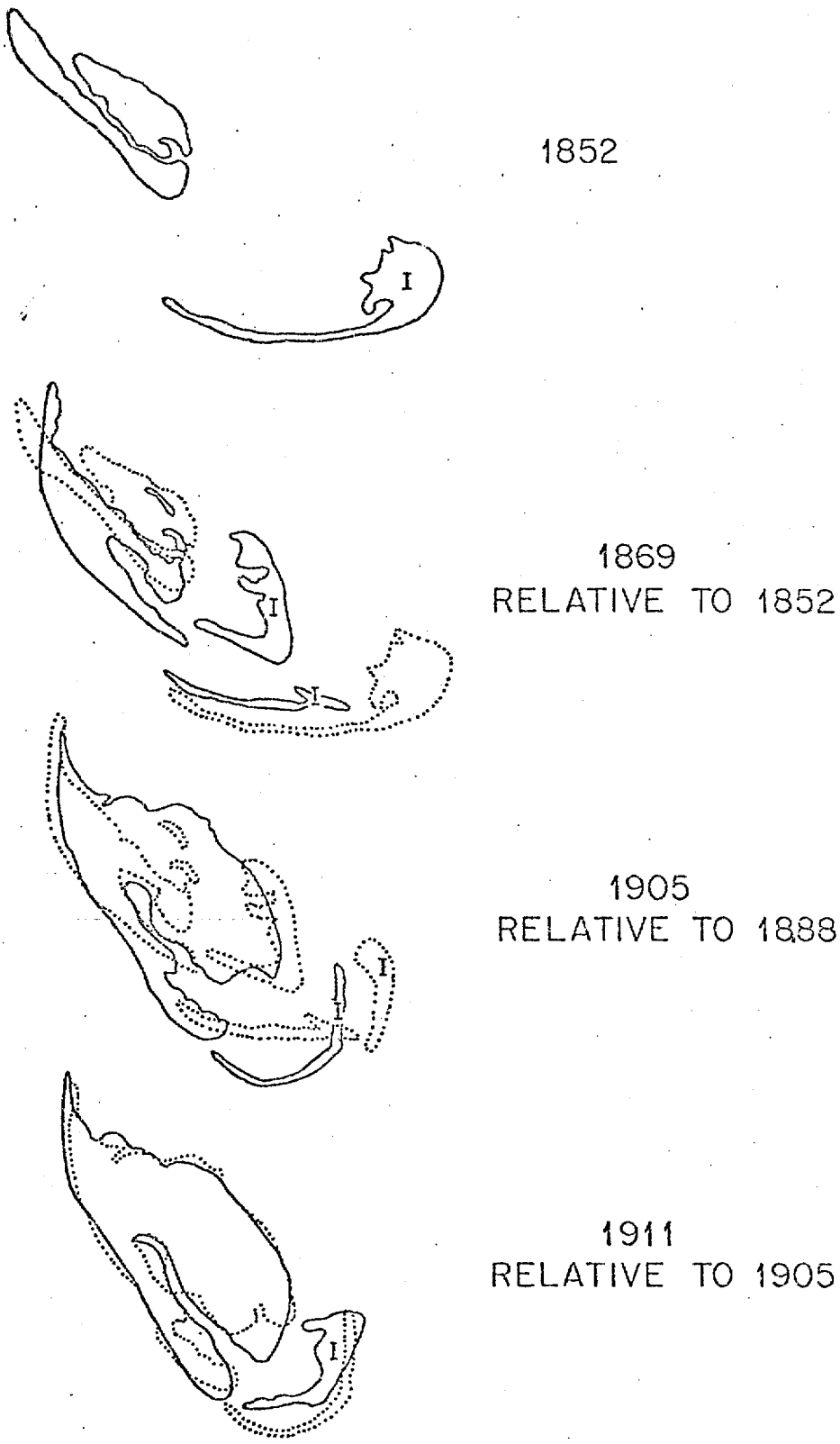


FIGURE 85. GROWTH STAGES OF FISHERMANS ISLAND; 1852-1911

Low areas between the ridges have been filled with sediment (mostly sand) carried in through tidal canals, and this too, has helped to obliterate details. The marsh has grown over these low sand deposits and has doubtlessly helped to stabilize the margins of the enlarging island and marsh area. Nearly all of this marsh has formed since the turn of the century, and it is clear that the marsh is still evolving, even in its interior.

There is a bold beach ridge standing in the marsh just east of the highway. It has a westward recurving sand spit at the south end. The ridge is highest along the northern half where elevations reach 5-8 feet, and small areas of forest are established. This ridge can be seen in Figure 83b at the center of the picture, and it is also shown in Figure 84a. This ridge is identifiable as the northernmost of The Isaacs of the 1890's, after it had been driven westward and welded on to the eastward growing Fisherman's Island. About 0.3 mile east of the southern end of this beach ridge, there is a second beach ridge jutting northward into the marsh (Figure 83b, upper right) from the modern beach ridge behind the southern beach. From the north end of this unit, a ridgeline can be traced first south then west into the modern east-west beach ridge. This is identifiable as the island that was called The Isaacs during the 1930's and 1940's, before it was driven close onshore and incorporated into the accreting Fisherman's Island in the late 1940's. In 1949 there were inlets in the southern beach east and west of this island, and tidal canals enclosed it on the north end. Incorporation was completed with the closing of those inlets in the early 1950's.

At the eastern edge of the larger marsh area there is a large north trending beach ridge area. The westernmost portion of this is a separate beach ridge system that lies within the marsh, except along the southeast side. The north end of this ridge unit recurves strongly to the west before it dies out. The ridge lines on it show that the beach ridge was overwashed near the middle of the unit. This beach ridge unit is identifiable as the remains of Adams Island after it had been driven into, and incorporated with, Fisherman's Island in the late 1950's or early 1960's. The rest of the beach ridges and linear sand flats that lie north and east of the remnant of Adams Island are beach ridge units that were added during the mid-1960's as sand spits grew northward and were driven westward until they welded to the island.

The physiographic features of the higher, sandier, part of the island fall into two groups; relatively modern beach deposits, and older features that are now isolated from the beach by younger deposits. The older features are found in the southwestern part of the island where they occupy an area resembling a right triangle with the hypothenuse oriented northwest-south-east and the right angle aimed to the southwest. The area contains several sets of beach ridges, some areas of sand flats, and a pond. The northwestern portion of the area has been extensively utilized by man. There is an artificial, conical sand hill, slightly more than 25 feet high, built upon the beach ridges. There are other lower artificial piles of sand. There are also numerous buildings, towers, two docks, and a number of roads that run all through the area. Fisherman's Island Naval Base was situated here, as were facilities for the construction of the Chesapeake Bay Bridge-Tunnel. As far back as the 1880's there have been National Quarantine facilities located in this same area. The activities of man have blurred the details of the northwestern ends of most of the beach ridges, and the details of large areas at other locations. These areas have been mapped as sand flats on the Geologic Map of Fisherman's Island.

The older beach ridges average 5-10 feet in elevation, but in several places they exceed 10 feet. The ridges are largely forested, except at their northwestern ends, and in areas where recent human activity has been concentrated. Those areas are more sparsely vegetated. The northernmost portion of this area of beach ridges

can be identified as the oldest part of Fisherman's Island. It is what is left of the southern half of the 1850's Fisherman's Island. A clear strand line marks the southern boundary. These features can be seen in Figure 83b, at the lower right of the picture. The beach ridge unit shows many active sand areas (white), and the strand line appears on the sharp right boundary of it. A second strand line lines south of the first, but it is truncated by a third strand line at the Interstate Highway. The portion of the beach ridge and sand flat area between the first and second strand lines can be identified as what is left of what was added to the island between 1869 and 1888. South of the second strand line a third, and other strand lines can be seen, but they cannot be traced (through areas disturbed by man) with sufficient clarity to be able to relate them to dateable charts. All that can be said is that they are younger.

The pond that is located in this area of older beach ridges is a salt pond. It is connected to tidal drainage on the southeast side of the highway by a culvert under the highway. It was formerly more than twice as long as it is at present, but the southeastern half was cut off and nearly filled in by the artificial fill emplaced between two arms of the island that grew southeastward between the 1860's and the early 1900's. The pond was created when the seaward end of the embayment filled with sediment, except for a tidal canal that maintained tidal circulation.

The physiographic features found along the western shore of Fisherman's Island have all been formed in this century. A sand spit extends north from the main body of the island. This feature has a half dozen transverse beach ridges that trail out into the marsh or lagoon behind it. These are beach ridges that formed across the broad north end of the sand spit as it grew northward. A new beach ridge is currently forming at the north end of the sand spit. A second sand spit extends southwest from the end of the artificial highway fill at Fisherman's Inlet to meet the first sand spit across a narrow inlet. The alignment of this second sand spit, except near the ephemeral inlet, matches that of the first sand spit, to effectively extend the north shore of Fisherman's Island to the highway bridge abutment at Fisherman's Inlet. There is a lagoon behind these two sand spits. The second sand spit contains several islands that had first formed in the position of the sand spit. The smaller islands gradually coalesced along their Chesapeake Bay shoreline to form a single, long, narrow island. The north end of this island then became attached, tombollo fashion, to the artificial fill of the highway. Continuing accretion is broadening this feature and allowing sand dunes and sand dune ridges to grow upon it. Accretion is also beginning to fill the lagoon.

Southward along the western shoreline of the island there are rows of low beach ridges that are of two distinct ages. The older of these two groups is built against the reoded ends of the beach ridges of the oldest part of the island. To the south, these newer beach ridges are all truncated, with each successively younger beach ridge truncated farther to the north. These ridges are grass covered and relatively well stabilized. The younger group of beach ridges parallels the modern shoreline. There are four to five ridges in this group, and they are only very sparsely vegetated. Seaward of these ridges, several berms lie at the top of the active beach, and along the beach numerous sand bars lie in the surf zone. This shoreline is, and has recently been, prograding toward Chesapeake Bay.

The physiographic features along the southern shoreline of the island are more varied. Along the south edge of the marsh there is a linear area of sand dunes and discontinuous beach ridges that runs the entire length of the island. The upland area varies in width from less than 250 feet to more than 800 feet. The discontinuous beach ridges lie near the marsh edge of the unit, and the ends of the beach ridges recurve into the marsh area. These beach ridges were islands and shoals that migrated northwestward until they welded onto Fisherman's Island. They

probably represent the various smaller islands that were called the Isaacs, that repeatedly formed off the eastern shore of Fisherman's Island and eventually welded to the island. The western end of this area is extensively grassed over, but the vegetative cover becomes more sparse toward the east where the dunes are younger and more active.

The next physiographic feature to the south is a narrow (200-300 feet) strip of low, sub-parallel beach ridges. The beach ridges at the western end of this unit trend southeasterly and are truncated at their eastern ends. Toward the east, the beach ridges trend more nearly east-west, but are still truncated at their eastern ends. This strip of beach ridges, and the sand dune area north of it, can be seen in the photographs of Figure 84.

The beach ridges in this group record the establishment and growth of the southern beach of Fisherman's Island. The truncated eastern end of each beach ridge marks the eastern limit of the island and the base of a sand spit that recurved into Smith Island Inlet at the time the beach ridge formed. Later, each sand spit was cut off and its sand overwashed into the marsh area, leaving the truncated beach ridge.

The next set of features to the south are an alternating series of lagoons and large southeast trending ridges. These features are shown best in Figure 84b. Each of the large ridges is truncated along the modern beach, and the lagoons are interconnected by tidal canals, and are connected to the sea by a narrow, shallow ephemeral inlet. The ridges are the landward ends of large sand ridges that came ashore and welded on to the island, and the lagoons are the runnels that formed between them and the island. The modern beach ties the eroded ends of all of these ridges together. Sand dunes and a beach ridge are forming landward of the active beach, and a smoother, more continuous beach is developing as sand bars and other sand ridges continue to come ashore.

At the eastern end of Fisherman's Island there is an area composed of beach ridges, sand dunes, and extensive sand flats on which new sand dunes are forming. These features fall in arctuate patterns that curve around the eastern end of the island from the sand dunes behind the southern beach until they trail off into the bay inside of Fisherman's Inlet. All of these features are better developed at their southern end where elevations of 8-10 feet are attained, but their elevations decline toward the north where they become active sand flats. These features have formed since the mid-1960's as sand ridges have migrated onto the island, welding first to the southern beach, then recurving into Smith Island Inlet until they are driven ashore on the east end of Fisherman's Island. East of these features there is an arctuate active beach with many transverse sand bars attached to it, some of which are emergent, but most of which lie below high tid level. This, too, is a sand ridge that has been driven ashore. The runnel behind it has been nearly filled, except for a short distance midway along the northeast face of the beach where open water still is found. Still farther to the east, the most recent sand ridge lies offshore (see Figure 83b) of the eastern end of the island, recurving into Smith Island Inlet as a broad sand spit. Southward along the sand spit, the ridge has already welded on to the southern beach and its sand is being reworked along the southern beach.

III. SHORELINE CHANGES AND COASTAL PROCESSES

Fisherman's Island is unique among the islands of the Virginia Barrier Island Group. Principally it is unique because it is an accreting island, growing in size and advancing against the sea. All of the other islands are retreating before the rising sea, and adjusting their size and shape as they do so. But Fisherman's Island is unique in other ways as well. It is a new island. Reportedly, it has grown

around the bones of a British merchantman that was wrecked on shoals at the entrance to Chesapeake Bay. The merchantman's cargo of linen, salvaged by local residents, gave rise to the island's original name, Linen Island. Historically, the island was known as Fisherman's Island by the mid-1800's. The validity of this report was not researched for this study, but is reported here as relayed by Mr. Hennessey of The Nature Conservancy on the basis of research done by others involved in the Virginia Coast Reserve Study.

Fisherman's Island is also unique in its position. No other island in the chain can be said to be the first in the chain. Wallops Island is followed by Chincoteague and Assateague Islands, and further north at Cape Henelopen the first "island" is a sand spit extending south from the mainland cape. But Fisherman's Island emerged from the sea to take its position at the southern end of the Delmarva Peninsula. It is pivotal in its nature; it extends the curve of the eastern shore of Chesapeake Bay, it defines the north shore of the mouth of Chesapeake Bay, and it offers the southern end point for the seaward curvature of the trend of the Virginia Barrier Island Chain.

An important point, in terms of coastal processes, is that this is a barrier island that emerged from the sea. It was originally proposed by deBeaumont in 1845 that barrier islands could form when offshore bars became emergent, but other investigators (McKee and Sterret, 1961; Leantyen and Nickiforov, 1966; and Hoyt, 1967) have questioned this origin. Hoyt (1967) has stated that if such an origin were possible, then there should be marine sediments and fauna deposited beneath the lagoon and marsh before the barrier island was formed. Fisherman's Island is such an island, and Hoyt's contention might be proven by coring operations in the marsh of the northern half of Fisherman's Island. The role played by the foundering of a linen-cargoed merchantman is questionable. The important fact is that the ship ran aground on shoals that were building in this area. The shipwreck was not a necessary ingredient in the history of the island. The shoals were building emergence by themselves as evidenced by the emergence of the Isaacs and other islands. The shipwreck only hastened and localized a phenomena that was already in progress.

The location of Fisherman's Island marks an area adjacent to a confluence of different sediment transporting current systems. The area operates as a sediment trap. As sediments have accumulated in that trap, Fisherman's Island has appeared and grown in size. To appreciate the creation of a sediment trap at Fisherman's Island, it is necessary to go back in time to be the beginning of the late Holocene. At that point in time the beach ridge province on the southern quarter of Smith Island did not exist, and the shoreline trend of the southern group of barrier islands curved in smoothly to the southern end of the mainland peninsula; to end at Cape Charles. (See Figure 82, p. 325).

Magothy Bay and Smith Island Bay shared a common inlet, and ebb tide deposits at that inlet formed part of the smooth curve of the barrier shoreline. Longshore currents along the barrier islands brought their sediment load south to this inlet, and perhaps across the ebb tide deposits to the mouth of Chesapeake Bay. The southward growth of Smith Island during late Holocene time changed those conditions and produced a new set of conditions.

The main inlet channel to Magothy Bay and Smith Island Bay grew southward with Smith Island. The sharply recurved sand spits that formed at the ends of the beach ridges on Smith Island indicate that the inlet channel remained close to Smith Island during this period of growth. The truncated ends of some of the beach ridges show that the channel even shifted in against the west side of Smith Island. Throughout this time sediment was being brought south by longshore currents to the south end of

Smith Island. Sediment may also have been introduced into the area by Chesapeake Bay currents, but that is unknown. The ebb tide deposits at the mouth of this channel were thus gradually shifted south, away from the shelter of Cape Charles and more directly into the realm of Chesapeake Bay currents and waves. The inlet, however, had only one functional side, the other side (at the south end of the peninsula) grew increasingly remote as Smith Island built south (growth of Smith Island eventually exceeded two miles). Inlet deposits, both flood tide and ebb tide lacked definition because of the absence of topographic constraints on the west side of the inlet. They also lacked topographic protection from waves and wave driven currents and consequently took the form of shifting shoals and bars that were gradually driven westward by wave activity.

The triangular area formed south of Magothy Bay by the extension of the Bay shore of the mainland and the seaward shore of Smith Island is the area into which the inlet deposits of Smith Island Inlet were driven. It appears to be an area that became unaffected by directed currents after the growth of Smith Island deflected the longshore currents away from it. Chesapeake Bay currents, principally in Beach Channel and North Channel, seem to have been directed south past this area (by the bottom topography of the bay mouth) throughout this whole time period. Thus, the triangular area served as a sediment trap, and sediments were reworked by waves and tidal currents until they came to rest in locations that did not interfere with tidal circulation to Magothy Bay and Smith Island Bay. Consideration of the wave climate reported for this location (Goldsmith, et al., 1974) would indicate that the effect of waves would be to drive shoals and bars in a west-northwesterly direction across this triangle. It was along the western margin of this triangular area that Fisherman's Island first appeared, and it is toward that direction that sand ridges are still being driven.

The type of analysis of shoreline changes followed with other islands in the Virginia Barrier Island Group is inappropriate for Fisherman's Island. Composite overlays of the type previously employed are unintelligible, and measurements of rates of changes from changes in shoreline positions produces figures with little meaning. It is more appropriate to acknowledge that the island is an accreting island, and to examine the pattern of that accretion for insight into the process. For that purpose, Figures 85 and 86 have been prepared. In these figures the outline of the island at one charted date is compared to the outline of the island at the previously charted date. The earlier outline is shown as a dotted line, and the younger as a solid line. The shorelines shown in Figure 85 are from Byrne's Historical Shoreline Positions Map (1972) and charts of the U.S. Coast and Geodatic Survey, and those of Figure 86 are from U.S. Geologic Survey topographic maps. In both figures, the letter "I" is used to denote islands that have the name "The Isaacs", and the letter "A" denotes Adams Island. The crosses are latitude and longitude intercepts that were used for maintaining correct indexing of the the shorelines. The series of seven diagrams in the two figures serves to clearly portray the history of growth of the island. Figure 87 compares three recent shoreline positions on a single overlay. The 1949 shoreline is from aerial photographs, the 1968 from the U.S. Geological Survey topographic map, and the 1974 is from aerial false color IR imagery. This figure shows the rapid nature of the change in shape of the island, and why the procedures for measuring shoreline changes on other islands would not be meaningful.

IV. GEOLOGY

Most of the geomorphology and geologic history of Fisherman's Island is contained in the foregoing parts of the this section dealing with physiography, coastal processes and shoreline changes. This study has not be able to establish a date for the first charting of Linen Island. Older charts examined at the Oyster Museum at

FIGURE 86. GROWTH STAGES OF FISHERMANS ISLAND; 1911 – 1968

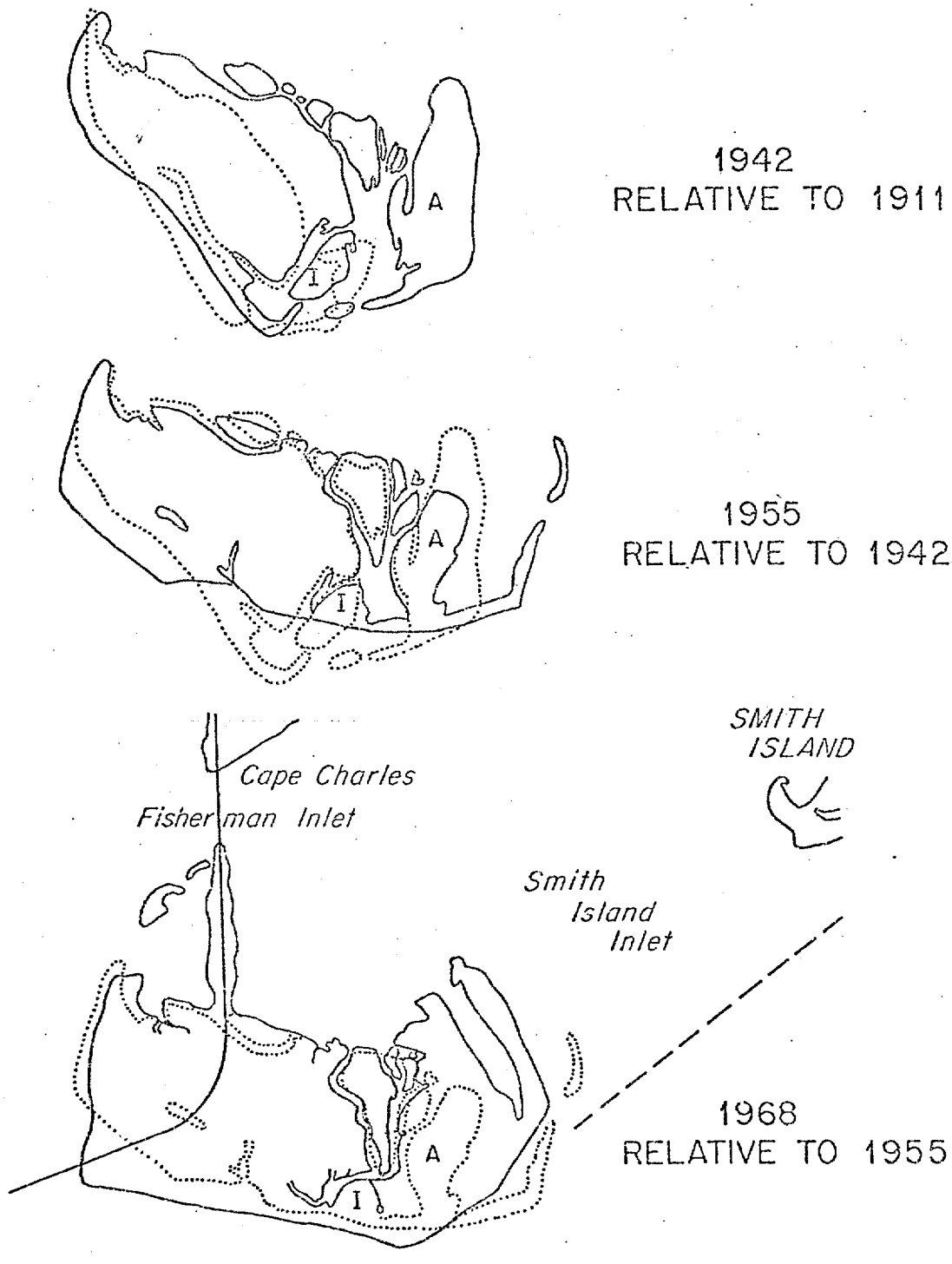


FIGURE 87.
SHORELINE CHANGES ON FISHERMANS ISLAND; 1949-1974

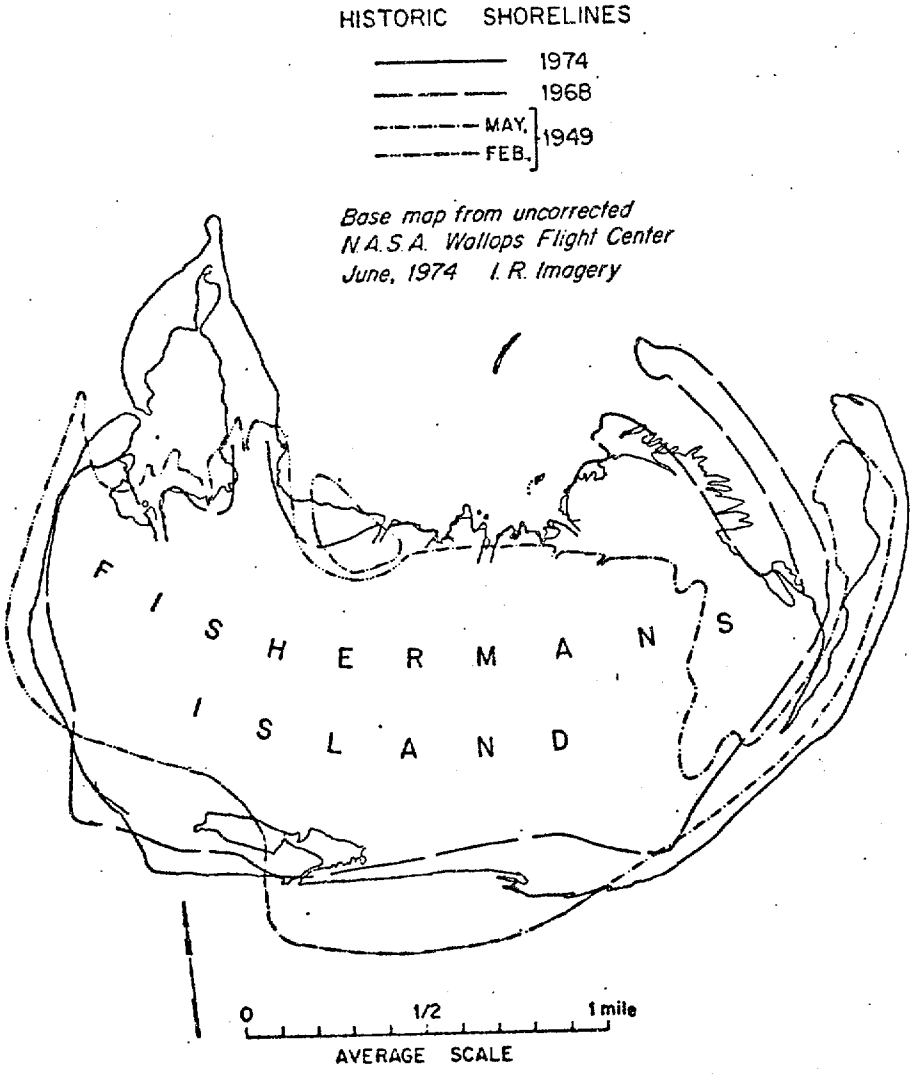
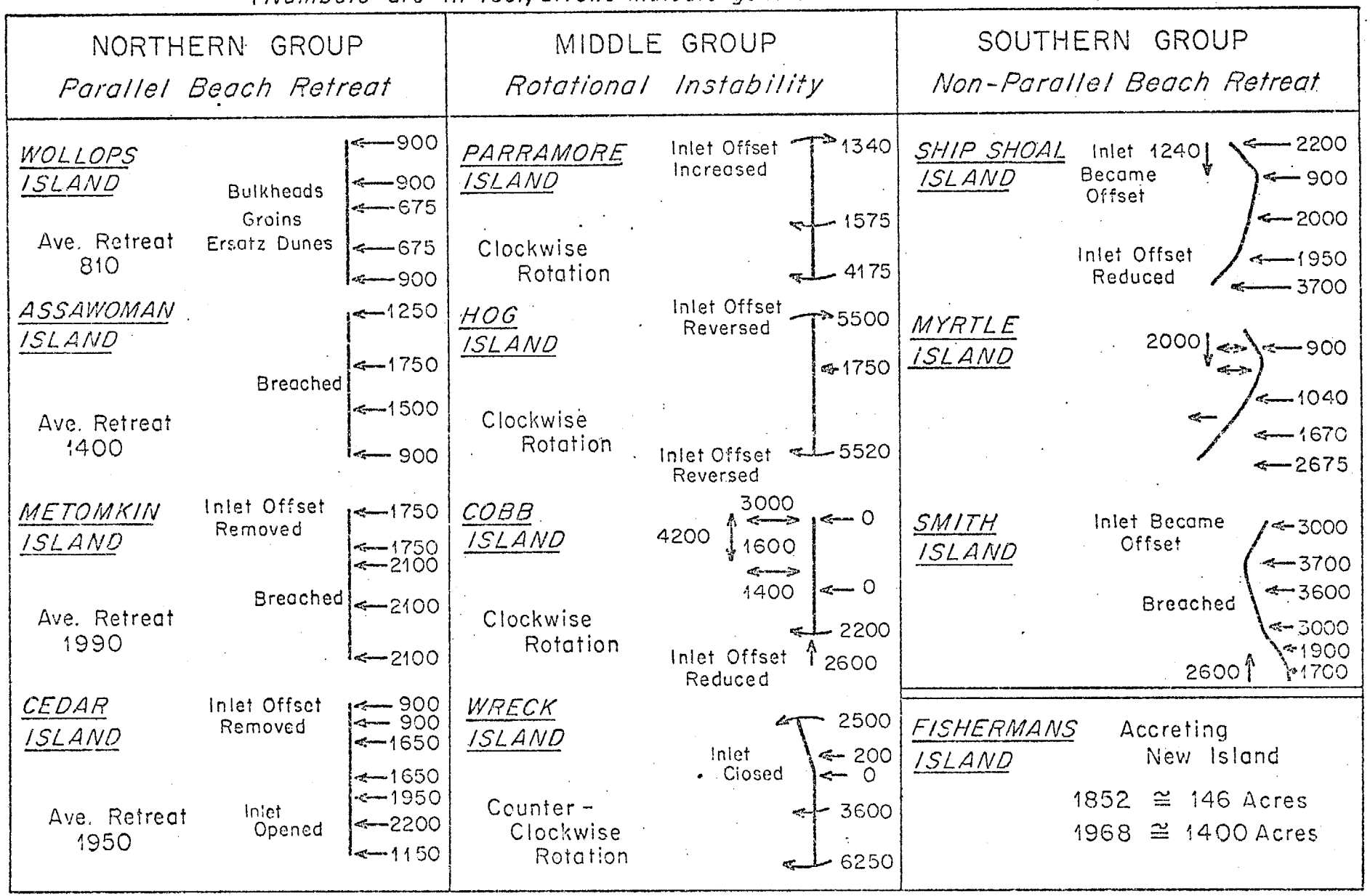


FIGURE 88. SCHEMATIC REPRESENTATION OF RETREAT SINCE 1852 IN THE SUBDIVISIONS OF THE VIRGINIA BARRIER ISLAND CHAIN

(Numbers are in feet, arrows indicate general direction of movement)



Chincoteague, Virginia and elsewhere failed to yield any early date for the island. However, some of those charts, dating back to the mid-1600's indicate shoals in the area south of Cape Charles and southwest of Smith Island. It is quite probable that prior to the formation of Linen Island around the wrecked merchantman, other ephemeral islands were forming in this shoal area. It is not known if one of those might have served as a nucleus for Fisherman's Island, but it seems quite probable that one would have.

On the basis of historical data, Fisherman's Island was established by 1852 as a northwest-southeast trending island. It was really a double island, as is shown in Figure 85. Another emergent sand island lay to the southeast. The diagrams of Figure 85 clearly show two developments in the evolution of the island. The western shoreline of the island rapidly stabilized in an orientation in line with the southward projection of the Chesapeake Bay shoreline of the peninsula to the north. This shoreline increased in length as the island grew. At the same time the sand island called The Isaacs and presumably submergent sand bars, migrated northwest and onto the southeast end of Fisherman's Island. As one "Isaacs" moved northwest, it was replaced by another, and Fisherman's Island grew steadily southeast, then south southeast. By 1911 a southern shoreline including The Isaacs had been established, and the island began to grow eastward. The eastward growth of the island is clearly shown in the diagrams of Figure 86. The growth of the island due to the addition of sediment from the east and southeast is clear. Functionally, Adams Island was just a bigger "Isaacs" and added a larger area to the east end of Fisherman's Island.

The appearance and growth of Fisherman's Island created Fisherman's Inlet and narrowed Smith Island Inlet. Continued eastward growth of Fisherman's Island extended the separation of these two inlets, and helped to define their channels, and their role in tidal circulation. Initially there was a deep channel along the south shore of Wise Point, and water depths to six feet in the bay between Fisherman's Island and the mainland. By 1911 the bay area had gradually shallowed to 1-2 feet and the deeper channel had shrunk and diminished in depth to 8-9 feet. The area immediately south of the mainland had filled in and a large area of new marsh had formed there. The infilling of the original channel and the growth of marsh area south of the peninsula continued until by the mid-1940's the channel was only 1-3 feet deep and a large part of the bay south of the mainland was tidal flat. However, the mid-part of the bay north of Fisherman's Island, 1-2 feet deep in 1911, began to increase in depth as the island grew eastward and Smith Island Inlet became more restricted and defined. By the mid-1940's, water depths of 2-6 feet were found in the bay north of Fisherman's Inlet and it is clear that Fisherman's Inlet was beginning to play a larger role in tidal circulation behind the new island.

By 1949 Adams Island was incorporated into Fisherman's Island and a sand spit had grown east of it. The sand spit recurved into Smith Island Inlet and provided a western shoreline for the inlet. The sand spit proved ephemeral and was soon driven westward onto the island. But it was quickly replaced by another that also was driven ashore on the island. The appearance of these sand spits signalled a change in the manner of accretion of the island. Large sand ridges began to form south and southeast of the island. One after another these sand ridges migrated inshore and welded to the island. The end of each ridge at Smith Island Inlet recurved into the inlet as a sand spit. Each sand ridge, after welding on to the island was reworked by waves and currents to build the south shore of the island and the sand spits were driven inshore to weld to the east end of the island. Each successive ridge welded to the island east of its predecessor, and the landward ends of these ridges along the southern beach produced the peculiar diagonal ridge and runnel pattern found there. The ridges have continually renewed the eastern sand spit and have provided a source of sand for the accretion of the southern shoreline. The most recently added sand ridge forms the sand spit and bulge in the southern beach that are shown on the Geologic Map of Fisherman's Island that accompanies this report.

It is clear that the eastward growth of Fisherman's Island has steadily defined and narrowed Smith Island Inlet. This has facilitated the definition and growth of an ebb tide delta at the mouth of that inlet. The position of the curving front of that delta can be seen in aerial photography, and is clearly shown in Figure 83a of this report. The sequential appearance of the sand ridges and sand spits in the mid-1950's, and the rapid growth of Fisherman's Island since that time, indicate that sand from the longshore drift system of the barrier islands was being directed to Fisherman's Island by the bypass around the newly defined ebb tide delta at Smith Island Inlet. With the establishment of independent inlets at each end of the island, each with its own tidal circulation and with its increase in length, Fisherman's Island had become the southernmost barrier island in the Virginia Barrier Island Chain.

REGIONAL RELATIONSHIPS AND PROCESSES

The preceding sections of this report have provided detailed descriptions and analyses of each island of the Virginia Barrier Island Chain. However, there are many topics which cannot be adequately discussed in terms of individual islands as they influence the entire island chain or large segments of this chain. These topics are covered in the following section.

I. COMPARISON WITH OTHER ATLANTIC BARRIER ISLANDS

The Virginia Barrier Island Chain is characterized by a strikingly smaller scale of physiography when compared with the adjacent barrier island chains to the north and south. Not only are inlets more numerous so that the length of the individual islands is smaller, but the overall relief and scale of dunes, beach ridges, washover channels and other geomorphic features are similarly reduced. The time averaged longshore transport direction is to the south along the entire coast from Cape Henelopen to Cape Charles. The Virginia Barrier Island Chain is thus the down drift half of the Delmarva Barrier Island Chain. Comparison of this coastal section with other coastal sections along the Atlantic Seaboard shows that the pattern of smaller scale barrier islands on the southern or down drift segment of a barrier island chain is not unique to the Delmarva Barrier Island System. A similar pattern is noted along the New Jersey Barrier Island Chain from Manasquan Inlet to Cape May, along the outer Banks of Southern Virginia and North Carolina from Virginia Beach to Cape Lookout, on the barrier island chain of the North Carolina shore from Cape Lookout to Cape Fear, and again along the Florida East Coast barrier island chain from Cape Canaveral to West Palm Beach. This pattern does not seem to develop among the Gulf Coast barrier island systems with the possible exception of the system from Fort Walton Beach, Florida to Gulfport, Mississippi. The reason that this pattern of large scale updrift and small scale down drift barrier islands develops is not understood at this time. However, the prevalence of this pattern clearly indicates that the Virginia Barrier Island Chain is a rather typical section of an Atlantic Coast barrier island system.

The Delmarva Chain, which extends from Bayard, Delaware to Cape Charles, Virginia, and all of the other barrier island chains mentioned above are not closed systems in regard to longshore sand transport. There are varying degrees of sediment input and loss to these barrier island chains as a result of sediment exchange with the continental shelves, adjacent lagoons and major estuary systems. The individual islands of each chain are not independent of the other islands of the chain either, so that a reasonable degree of interaction is always apparent. This point is detailed later where the effects of changes occurring along Assateague Island on the Virginia Barrier Island Chain are discussed.

The Atlantic Coast of the United States is characterized by varying degrees of submergence during the last 15,000 years as a result of post glacial world-wide rise in sea level. This has been discussed in detail in the introductory portions of this report. However, it must be noted that the rate of sea level rise varies from one point to another along the Atlantic Coast as a result of many factors. Two of the most important factors are the crustal uplifting which has occurred in northern areas owing to the loss of the glacial mass which recently rested upon it, and the effects of local crustal warpings in other areas which have occurred

since the retreat of the Wisconsin glacier. Although these factors complicate the pattern in local areas, it is obvious that the rise of sea level during the last 15,000 years has caused the Atlantic barrier islands to migrate westward, and this process continues. Thus, it is highly significant to examine the evidence for local recent crustal warping to find reasons for some of the differences between the various Atlantic barrier island chains. The effect of these local crustal warpings are given in the following section of this report. It is likely that these crustal movements have strongly contributed to the development of the particular configuration of the Virginia Barrier Islands.

II. GENERAL SUBDIVISION OF VIRGINIA BARRIER ISLAND CHAIN

Examination of a map of the Eastern Shore of Virginia shows that the barrier island chain that lies along that shore is divided into three segments: northern, middle, and southern. The northern section begins with Wallops Island and includes Assawoman Island, Metomkin Island, and Cedar Island. All of these islands (with the possible exception of Wallops Island) can be described as narrow barrier islands with extensive marsh areas between them and the mainland. The islands in this group have been experiencing parallel beach retreat during the past 125 years. Assawoman Island and Metomkin Island have breached into bay areas west of their southern ends and a small ephemeral inlet opened in Cedar Island.

The islands in the middle group include Parramore Island, Hog Island, Cobb Island, and Wreck Island. These islands have not shown the parallel beach retreat characteristic of the northern section of the barrier island chain. Instead, the islands in this group have shown what is best described as rotational instability during the past 125 years. The term rotation is used herein to describe changes in island orientation that have been brought about by a combination of erosion of one end of an island accompanied by accretion, or no change, at the other end of the island.

On each of the islands in this group there is at least one area where the beach in 1975 lay near, or east of, the position of the beach in 1852. However, the greatest amounts of beach retreat (2200-6250 ft.) have been associated with other areas of these islands. Furthermore, some parts of the islands have accreted, and two of these islands have actually advanced seaward along part of the island. It is difficult to say whether these islands are retreating. Because at least part of each island has maintained its position while other parts of the island have changed position, the shoreline changes have been termed rotational movements. None of these islands has been breached in the last 125 years, although small ephemeral inlets have appeared on Cobb, Hog, and Parramore Islands.

The southern segment of the barrier island chain includes Ship Shoal Island, Myrtle Island, Smith Island, and Fishermans Island. Within this segment, Fishermans Island is atypical and unique. It is a newly formed barrier island that has increased in area nearly ten-fold since 1852. Despite its newness and growth, Fishermans Island is included with this southern segment because its growth is bringing the island to a terminal position in this segment. The other three islands in this group have all suffered severe beach retreat. The retreat has not been parallel beach retreat, however, but has varied along the length of each island. This retreat has been termed non-parallel beach retreat that appears to relate to various causes,

but generally to a straightening of the outer face of the barrier island chain.

The reason that the Virginia Barrier Island Chain is segmented is not known, and should be the subject for further research. Observations of this study indicate that two factors are most likely involved in producing the segmentation. The work of Holdahl & Morrison (1974) shows that there are differential rates of elevation change (Figure 10, p. 134) along the Eastern Shore of Virginia. For example, subsidence at Wachapreague Inlet is occurring at the rate of 1.6 mm/yr., while at Fishermans Island the rate is only 1.2 mm/yr. Their data is derived from a relatively small number of re-leveling stations (at tide gauge sites), and was used to derive the contours of Figure 26.

The work of this study has revealed two northeast trending areas in the marsh that suggest troughs or bands of local subsidence. Within the bands, the marsh areas appear to be drowned, marsh canals are unstable, and they have undergone recent changes in drainage networks and direction. One of these bands of drowned marsh was mapped across the southern part of the marsh on Cedar Island and along the northern edge of Burtons Bay where it conforms well with the division between the northern and middle segments of the barrier island chain. The second band of drowned marsh was not mapped as such, but it extends across the western end of Godwin Island and through New Inlet; where it coincides with the boundary between the middle and southern segments of the barrier island chain.

The second factor that might be involved in the segmentation of the barrier island chain is the focusing of wave orthogonals from the southeast quadrant. The work of Goldsmith, et al. (1974) on a wave climate model for the mid-Atlantic shelf and shoreline indicates that waves from the southeast are focused by offshore bathymetry so that they do not affect the barrier islands uniformly. Wave paths (orthogonals) are turned (bent) by bottom topography as the waves cross the shallow continental shelf, and are sometimes focused or concentrated on particular reaches of the barrier island chain. Longer period waves are focused more sharply than are short period waves. Because waves from the southeast quadrant affect the islands for the greatest part of each year, this focusing of wave orthogonals may be an important factor in the coastal processes affecting the islands.

Goldsmith's (op. cit.) work shows that there is very little focusing of wave orthogonals along the islands of the northern segment of the barrier island chain. Wave attack is thus more uniform along the beaches of those islands. The effect of focusing of wave orthogonals along the beaches of the southern segment of the chain also is not severe. More focusing of orthogonals occurs in this section than in the northern section, but focusing is not significant. Depending upon the period of the waves, the points of focus shift along the shoreline so that in the average, wave attack on the beaches is reasonably uniformly distributed. However, the increased effect of focusing along this segment, particularly of long period waves, might account for the unequal, and greater, rates of shoreline retreat along this segment of the barrier chain.

The most severe focusing of wave orthogonals for waves of all periods occurs along the shoreline of the middle segment of the barrier island chain. Here, wave attack is concentrated on short (8-10 mile) reaches of shoreline, and diverted from other reaches of shoreline. A frequent target of wave attack is Hog Island, and the affected area includes the north end of Cobb Island and the south end of Parramore

Island. A second important area of focus occurs at Wachapreague Inlet.

The effect of the focusing of wave orthogonals may have more to do with explaining the erosional behavior of each of the segments of the barrier island chain than it does with causing the segments themselves. The phenomena is cited here because it may be a causative factor, and it should be investigated further. The results of this study (geomorphology, shoreline changes, geologic history) would all indicate that the segmentation of the barrier island chain is mostly tectonic in origin, and not entirely a consequence of coastal processes alone.

III. PROCESSES WITH AMPLIFIED EFFECTS

Some coastal processes appear to have an amplified effect at places along the Virginia Barrier Island Chain. Most notable are the effects of processes acting at inlets where rapid and frequently severe alterations of the islands have occurred. This study has shown that along the Virginia Barrier Island Chain, inlets, not overwash, have played the major role in maintaining and repositioning the islands. The role of the inlets on each island has been described in the section covering the islands affected by an inlet.

A. Inlet Types

In the Virginia Barrier Island Chain, four categories of inlets can be recognized: permanent, intermediate, small ephemeral, and major breaches. Two of the inlets in the barrier island chain (Wachapreague and Sand Shoal) can be described as permanent; that is, their position and channel direction have remained remarkably unchanged over long periods of time, perhaps more than 1000 years. There is evidence that Sand Shoal Inlet has existed as both an inlet and a stream valley since the late Sangamon interglacial period or the beginning of the Wisconsin glacial period. Historically, its channel has remained in the same position over the past 125 years, despite the shifting sand shoals within it that have given it its name. Wachapreague Inlet has similarly occupied the same position for a very long time. The geomorphic and other evidence of this study indicates that Wachapreague Inlet opened between 1905-2200 yrs. B.P. This was at a time when a previous transgression was breaching an ancient barrier island that occupied the position of the southern half of Cedar Island and Parramore Island.

Intermediate inlets in the Virginia Barrier Island Chain would include all of the other inlets that separate the barrier islands in the chain. Although large and deep, all of these inlets have experienced appreciable change (in the past 125 years) in either their position or the direction of their channel, or both. Some have also experienced changes in depth and dimension of the inlet throat. Inlets in this category are obviously much less permanent than the two mentioned previously.

Ephemeral inlets are of two types; small, discreet openings through the barrier island, and large (sometimes multiple) shifting breaches that affect long lengths of the barrier islands. The larger breaches that have occurred in the past 125 years have all been located at sites where the island was backed by relatively deep bay waters. Along other bays, where water depths were shallow, breaching of the island has produced narrow discreet inlet openings that usually close within a decade.

The opening of either type of inlet into a bay has been followed by a period of active trapping of sand from the longshore drift system, accelerated erosion of

the beach in the up drift direction, and usually the building of a sand spit on the down drift side of the inlet. The sand trapped by these inlets builds into broad sand deltas on the floors of the bays. Flood tide islands may appear on the surface of the sand deltas if the life of the inlet is sufficiently long. Eventually, the sand deltas cut off circulation through the inlets and they close. The site of the opening frequently remains as a large overwash channel for many years. Sand carried through these overwash channels is added to the sand deltas, often raising part of their surfaces above mean high water, and extending the area that can be colonized by marsh grass. A large radial sand delta can be seen along the sand spit of Cedar Island where it built through a narrow discreet ephemeral inlet that opened and closed between 1955 and 1963. Multiple sand deltas, inlet islands, and later overwash deposits have added up to 2000 ft. to Smith Island along Smith Island Bay where the island experienced multiple migrating breaches. Substantial amounts of sand were also deposited in Smith Island Bay.

B. Inlet Control of Ocean Beach

Careful study and analysis of shoreline changes along certain of the barrier islands was coupled with analyses of the changes in the known offshore bathymetry. The results revealed that inlet processes have far-reaching effects on the ocean front beaches of the islands. Detailed accounts of these effects will be found in the section dealing with Hog Island, Cobb Island, Ship Shoal Island, Myrtle Island, Smith Island, and Fishermans Island.

Many of the islands along the Virginia Barrier Island Chain have a distinct east facing beach at the north end of a longer southeast facing beach. Over the past 125 years these east facing beaches have advanced and retreated, lengthened and shortened, in accordance with the shifting of the principle channels on the ebb tide delta just outside of the inlet. When a secondary flood tide channel lay close offshore, these beaches tended to become longer and straighter and to accrete. When such a channel was absent, or lay farther offshore, these beaches shortened, and frequently retreated. It is clear that the character of these beaches is a function of inlet currents interacting with wave generated currents responding to the bathymetry of the ebb tide delta. When the down drift lobe of the ebb tide delta extends far down the island, and there is no near shore channel across the delta, these east facing beaches lose their straight character and advance or retreat with greater irregularity.

Another feature that illustrates inlet control on ocean beaches is the formation of a distinct nickpoint in the face of the beach down drift of the location where the influence of inlet processes ends. The nickpoint appears as a distinct scallop eroded in the beach face. The length of the scallop varies, but is in the range of 0.3-0.6 miles long, and the width generally varies from 150-300 ft., but may be more on some islands. The location of the nickpoint also lies down drift of the location on the island that is inshore from the place where the down drift lobe of the ebb tide delta curves inshore to meet the island. Nickpoints may be found on Cedar Island, Parramore Island, Hog Island, Cobb Island, Myrtle Island, and Smith Island. In recent years, the nickpoint on Parramore Island has been eroding into the maritime shrub province behind the beach and migrating to the south. The shoreline analyses made for many of the islands reveals that these nickpoints migrate along the beach in accordance with the changing position of the ebb tide delta. The cause of the nickpoint was not investigated in this study,

but it is inferred that it is due to a different current regime at the up drift end of the area not influenced by inlet processes. It would appear that less sand reaches the nickpoint from the up drift side than is leaving it on the down drift side, and that the difference is made up by erosion of the beach prism.

C. Ebb Tide Deltas

The erosional history of many of the islands in the middle and southern segments of the Virginia Barrier Island Chain during the past 125 years, has been influenced directly by changes taking place on the ebb tide deltas that lay outside of the inlets. Changes that have taken place on the ebb tide delta in one time interval are inevitably followed by changes to the adjacent islands in that, or the succeeding time interval. Changes to an ebb tide delta, once set in motion, continue for various periods of time that are believed to be on the order of decades and perhaps a century. Changes observed in the ebb tide delta at Little Machipongo Inlet that were set in motion in the latter half of the 1800's, have not yet (1975) ended. A similar time span is involved with changes that have been occurring in the ebb tide delta at Ship Shoal Inlet. The changes at Great Machipongo Inlet occurred in a time span of shortly less than one century.

The initiation of changes in the shape and configuration of an ebb tide delta appears to be triggered by a relatively rapid change in direction of the principal channel leading across the ebb tide delta from the inlet. The changes at Little Machipongo Inlet and Great Machipongo Inlet were initiated by nearly 90° changes in channel direction that occurred quickly. How quickly could not be determined by this study, nor could the cause of the change be determined. The time of change only can be narrowed to a time period of about a decade. The change is termed to have occurred quickly, because previously existing portions of the ebb tide deltas were still intact (or nearly so), when the next bathymetric survey showed that the changes had taken place. Abandoned portions of ebb tide deltas often remain undisturbed for three or four decades before they begin to change, although new parts of the ebb tide delta begin to form immediately after the change in channel direction.

The adjacent islands begin to show changes soon after the channel across the ebb tide delta has moved. Generally the island toward which the channel has moved begins to accrete, and the island that it has moved away from begins to erode. This was precisely the case when the channel across the ebb tide delta at Little Machipongo Inlet turned 90° southward toward Hog Island. The north end of Hog Island began to accrete rapidly, and the south end of Parramore Island began to erode rapidly. Another phenomena that was noticed in association with these inlet changes was a sharp acceleration of sand trapping on the side of the inlet toward the island that was experiencing rapid erosion. The rate of sand trapping was greatest in the one or two decades following the onset of change to the ebb tide delta, and fell off quickly thereafter, usually allowing channels leading to the marsh from the inlet to deepen and re-establish themselves. The inlet end of the Swash behind Parramore Island became choked with sand in the quarter-century following the onset of changes at that inlet. The role of changes in the ebb tide deltas on the erosional and depositional history of the islands, and their marsh and bay areas is more fully covered in the sections describing the islands.

D. Rapid Marsh Changes

Geologically rapid changes have been found to be occurring in some marsh areas west of the barrier islands. The causes of these changes have not always been apparent,

although the occurrences of such change were noted in the sections describing the islands. Bands of apparently drowned marsh that occur on Cedar Island and Godwin/Ship Shoal Island have been cited earlier in this section. Within these marsh areas, tidal canals are typically building natural levees and deltas where the canals bifurcate and connect to ponded areas and interior mud flats. There are numerous unfilled portions of former tidal canals located in the interior of these marsh areas, indicating the disruption of a former canal system. A southwestward extension of the band of drowned marsh on Godwin Island coincides with a location on Mockhorn Island east of Steelman's Landing where a piece of private property on an ancient beach ridge has reportedly been diked to hold back a rising sea level (McCaffrey, 1975; personal communication). As stated earlier, these bands of drowned marsh (and ancient beach ridge) suggest local crustal subsidence. The fact that changes can be seen from one set of remote sensing imagery to another, since 1949, suggests that this apparent subsidence is occurring at a rapid rate.

Rapid changes in the nature of marsh areas have also been found at other locations along the barrier islands. West of the northern half of Smith Island, on Mink Island and in Big Creek Marsh, there have been significant changes in the marsh area. These changes have been brought about by the disruption of a former tidal circulation pattern when Smith Island breached into Smith Island Bay. The changes have included the filling of former tidal canals, bays, and mud flats, the cutting-off or blocking of other tidal canals behind the beach, and the establishment of an entirely new tidal drainage system as the breaches in Smith Island slowly healed. Similar, but less dramatic, changes in tidal drainage networks were found and described at other locations along the barrier island chain where changes in tidal circulation had occurred.

The role of the Intracoastal Waterway and other dredged channels in changing tidal circulation through the marsh areas is also instrumental in causing changes in the marsh areas, and perhaps at the nearby inlets. Teagle's Ditch, when it was dug, served to connect Cedar Island Bay to Burtons Bay. Today, tidal circulation through this ditch, has scoured the opening to nearly 100 times its original width (see Decar Island section), and filled Cedar Island Bay until most of the bay area is mud flat. Similar conditions are found in the marsh west of Metomkin Island where dredging for the Intra-coastal Waterway has caused changes in the drainage system of the marsh and altered the position and configuration of Gargathy Inlet (see Metomkin Island section). The role that the Intracoastal Waterway is playing in terms of changed tidal circulation in the marsh behind Metomkin Island may become more apparent over the next two decades as the breaches into Metomkin Bay are healed. The data of this study strongly suggest that Metomkin Inlet will close and a new inlet will form near the north end of Metomkin Bay, in part because of increased north to south tidal drainage in the marsh area that is fostered by the Intracoastal Waterway.

In the marsh along the west side of Parramore Island, west of Little Beach and the beach ridge south of it, there are other, different changes in the marsh. These changes, too, have been occurring rapidly, and they suggest a falling sea level, or conversely, uplift of Parramore Island marsh. The marsh in this area is built upon sand deltas that were built into Swash Bay long ago. Tidal canals in this area exhibit a dendritic drainage pattern. Furthermore, comparison of remote sensing imagery shows that stream piracy has occurred among these tidal canals since 1942. A large tidal canal has also extended (since 1949) inland on the island by headward erosion to connect to the large pond east of Little Beach. A delta at the end of this canal has divided the former large pond into two ponds. These features are described more fully in the section on Parramore Island.

E. Rapid Retreat

The islands in the Virginia Barrier Island Chain experience more rapid shoreline changes than would be expected for barrier island at other locations, although the entire Delmarva Barrier Island Chain seems to experience large scale changes. Typical high retreat rates along sandy coastlines have been reported to be in the range of 3-5 ft./yr. Retreat of the outer shore of Cape Cod averages slightly more than 3 ft./yr., and annual retreat of Plum Island (a barrier island on the northeast coast of Massachusetts) probably does not exceed 1.5 ft./yr. Retreat rates of 5-10 ft./yr. have been reported along sections of the Chesapeake Bay shoreline at some locations. But none of these retreat rates approaches the retreat rates observed in the Virginia Barrier Island Chain, where retreat rates of 5-6 ft./yr. are unusual. The typical retreat of the northern segment of the barrier chain has been at rates of 15-18 ft./yr. Where retreat has occurred in the middle segment, retreat rates of 40-60 ft./yr. are typical. In the southern segment, retreat at rates of 16-24 ft./yr. have been found. Over short intervals of one to two decades, rates of retreat of up to 150 ft./yr. are not uncommon among these islands.

Retreat of this magnitude is quite unusual. The data of this study indicates that such rates of change of shoreline positions for these islands are not unusual. A period of progradation of the islands that is reported in this study probably occurred at an average rate of between 8-10 ft./yr. The retreat of the islands which followed that progradation seems to have occurred at similar rates, at least until sometime into modern historical time. There is strong evidence to suggest that in the previous two centuries, the islands have been retreating more rapidly. The reasons for this historically increased rate of retreat are not certain. A thorough historical search of the efforts and effects of man should be made to determine if man has contributed to this increased rate of retreat. However, the cause may be natural (see page 453).

IV. HISTORICAL DEVELOPMENT OF BARRIER ISLANDS

The very early history of the geomorphic features associated with the Virginia Barrier Island Chain is somewhat obscure. Mixon, et al (1974) have established that the Eastern Shore peninsula is formed of Sangamon aged barrier island deposits. The older part of the peninsula lies north of Painter, and averages 40-60 ft. above modern sea level. The barrier island deposits of this part of the peninsula yield dates of 126,000 yrs. B.P. East and south of the older part of the peninsula are found younger barrier island deposits that yield dates of approximately 65,000 years. B.P. Fossil assemblages of these younger barrier island deposits are typical of warm climates. The Mappsburg Scarp, which is more or less continuous from north of Chincoteague Inlet to Cape Charles, has been eroded into these older barrier island deposits.

A. Pre-Wisconsin

Seward of the Mappsburg Scarp there are beach ridge deposits that are younger than the scarp. These younger beach ridges are clearly related to a regression in sea level that is believed to be the early Wisconsin regression. These beach ridges diverge from the Mappsburg Scarp in a northward direction, but southward they converge and merge at various locations with the scarp. In the area west of the northern segment of the barrier island chain, these ridges are not prominent in the marsh area as they are west of the two southern segments of the island chain. The reason for this is not known. The eastern portions of the marsh and bay area do

not exhibit any of these very ancient beach ridges, and it is presumed that in this area they lie below sea level.

B. Early Holocene

During the Wisconsin stage of glaciation, sea level was lowered until the shoreline lay many tens of miles eastward of its present location. When sea level began to rise again, following the Wisconsin glaciations, the shoreline began to retreat westward toward its present location along the modern barrier island chain. The retreat of the Virginia Barrier Island Chain as sea level rose has not been at a uniform rate. The rate of retreat has been influenced by changes in the rate of rise of sea level, and by movements of the earth's crust beneath the Eastern Shore area. Harrison, et al. (1965) have shown (Figure 9, p. 132) that past crustal uplift of this area has been substantial. Holdahl and Morrison, (1974) have shown (Figure 10, p. 134) that crustal movements are continuing at relatively high rates, and that there is differential movement along the Eastern Shore. The interaction of vertical crustal movements with sea level rise determined the relative rate of sea level change along the eastern shore at any point during post Wisconsin times. The rate of retreat (or advance) of the barrier island chain has thus been determined by this relative rate of sea level change.

C. Late Holocene

The geomorphology of a barrier island reflects the history of movement of the island. A barrier island that has been retreating steadily for a long period of time usually is narrow with only a single beach ridge unit along its length. A barrier island that has been advancing for a period of time should show a succession of beach ridge units and other landforms that record the advance of the island. The geomorphic features of the Virginia Barrier Island Chain are varied, recording both advance and retreat of the barrier islands.

The geologic history of the barrier islands that has been determined during this study shows that at some prehistoric time, the barrier island chain had retreated westward to a position near, or slightly west of, its present position. At that time Wachapreague inlet did not exist, and the northern half of the chain does not appear to have been segmented as it is today. That ancient barrier island chain also had a smoother ocean front than the modern chain has. The date of that ancient transgression is not known with certainty, but what has been learned during this study suggests that a date in the range of 1905-2200 years. B.P. is reasonable. The data upon which this conclusion is based are presented in earlier sections of this report.

The ancient retreat of the barrier island chain was followed by a period during which the barrier islands advanced seaward against an apparently falling sea level. Because no eustatic drop in sea level is known for the time period involved, it is presumed that the apparent drop in sea level was due to crustal uplift. Whatever the cause, the islands advanced, and the geomorphology of many of the islands records the beginning of that advance. Recent retreat of the islands has eroded away most of what was added to the islands. The change in the relative position of sea level is believed to have been in the order of 6-10 ft., and the advance of the islands on the order of 2-3 miles.

The prehistoric advance of the islands was eventually reversed, and the islands began to retreat westward again. That westward retreat, and the relative rise of sea level that it implies, has continued to the present. The time when the islands rereturned to a condition of retreat is not known. Newman and Rusmak (1968 report that the marsh west of Wachapreague Inlet began to form about 1000 yrs. B.P., but this

could have occurred with a falling relative sea level. Harrison, et al.(1965), reports a date determined from peat exposed on Hog Island that is 1170 yrs. B.P. That peat exposure is above modern high water, and may also have been formed with a falling relative sea level. Thus, the date of the beginning of subsidence (relatively rising sea level) is not known, but may have occurred more recently than 1000 years B.P.

D. Historical Retreat

The historical time span covered by this study is from 1852 to the present, although some of the hydrographic data goes back to 1847. Figure 88 has been prepared to aid in summarizing the historical changes in position of the Virginia Barrier Islands. In the figure, the islands have been grouped as they occur in the three natural segments of the barrier island chain. For simplicity, each island is schematically represented by a line. The lines are not drawn to scale for the islands, nor are they correctly orientated to the islands' axes, except that the top of the page represents a northerly direction. Arrows are used to indicate the direction of movement of the island's shoreline, and numbers indicate the general net amount of movement in feet. The column headings for each segment of the barrier chain are phrased to reflect the general nature of shoreline and island movement.

Comparison of the three columns of Figure 88 shows that the amount and nature of shoreline movememt is quite different in each of the three segments of the island chain. Along the northern segment of the islands, beach retreat has not been everywhere equal on an island, but it has been such that the islands have retreated without changing their orientation, and their modern beaches are approximately parallel to older beach positions. Locally higher amounts of retreat on an island are traceable to ephemeral inlets that have opened during the historical period. The column for this northern segment of the barrier chain also shows that retreat increases along the segment, to the south, past Metomkin Island.

The columns in Figure 88 for the middle and southern groups of islands in the chain show that these islands have experienced greater amounts of movement, and changes in the orientation of the islands. For both groups of islands, the numbers reflect the net movement of the islands during the historical period, but they do not show the fluctuations in shoreline positions that have occurred. All of the islands in these two groups have shown one or more periods when parts of their shorelines have advanced and then retreated again. The seaward beaches of all of these islands are influenced by inlet processes and the ebb tide deltas associated with them. The rotation of the island orientations that is seen in the islands of the middle group is directly attributable to changes in the ebb tide deltas at the inlets between these islands. The rapid changes in shoreline position that are indicated for the north end of Cobb Island are related to changes on the ebb tide delta at Great Machipongo Inlet. Similar changes have occurred to the sand spit at the north end of Wreck Island.

The islands of the southern group, with the exception of Fishermans Island, have shown the greatest amount of retreat. Because changes at inlets, and to their ebb tide deltas, have occurred, these islands also have undergone changes in their shape and orientation. The changes that have affected these islands are described and discussed in the sections of this report covering those islands. Average retreat rates for the islands have little real meaning because retreat has varied so greatly along the length of each island. Maximum retreat of Ship Shoal Island and Myrtle Island has occurred at the ends of the islands where changes in the inlet openings and channel positions were occurring. Both islands have built east facing beaches near their north ends, which have had the effect of reducing retreat of that por-

tion of the islands. Maximum retreat of Smith Island has occurred along the northern two-thirds of the island where the effects of breaching into Smith Island Bay have been concentrated. Net retreat on these islands, away from locations that have been affected by localized processes, appears to have been in the order of 1500-2000 ft., which is not significantly different from net retreat along the norther group of islands.

Little is known about the volume of sand that is moving along these islands in the longshore drift system. The analyses of shoreline changes and coastal processes that were done for this study suggest that there is not much sand moving from island to island in the longshore drift system north of Wachapreague Inlet. It was only south of that inlet that any evidence was found to suggest that sand was moving from island to island. It appears that the volume of sand so moved increases toward the southern end of the barrier island chain.

The reduction in the volume of sand in the longshore drift system along the northern segment of the barrier island chain can be traced to a loss of sand from the drift system at the south end of Assateague Island. Fishing Point, which is the hooked sand spit at the south end of the island, has grown in its entirety since 1852. Prior to 1852, the beach along the southern end of Assateague Island had grown past Chincoteague Island and had begun to accrete seaward. Fishing Point then built southward from that portion of Assateague Island for more than two miles before it recurved toward Chincoteague Inlet. The seaward, and southward growth of Fishing Point removed very large volumes of sand from the longshore drift system. In addition, the growth of the sand spit created a sand trap wherein sand in the longshore drift system is drawn off into the area sheltered by the sand spit where it is deposited. Byrne (unpublished report) has reported that the U.S. Corps of Engineers estimate that sand is being trapped in this area at a rate of 500,000 cu. yds./yr. This is about double the amount of sand that is generally believed to be moved in a longshore drift system in a year's time.

The sand trap at Fishing Point is a feature of historical origin, within the historical time period of this study. However, the accretion of the south end of Assateague Island, which led to the growth of the sand spit, undoubtedly reaches back into prehistoric time. It is, therefore, quite probable that there has been a reduced volume of sand reaching the northern segment of the Virginia Barrier Island Chain for many hundreds of years. The cause of the recessed nature of that northern segment of the barrier chain is then seen to be due to an excess volume of sand removed from the longshore drift system, over the volume introduced into the area by the drift system.

SPECIAL TOPICS

I. ORIGIN OF PARRAMORE PIMPLES

Some of the barrier islands along the Delmarva Coast exhibit peculiar mounds which are most frequently oval or crudely circular in shape. The mounds are invariably found as features of broad, sandy plains which have been referred to in this report as sand flats or swales. The relief of these features above the surrounding plain is generally quite low, ranging from 0.5 ft. to 3-4 ft. The mounds have been referred to in the literature as Parramore Island Mounds, or Parramore Pimples because they are abundant, and generally most well developed in the central area of Parramore Island, but may also be seen on Assateague Island, Cedar Island, Hog Island, and Smith Island.

Several authors have suggested modes of origin for these features. Melton (1929) suggests that they result from recent erosion of older features. Rich (1934) indicates that this origin is unlikely because the areas exhibiting Parramore Pimples today are remote from open stretches of water which could produce erosion. An alternate hypothesis is offered by Deitz (1945), he suggests that these features develop during the establishment of new marsh in areas of pre-existing lagoon bottom. His idea is that circular clumps of marsh grass developed, which served to trap other sediments and eventually produce the elevated mound. Despite the fact that Redfield (1958) shows that newly vegetating marshes tend not to produce such circular clumps in northern marshes, the imagery used for this study shows numerous circular clumps of marsh in areas of newly forming marsh. More recently, Cross (1964) suggests that subsurface flow of muddy strata may produce mound-like structures at the surface. This argument likens the origin of Parramore Pimples to that of the giant salt dome structures of the Gulf Coast, which are diapir structures.

Various Parramore Pimples were examined on Cedar Island, Parramore Island, and Smith Island when field work was conducted in September 1975. The mounds that were examined were all found to be composed entirely of fine sand and to rest upon a sandy substrate, including those that were located in marsh areas. Borings and excavations were employed to investigate both the mounds and the plain upon which they were found. Borings were carried to a depth of eight feet. The substrate upon which the mounds are located was found to consist of sandy strata with some minor silty-sandy layers up to 6-8 ins. thick. Most of the strata were firm and compact, but occasional layers up to two feet in thickness were found to have a high water content. The auger would sink freely into them as the hole was bored. However, the possibility of flow in these layers seems unlikely because it was possible to auger past them without the hole filling with water, or caving.

The Geologic Maps of Cedar Island and Parramore Island show that most Parramore Pimples occur in rows which probably represent former beach ridge or dune ridge deposits. However, they are also found with more random distribution, particularly on sand flats along the marsh side of the islands. The features are easy to identify on the IR imagery employed for the study, and although many were drawn on the geologic maps, many more were too small to show on the map. Wherever Parramore Pimples were found on the islands, they were always associated with geomorphic features that represent rapid progradation of the island, accompanied by occasional storm overwash.

The association of Parramore Pimples with features of rapid progradation and overwash, and their absence at other locations, suggests hypotheses to account for their formation. The occurrence of these features in rows on sand plains that have accreted

rapidly indicates that low sand dune ridges or beach ridges behind the accreting beach were breached at close intervals by storm overwash. This would leave a row of low, isolated, mounds protruding a few inches to several feet above the surrounding overwashed sand flat. Following a period of storm overwashing, the mounds would be nourished and perhaps enlarged by wind-blown sand, before overwashing again reshaped them and enlarged the gaps between them.

Gradually the prograding beach would leave these isolated mounds inland and a new sand dune ridge, or beach ridge, would form seaward of the first row of mounds. Apparently, as long as the relief of the overwashed sand flat above sea level remains low, and rapid progradation continues, successive rows of Parramore Pimples are started. It is believed that repeated flooding of the sand flat area by successive storm high tides produces wave wash effects that help to maintain the general circular character of the mounds. Drift lines of marsh grass that build around some of the mounds probably help to trap washed, and wind-blown, sand to create the annular character of some of the Parramore Pimples. The formation of a high beach ridge, the relative lowering of sea level, or both, appears to terminate eventually the process of forming Parramore Pimples.

Parramore Pimples that occur with a more random pattern of distribution appear to occur on sand flats that have been built by overwash on the marsh side of the islands. Such sand flats may not always be associated with rapid progradation, but they are aggradational features which form over short spans of time. An alternate mode of origin for Parramore Pimples is found at these sites. Clumps of water borne detritus left on the surface of the overwashed area, and damp areas, serve as sites for accumulation of wind-blown sand derived from other, drier, areas of the sand flat. Rapid colonization (within 2-5 yrs.) of the sand flat by vegetation after overwashing ends, prevents further modification of the low mounds by the wind. While these hypotheses are tentative at this time, the field observations and data of this investigation support them quite well.

II. INFRARED PHOTOGRAPHY FOR COASTAL PROCESSES DATA BASE

This study of geomorphology and coastal processes has profited greatly from the use of false color thermal infrared aerial photography obtained from, and via the kind permission of, the Environmental Studies Program of the N.A.S.A., Wallops Island Flight Center. During the course of this study, techniques have been developed to determine the significant processes which dominate the various sections of each barrier island. These techniques generally consist of careful study of each available photo and the determination of the form of each geomorphic feature shown. With practice and training, an extremely detailed map can be produced. High quality IR photography should not be used exclusively in future studies as all information obtained from this photography should be verified through comparison with other forms of aerial photography, map data, and field work to check the assumed nature of features shown on the IR photography. These verification techniques were utilized in this study with the pleasing result that interpretations from different sources agreed well.

SUGGESTIONS FOR FUTURE RESEARCH

I. GENERAL STATEMENT

This study has been of a reconnaisance nature and should not be considered the final word in regard to any of the geomorphological processes operating in the Virginia Barrier Islands. The study has produced a valuable regional analysis and yields many new insights into the coastal processes and geomorphology of this area. The authors do not possess the wisdom or hubris to foresee all of the potential future research which will be accomplished in this area. However, the Virginia Barrier Islands are a valuable scientific resource with an undisturbed array of natural processes to be studied. The results of many future studies will have applications well beyond the local area, as they can be used for undisturbed analogs for many other coastal areas which are already too heavily developed to permit study of natural processes.

II. SPECIFIC PROJECTS

Many future studies appear to be significant in light of the study performed in producing this report. Some are given in relatively random order in the following paragraphs.

The most important unknown item in the present state of knowledge of the coastal processes acting on the Virginia Barrier Island Chain is the rate of longshore sediment transport. Byrne, et al. (1965) and Goldsmith, et al. (1975), as well as others, indicate that the general longshore drift along the northern five islands appears to be to the south. The results of the present study indicate that general longshore drift is to the south along the entire barrier island chain. They also indicate that the volume, or rate of drift, along the northern five islands is low, and that the rate increases in a southerly direction. However, the existing data are qualitative, not quantitative. If studies could be conducted to determine the rate of sediment transport over a long period of time at each of the barrier islands, valuable information would be derived, which could be used to determine future natural changes to these islands.

A second marine geomorphological study which would be of value would involve making a quantitative determination of the rate at which the lagoon and marsh areas are undergoing sedimentation. Newman and Munsart (1968) and John Boon (V.I.M.S., Ph.D thesis) have studied this topic at local areas. Newman and Munsart (1968) report that the age of the marshes may be relatively young (1000 years B.P.). If this is the case, then the filling of these lagoon and marsh areas may be reaching a waning phase. This in turn implies that less sediment may be worked into the lagoons from the ocean beaches in the future. Thus ocean beach erosion rates may decrease in the future.

A related problem of interest is the cause of the virtual absence of peat deposits in the Parramore Island marshes, as well as in other marsh areas. The augering and probing conducted by the authors of this report indicate a sand substrate and virtually no peat in these marshes. This may imply that they are very young. If this proves true, a determination of why they are young may provide new insight into the pre-historic development of this area.

Further insight into the pre-historic development of this island chain could be obtained by acquiring dates on the live oak (Quercus virginiana)stumps on the

seaward face of Parramore Island and the marsh peats exposed south of the Mud Hole on the seaward beach of Smith Island.

Additional study of the drowned beach ridges called Holly Bluff, Skidmore, Racoon, and Mockhorn Islands may yield datable material. It would be useful to confirm the pre-Pleistocene age of these features.

Complete studies of the tidal hydrodynamics and sedimentation patterns at all inlets are important to gaining insight into the processes which dominate much of the development of these islands. Byrne et al. (1974) reports on one such detailed study of Wachapreague Inlet. Byrne and his students have been engaged in other similar studies, and this work should be continued. The inlet which offers most promise for new productive study is Ship Shoal Inlet. This inlet plays a dominant role in the southern sections of the Barrier Island Chain. It has a recent history of abrupt changes in the position of the channels on its ebb tide delta. It has shifted its marsh and inlet channel southward by about 3700 feet, and it exhibits a series of relatively long beach ridges on the northern shore of the marsh channel leading to the inlet.

The value of high quality, large scale, false color thermal infrared photography for geomorphic studies of the Virginia Barrier Islands has been documented in this report. Future research would benefit if a series of such aerial photography were produced from flights at regular intervals. The optimum series would consist of a flight once every two years at the same seasonal period.

MANAGEMENT RECOMMENDATIONS

Clearly the generally small physiography and the comparatively rapid rates of geomorphic change in the position, size, shape, and number of barrier islands in the Virginia Barrier Island Chain dictates that a carefully designed system of land stewardship be applied by The Nature Conservancy. The great natural beauty of this area as well as the general shortage of undeveloped coast, immediately suggests a land custody system which preserves these islands. However, this report has gone to great length to show the large and rapid changes which continually occur on these islands. It is most important to begin any management plan by recognizing the ubiquitous nature of these changes. It is important to recognize that the changes in the position, size, shape, and number of barrier islands in this chain do not fit well with our legal system's concepts and regulation of land ownership. Thus an enlightened management policy must not only consider the social value and ecological implications of its policies, but also the legal realities of implementing any given policy or course of action. The authors of this report would be loath to see widespread commercial or private development of these barriers. However, there will always be an economic incentive to allow this to occur. Therefore, it must be stressed that private ownership of lots will be difficult to maintain as almost all areas are subject to erosion and flooding hazards. The tendency to wish to maintain the position of sea facing lot boundaries implies increasing activity and expense to control coastal erosion. Such activity is generally only marginally successful, but is prone toward seriously disrupting the finely balanced array of geomorphic processes which presently control these islands. The high rate of retreat of these islands and the lack of knowledge of the rate of longshore drift of sediment, serve to emphasize the need to restrict efforts to control beach position.

On a larger scale, the questions of land stewardship, coastal change, and our present legal system, indicate that The Nature Conservancy must act at an early date to assure that its control of all land areas of the islands which they presently own is maintained. As each island undergoes its natural migrations, some land areas disappear while new land areas are created. Steps must be undertaken to assure that all new land areas become the property of the owners of the migrating barrier island. This should be rather trivial in the case of new land areas which are always contiguous with the barrier island, but is more of a problem when small islands emerge adjacent to the main barrier island. Such new minor islands are common in the Virginia Barrier Island Chain. They tend to fall into three groups: (a) ebb tide delta islands; (b) flood tide delta islands; and (c) inlet islands. The first of these categories is exemplified by the islands which have developed and disappeared off the northeast shore of Hog Island, Cobb Island, and Myrtle Island during the last century. Only the island off Cobb Island appears to have been named and was called Pig Island. All of these small islands developed on the downdrift side of the ebb tide delta of the adjacent inlet. In time, each migrated towards the adjoining major barrier island and ultimately the two islands fused together. Some of these islands are quite extensive (Pig Island was 1.0 mile long) and one may last a decade before it fuses with the major barrier island. It appears likely that similar islands will develop off Hog, Cobb, and Myrtle Islands so The Nature Conservancy must be prepared to establish its control over these new lands before they appear. Such occurrences are definitely not limited to these three islands, although they are most likely there, so the policy must be of a general nature.

The second and third types of new minor islands will probably be more difficult to

deal with. Both the flood tide delta islands and the inlet islands do not tend to migrate, and thus do not fuse with the adjacent major barrier islands. Flood tide delta islands are generally marsh islands with small sand beaches where they face a large open body of water. Inlet islands tend to be sand islands with little or no vegetation. Both types develop from some degree of horizontal assymetry between the flood and ebb tidal currents at the inlet and are both really mated to the inlet processes, rather than processes unique to either of the adjacent major barrier islands. Thus, it appears difficult to establish ownership of these new islands based on ownership of the adjacent barrier islands. The authors of this report have no legal expertise and thus recommend that legal advice be sought elsewhere to create a system wherein all new islands developed within the section of the barrier chain owned by The Nature Conservancy will be possessed by The Nature Conservancy. As these types of new islands develop commonly, and are already producing disputes at Wachapreague Inlet and Quinby Inlet, it would be well to take early action to determine the correct legal actions to acquire title to these small islands. Finally, it must be recognized that inlet islands are most often short-lived, but some may grow to be major islands as in the case of Little Cobb Island. Other new islands, such as those produced by the recent breaching of Metomkin Island, can grow to be major barrier islands.

The nature of the islands in the Virginia Barrier Island Chain has been defined in this report. The high rate of retreat of the islands, combined with their low relief, makes them prone to frequent overwashing and storm flooding. These conditions are unfavorable for private, or commercial, development, but they favor the maintenance of a productive natural ecologic system. Management plans developed by The Nature Conservancy for their stewardship of this area should be framed with these conditions in mind.

Because it is understood that the intent of acquisition of the island area was its preservation, and not its development, the management recommendations of this report do not consider the many problems that development would create. The recommendations are directed to large-scale policies and procedures that would benefit the entire chain of islands. They also advise on practices that might be employed (or should be avoided) in local areas.

A most important concept to be expressed by this geomorphological report is that the existing barrier island chain is the result of relatively delicately balanced natural processes and that rapid rates of physiographic change are common. This has clearly been the case for the several thousand years that this barrier island chain has existed, and thus the islands are resilient and durable in their natural condition. All too often this fact has not been recognized in other areas so that landowners and managers have attempted to modify and control natural processes so as to stabilize some arbitrary position and outline of the barrier islands. The barrier islands from the southern coast of Long Island, New York, to the eastern coast of South Florida which have been developed and "stabilized", have proven to be extrememly difficult to control and very expensive to maintain. Clearly, the proper future management of the Virginia Barrier Island Chain requires a policy of minimum interference with the natural processes acting on these islands. However, this policy should not develop by default nor appear to local citizen and governmental agencies as neglect. Inevitably both local citizens and government agencies are prone to producing schemes to "stabilize" or "improve" coastal systems. This sociological phenomena too frequently results in pressure to "do something" about the natural changes of such coastal systems. This in turn produces hostility, legal problems, or unnecessary and expensive projects. Therefore,it is recommended that a policy of minimum maintenance of the Virginia Barrier Island Chain be deliberately chosen. A public information system should be developed to make all concerned individuals aware of the specific reasons that such a policy has been adopted. This public information system can take the form

of periodic news releases, a pamphlet series, talks by Conservancy personnel at civic or social organization meetings and any other method of publicizing the sound rationale which has led to this policy. In the short run, this will probably result in some noisy dissent but in the long run it will forestall many specific public and governmental pressures as well as be more economical than an unending series of stabilization and maintenance projects.

A minimum maintenance/minimum interference policy does not preclude any activity designed to control or modify natural processes. It does preclude any action which has not been fully planned and thoroughly researched, so that the far-reaching effects and interactions are understood, as well as the immediate local effects which are intended or a necessary byproduct of the action. Certain government agencies have developed a reputation for producing planning documents which are made up of non-specific information as well as generalized data indicating that proposed projects have favorable economic effects while creating a minimum of immediate environmental problems. These documents exemplify the form of incomplete environmental analysis which frequently results in widespread environmental damage that could have been foreseen. On the other hand, there are many fine examples of well planned projects which have greatly benefitted coastal areas.

In making future assessments of any plan which will affect the coastal systems of the Virginia Barrier Island Chain, the following recommendations should be fully considered.

I. INLET STABILIZATION

This report has documented the close interrelationship between the historic changes in various inlets (via natural processes) and changes in the ocean beaches, marsh channel and tidal creek systems, and in lagoonal currents and sedimentation patterns. Thus, any plan intended to stabilize an inlet, improve its navigability, or change its sedimentation pattern should be carefully studied and evaluated in terms of the probably large scale side effects of the project. It must be stressed that the inlet does not merely consist of the passage between adjacent islands, but also involves the ebb and flood tidal deltas which may extend for many miles about the inlet throat.

II. BEACH EROSION CONTROL PLANS

It is unlikely that serious pressure to control beach erosion will occur if the Virginia Barrier Islands remain undeveloped. However, in the event that evaluation of such plans should become necessary, the following recommendations should be considered. Considerable documentation exists in this report and other documents and publications to prove that there is a general westward migration of these barrier islands due to a continued, slow rise in sea level. Thus, the natural future development of these islands involves continued westward migration realized by continued erosion of their ocean beaches. The natural maintenance of these islands is assured through the variety of barrier island processes described in the introductory sections of the report which serve to transport and deposit sediment behind, over, and through barrier islands. The only exceptions to this natural pattern of westward migration occur at the north ends of the islands in the middle segment of the barrier island chain and over much of Fisherman's Island. In the case of the middle segment of the barrier chain, there is no assurance that the present accretion of the north ends of the islands will continue long into the future. Thus, any system to control beach erosion will eventually be overridden by this general migration.

Attempts made to retard erosion at a specific location can produce only short term benefits. If it is crucial to retard erosion at such an area for a period of five to ten years, then the services of a licensed engineer should be sought to design a sea wall or groin field. It must always be borne in mind that trapping of sand with groins or the retarding of erosion at one place with a sea wall, usually results in considerable disruption of the longshore transport of sand. This, in turn, can and often does, produce acceleration of erosion in other areas (usually, but not always, down drift of the site of the erosion control area).

Another method for locally stabilizing the position of a portion of ocean beach is beach nourishment. Sand from some remote area is dredged and deposited at, or up drift of, the area to be protected. Such projects are costly, as they require tremendous volumes of sand, and their beneficial effects are short-lived. In many areas the source of the large volume of sand is difficult to determine. Recently, beach nourishment plans in other areas have required an offshore sand source. The seaward margins of the ebb tide deltas of the Virginia Barrier Islands appear to be adequate sources for such large volumes of sand but great care must be exercised to avoid changing the channels, or pattern of currents through the inlet as this can lead to major changes in island shape and position.

III. DUNE STABILIZATION PLANS

Many Atlantic Coast barrier islands have experienced attempts to stabilize their coastal dune system. These efforts have been made to control beach erosion, to limit the occurrence of storm flooding, and to inhibit overwash processes from innundating inshore areas with overwash sand deposits. The plans vary from the partial burial of a few scattered old Christmas trees to trap windblown sand, through the use of snow fence for similar purposes, to extensive artificial dune ridges which are bulldozed into position and stabilized with beach grass. The results of these efforts has been varied. Dune stabilization systems do offer some promise for protecting some upland areas in the Virginia Barrier Islands from storm flooding dangers, but they must be used cautiously.

It is impossible to predict all of the circumstances where dune stabilization may appear to be beneficial. However, the following recommendations and cautions should be considered. In all cases, the services of a competent coastal geologist should be secured to determine the feasibility of the project, and the long term or distant side effects which may occur.

Dune stabilization projects can work in almost any coastal area where there is an adequate source of windblown sand. However, these projects should be limited to areas immediately adjacent to broad portions of the barrier islands which show no indication of overwash and recent ephemeral inlet deposits. Therefore, the thin and low portions of each island, which may appear to be most in need of stabilized dune fields, should <u>not</u> be the site of such projects. These areas depend for their existence on the landward migration of dunes, the growth of sand deposits within the lagoon via ephemeral inlets and the deposition of sand through storm overwash. These processes slowly extend the lagoon side of the islands so that the island's existence is maintained as the ocean beaches erode. A dune stabilization project in such an area can increase the height of the backbeach dunes. However, this creates a situation wherein continued beach erosion eventually breaches the dunes with far more catastrophic results than would occur had the dunes been left to migrate in their natural condition. These areas of low, thin barrier island with migrating dunes, ephemeral inlet deposits, and many overwash channels are easily located on the geo-

logic maps which accompany this report.

In areas within the broad portions of the barrier islands where the above-mentioned geomorphic features are uncommon, it may be desirable to stabilize the coastal sand dunes. This may be accomplished with snow fence or by bulldozing and grass planting. However, it must be remembered that the stabilized sand dunes may ultimately be eroded as the ocean beach erodes back. The eventual effect of this large reservoir of sand in modifying the longshore sand transport system should be considered, as should the effect of depleting the longshore sand transport system at the time of stabilization.

IV. CONTROL OF ISLAND BREACHING

The geologic history of the islands in the Virginia Barrier Island Chain shows that breaching of the islands is a common natural phenomenon. The nature of the ephemeral openings thus formed has been discussed in an earlier section (page 436). The lifetime of ephemeral inlets varies from a few days to many years, and is determined by many factors; chief among which are the location of the breach on the island, the morphology of a large area surrounding the breach, and tidal circulation on the marsh side of the island. This study has shown that along these islands the lifetime of narrow discrete ephemeral inlets is usually less than a decade, while that of the larger, major breaches is on the order of 25-40 years.

The frequency at which breaching and the development of ephemeral inlets occurs is less certain. The number of minor ephemeral inlets that have opened, and closed again, in time periods between a few days and a few years, is unknown. Such openings are too short-lived to have left significant and noticeable deposits. Because the retreat rate of the islands is quite rapid, the number of such breaches into tidal canals is probably quite large. Unfortunately, hydrographic, photographic, and topographic surveys of the islands have been too infrequent to provide any meaningful data on this rate of occurrence. The work of this study suggests that many of the larger (0.1-0.3 mile wide) overwash channels may have been initiated as shortlived ephemeral inlets.

The data base of this study does provide evidence bearing on the opening of significant ephemeral inlets. During the century and a quarter of the historical period of this study, every island in the chain, except Fisherman's Island, Wallops Island, and Wreck Island has experienced only one period of breaching. In each instance, the breaching period has occupied no more than several decades, and often less than one decade. In every case the ephemeral inlets have altered tidal circulation and shallowed the inland marsh and bay areas, thus stabilizing that portion of the barrier island.

Metomkin Island and Smith Island have both experienced major breaching within this century; Metomkin Island, most recently. The episode of breaching on Smith Island is drawing to a close. Both major breaches have healed, but retreat is still rapid near Mud Hole, and short-lived breaches may be expected in that area as the retreat of the beach intercepts marsh canals. As the beach along Smith Island recovers from its breaching episode, a new, and higher beach ridge should form, and the present process of breaching should come to a close. The breaching of Metomkin Island has been more recent, major changes and inlet migration are still occurring, and can be expected to continue to occur for the next 10-20 years.

The data of this study may be used to prognosticate. Cedar Island breached once (about 1956) and will probably breach again just south of the northern marsh area at the base of the southern sand spit. However, Burtons Bay is very shallow, and

the breach may be predicted to occur as a narrow, discrete, ephemeral inlet, and produce another extensive sand delta as was produced by the earlier inlet. Cobb Island, south of its midpoint is the next most likely candidate for major breaching. A long section of this island faces open bay, and is already overwashing at a rapid rate. The nature of the breach that will probably occur here is difficult to predict because of the marsh configuration. A "best estimate" would suggest that it will be a discrete inlet opening.

The Nature Conservancy should resist the temptation to try to forestall these events as those attempts are unlikely to be successful over the long term, and may commit the organization to an expensive policy where attempts are made to plug all possible future breaches. These temporary breaches are necessary to bring sand to the lagoon side of the islands, and are simply natural events in the continued development of the islands. They should, therefore, be left alone to conduct their function.

In some restricted cases it may be profitable to limit the distance that overwash deposits are spread into the lagoon. These deposits occasionally threaten commercial shellfish grounds. A system of marsh grass transplanting may be attempted to artificially induce marsh development behind the barrier island so that the future overwash is trapped by the marsh rather than spread into the lagoon. An attempt to induce marsh development via this method was tried by P. Godfrey in North Carolina and was successful (Godfrey, personal communication, 1974). However, the services of a competent agricultural agent or botanist should be secured if this method is attempted.

V. WATERWAY AND CANAL DREDGING

Preceding sections of this report have shown the importance of tidal inlets to the maintenance of the barrier islands. The tidal inlets also are intimately related to the exchange of tidal waters within the lagoon and marsh system. Changes in the natural circulation patterns within the lagoon and marsh may often have substantial detrimental effects at inlets, as well as within the marsh and bay areas. Examples of the effect of tidal scour on artificial channels such as Teagles Ditch and the Intracoastal Waterway have been cited earlier. Moody (1963) documents two other similar situations where artificial ditches within the marsh of the northern Delmarva barrier island chain were widened greatly by tidal scour.

The alteration of tidal channels within the marshes and lagoons can change the tidal flow at the adjacent inlets. It has been shown several times in this report that changes in the inlet tidal currents have dramatically altered the pattern of erosion and deposition on the ocean beaches. Therefore, any project which involves dredging existing or new channels should be carefully evaluated in terms of its system-wide effects by a coastal geologist.

If a project of this nature becomes necessary, and if it can be shown to have minimal harmful effects to the entire environmental system, then the site for depositing dredge spoil must be considered. At present, there are several old dredge spoil deposits on old marshes behind the Virginia Barrier Islands. This practice probably only damages the least productive portions of the marsh and thus does not critically endanger the estuarine system. However, these old dredge sites do not revegetate rapidly (the process appears to require some decades) and thus produce long-lasting scars. It would be better to use this dredge spoil as artificial beach nourishment wherever possible. The suitability of the spoil for this purpose is determined by its grain size and pollutant content. The economics of dredging are seldom

favorable for using long pipes to transport the spoil from the site of the dredge to a remote ocean beach. Thus, dredge contractors resist having to do this wherever possible. The Nature Conservancy should be prepared to insist on this practice whenever it appears beneficial. The services of a coastal geologist and an engineer should be sought to work together in assisting The Nature Conservancy in planning such projects.

VI. THE USE OF THE VIRGINIA BARRIER ISLANDS AS A SCIENTIFIC RESERVE

The Virginia Barrier Islands which are owned by The Nature Conservancy appear destined to become a reserve for scientific research. If this course is followed, there are several specific recommendations which would serve to enhance these islands for scientific study. First, a full-time management team is required to lend supervision and continuity to the program. The uses of the islands and the qualifications of individuals who will be permitted to carry out research must be clearly stated at an early date. A local library should be promoted, possibly in conjunction with, or through support of, the library at the V.I.M.S. Marine Station at Wachapreague. That library has already collected many of the books, journals, theses, articles, and reports which are of interest to investigators of the adjoining coastal areas. However, an effort should be made to assist that library in future acquisitions. This may be particularly important in regard to the many limited circulation reports which have been, and will be, written about this area.

A detailed map series should be available to investigators with navigable channels, landing sites, and basic topography indicated so that scientists can adequately plan their research. These maps should be of large-scale for use as base maps where such are required.

A standardized report should be required from all projects, regardless of funding source, so that The Conservancy is kept aware of all scientific finds. Such reports should be kept on file so that subsequent investigators will be aware of all previous research.

Some prepared landings might be established on the marsh side of some of the islands to allow access to the island over the greatest range of the tide possible, and to guide foot traffic to a central pathway. If it becomes possible to acquire some of the abandoned U.S. Coast Guard facilities, they could be maintained as base camps for scientific parties, with minimal inconvenience to The Nature Conservancy personnel.

VII. POTENTIAL HARBOR EXPANSION

At the present time, there is a potential for the need to develop harbor facilities which will support an offshore oil industry near the Virginia Barrier Islands. If such a course develops, then it is recommended that Sand Shoal Inlet be considered as the best inlet for access between the ocean and the mainland. This inlet has shown relative stability during the historic period covered in this report. It has also maintained maximum depths in the order of 90 feet and minimum depths across the ebb tide delta of 20-24 feet. The natural channel across this ebb tide delta is prone to drifting sand shoals that modify its position, but its depth is naturally maintained and the shifts in channel position can be monitored, and channel markers can be moved. The use of most other

inlets in the southern portion of the Virginia Barrier Inlets will likely require jetties and dredging, which would probably produce substantial environmental and erosional damage to the islands.

A final management recommendation which should be made concerns activities that may occur along the entire Delmarva Barrier Island Chain, and mainland coast. The bay, island, marsh area owned by The Nature Conservancy is a very delicately balanced system. Many factors which have been discussed in this report affect that delicate balance, and changes in those factors can cause rapid and significant changes in the islands, or the entire barrier island system. It is imperative that The Nature Conservancy realizes that changes in factors remote from their property can affect their property. A case in point is the recently proposed Delmarva Waterway (U.S.A.C. of E. proposal), which would seriously disrupt tidal circulation in the bay and marsh areas, as well as at inlets, to say nothing of the problems associated with dredge disposal. The Nature Conservancy must remain aware that any changes within the system will affect their holdings, and they must be prepared to intervene in any proposal that will affect the Virginia Barrier Islands, even though it may be many tens of miles away.

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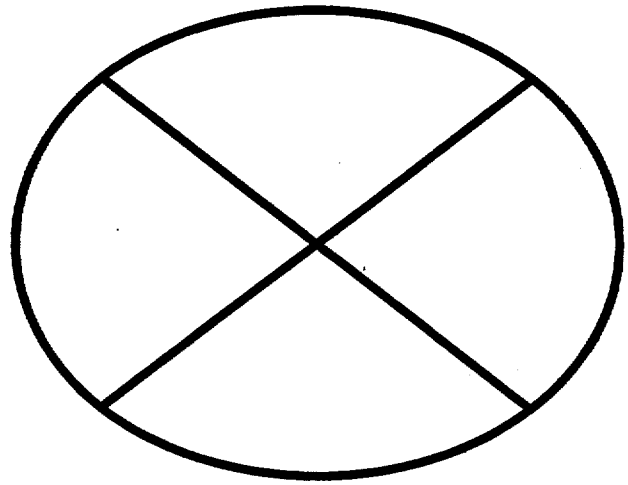

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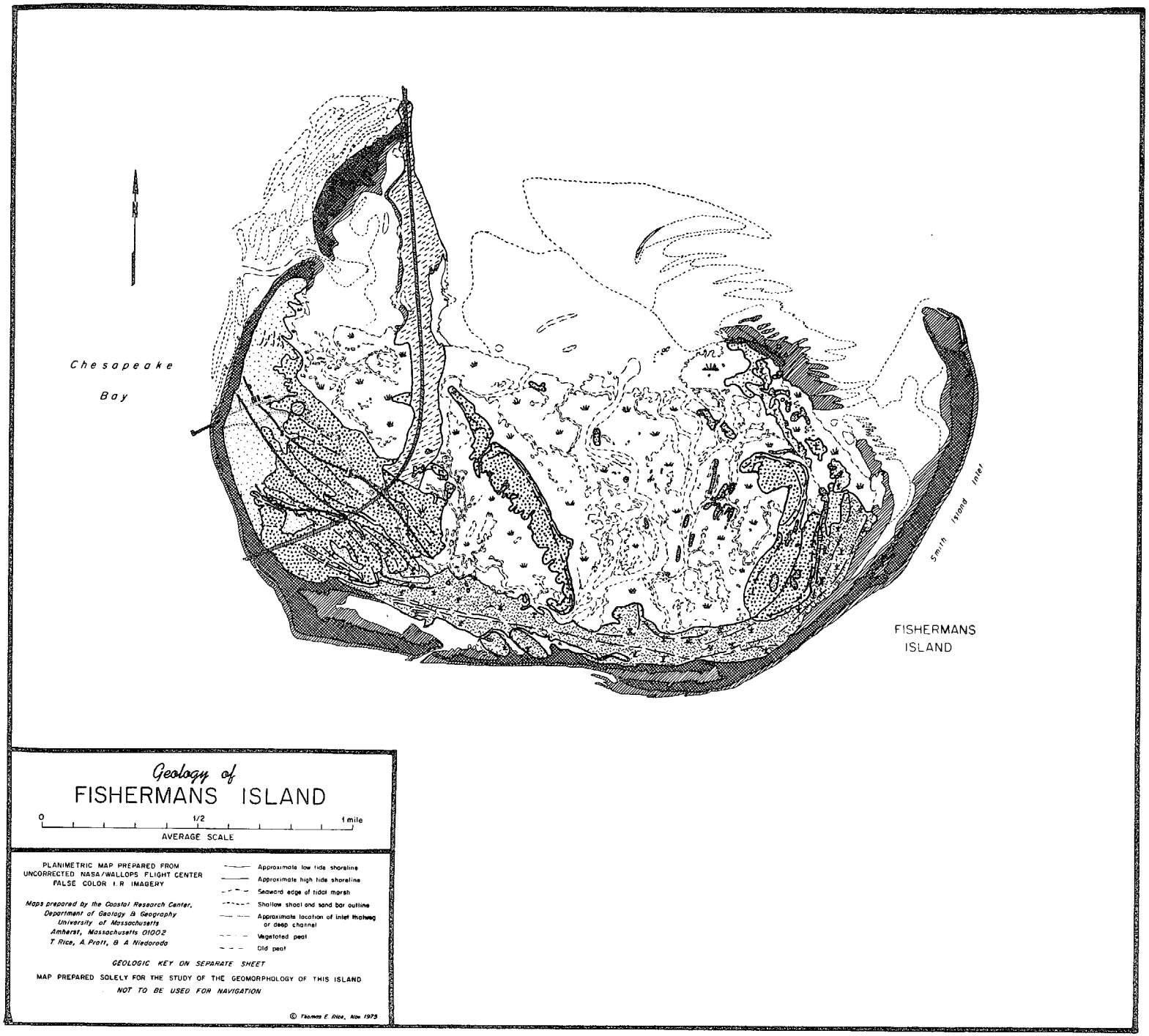
Chesapeake
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AVERAGE SCALE
PLANIMETRIC MAP PREPARED FROM
UNCORRECTED NASA/WALLOPS FLIGHT CENTER
FALSE COLOR I.R IMAGERY
Maps prepared by the Coastal Research Center,
Department of Geology & Geography
University of Massachusetts
Amherst, Massachusetts 01002
T. Rice, A. Pratt, & A. Niedoroda
Approximate low tide shoreline
Approximate high tide shoreline
Seaward edge of tidal marsh
Shallow shoal and sand bar outline
Approximate location of inlet thalweg
or deep channel
Vegetated peat
Old peat
GEOLOGIC KEY ON SEPARATE SHEET
MAP PREPARED SOLELY FOR THE STUDY OF THE GEOMORPHOLOGY OF THIS ISLAND
NOT TO BE USED FOR NAVIGATION
© Thomas E. Rice, Nov 1975

Flora

THE MAJOR VEGETATION COMMUNITIES

OF THE

VIRGINIA COAST RESERVE

This Section of the Ecosystem Description Volume of the Virginia Coast Reserve Study has been compiled from information contained in a report prepared by Cheryl McCaffrey under contract to The Nature Conservancy. The original document entitled, "Major Vegetation Communities of the Virginia Barrier Islands: Metomkin Island through Smith Island Inclusive" is in The Nature Conservancy's National Office.

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INTRODUCTION

I. LOCATION

The Virginia Barrier Islands from Metomkin Island through Smith Island extend about fifty miles along the ocean fronting the Eastern Shore of Virginia. The sixteen islands included in this study are, from north to south: Metomkin (a complex of three main island segments), Cedar, Parramore, Revel, "Crescent", Chimney Pole Marsh, Hog, Rogue, Cobb, Little Cobb, Wreck, Ship Shoal, Godwin, Myrtle, Mink, and Smith. They extend from about ten miles south of Assateague National Seashore to the north entrance of the Chesapeake Bay Bridge-Tunnel.

A wide variety of plant communities are represented here, including: frequently overwashed, sparsely vegetated salt flats, dense grassland, shrub thickets, upland forests of pine and hardwood species, brackish marshes, fresh marshes, and tidal salt marshes.

II. GENERALIZED ISLAND CHARACTERISTICS

The islands are generally low and sandy. A beach, varying from about fifty feet wide to 1800 feet wide on accreting sections, fronts the ocean and inlet sides of all islands. A natural foredune generally separates the beach from the interior grassland community. The grassland may be well protected and dense, or it may be sparse, often in various stages of recovery from overwash.

Some islands appear particularly lower than others with a narrow super-tidal zone experiencing extensive overwash and maintaining a relatively sparse herbaceous cover. These include Metomkin, Little Cobb, "Crescent", the south ends of Cedar and Hog, and the north ends of Ship Shoal and Smith Islands. Some islands are predominantly dense grasslands or beachgrass grasslands, including Cobb, Wreck, Myrtle, and the south end of Ship Shoal. Others support more advanced communities with shrub thickets. The taller thickets are very dense and may be considered nearly forests. They occur on Parramore, Hog, the north end of Cedar, and the south ends of Revel and Smith Islands. Large forests of pine and hardwood species exist on Parramore and Smith Islands. A small forest similar to that on Parramore is located on the north end of Revel Island. The wider islands have fresh or brackish marshes which resemble extensive lush meadows. Such interior marshes are found on Cedar, Parramore, Hog, and Smith Islands.

Behind all of the islands are extensive low *Spartina alterniflora* marshes extending to major creeks and interlaced thoroughly by smaller ones. Several of the islands are composed mostly of such salt marshes including Revel, Chimney Pole Marsh, Rogue, Ship Shoal, Godwin, and Mink. A vast interior salt flat is a unique feature of Hog Island. Thin bands of essentially bare salt flats or mud flats are found either fringing or within the marshes on all islands.

The islands vary considerably from each other. Their main characteristics are outlined in Table 1 with more detailed descriptions following later.

III. DISTURBANCE

The Virginia Coast Reserve is believed to be one of the few remaining eastern coastal areas left relatively undisturbed by human influence. Use of the islands was once more wide-spread than it is today. A thorough treatment of human influence on the

TABLE 1

GENERAL ISLAND CHARACTERISTICS

Metomkin: Narrow; overwash and inlet influenced

Cedar (north end): Juniper - poison ivy thicket
(south end): Narrow; overwash influenced

Parramore: Pine and hardwood forest; fresh marshes (cattail); extensive inland brackish marshes; interior open dune - thicket complex

Revel: Pine-hardwood forest (similar to that of Parramore); northernmost island with yaupon holly

"Crescent": Recently formed; overwash influenced

Chimney Pole Marsh: Marsh island with salt pond and grassland sections

Hog (north end): Salt flats; accreting beach; dense, tall wax myrtle thicket; dune grassland complex; open dunes - tall thicket complex
(south end): Erosion and overwash influenced

Rogue: Marsh island with pond and dense grassland

Cobb: Dense, mesic grassland (salt meadow cordgrass) with xeric dune ridges

Little Cobb: Erosion and overwash influenced

Wreck: Dense grassland and dunes (American beachgrass)

Ship Shoal: Marsh island
(north end): Overwash influenced
(south end): Dense mesic grassland (salt meadow cordgrass)

Godwin: Marsh island

Myrtle: Dense foredune-grassland (American beachgrass)

Mink: Marsh island; high area of dense grassland (salt meadow cordgrass)

Smith (north end): Narrow; overwash and inlet influenced
(south end): Wooded dune ridges alternating with brackish marshes; hardwood forest different from that on Parramore Island; only island with oaks, northernmost island with live oak; juniper is uncommon

barrier island ecosystem is found in Land Use History - A Study of Man's Influence on the Virginia Coast Reserve, Section one of this report. Some of the most dramatic examples of plant community distribution are the result of the naturally occurring geological processes previously mentioned in this volume. See Figure 6.

These are all natural phenomena caused by wave dynamics, storms, and sea level rise. They occur frequently on barrier islands. It has been shown that the herbaceous communities are well adapted to respond and recover from the effects of overwash. They also are adapted to recolonize former inlet areas (Godfrey, 1970; Godfrey and Godfrey, 1974a).

Shoreline stabilization attempts have been made at many locations along the east coast. Since the processes responsible for shoreline changes (sea level rise, storms, and wave dynamics) have not been stopped, the processes continue, sometimes aggravated by man's alterations.1/

IV. LITERATURE REVIEW

Only three sources were found in the literature dealing with the upland plant communities (Clovis 1968, Harvill 1965, and Marsh 1969). They are all short, general descriptions of the communities including some major species of each.

Little has been studied of the flora here. Several plants at both the northern and southern ends of their respective ranges are found on these islands. Many important species here differ from the vegetation of Assateague Island, though they are all part of the same grouping of islands (Higgins, et al. 1971). Comparison with a northern coastal vegetation such as that of the New Jersey coast reveals many major differences (Martin,1959). The Chesapeake Bay presents a natural barrier to the northern range extension of many southern plants. This is one reason why many species on the Virginia Barrier Islands vary from those to the south on North Carolina's Outer Banks (Burk,1961). Despite the geographical barrier of the Chesapeake Bay, many species important in southern coastal communities are abundant on the Virginia Barrier Islands. The plant communities here generally exhibit more southern than northern characteristics.

V. PURPOSE

This study has been conducted under the support of The Nature Conservancy to provide a sound botanical background upon which to base stewardship plans for the Virginia Coast Reserve. It provides an inventory of major communities, their location on the islands, and their species composition.

VI. CONTENTS

This report includes a generalized description of the islands and unique features of particular islands. The main focus is the series of vegetation maps keyed to a legend. The maps are reproduced at a scale of approximately 1:20,000. The legend is explained in detail with a generalized description of typical communities including major variations and the most abundant species. Each island is described in some detail including vegetation types (main communities, variations in communities and species, and island peculiarities).

1/ Several papers are available on the nature of overwash compared to man's stabilization attempts. Those unfamiliar with principles and processes of coastal geology and ecology relating to overwash and erosion are encouraged to read: Dolan 1971; Dolan, Godfrey 1973; Dolan, Godfrey, Odum 1973; Dolan, et al. 1974; Godfrey 1970; Godfrey and Godfrey 1971, 1973, 1974a, 1974b; Soucie 1974.

A plant species list of 222 species representing 60 families is included as an appendix. This includes the location of each species by island and abundance within a community there. Voucher specimens for all plants listed (unless otherwise noted) are located at the University of Massachusetts herbarium, Amherst, Massachusetts, and with The Nature Conservancy's office, Wachapreague, Virginia. Nomenclature follows that of Radford, et al. (1968). Manual of the Vascular Flora of the Carolinas unless otherwise noted in which case that of Fernald (1950) is followed.

The plant species list is not intended as a complete species list and omissions in the distribution and abundance of some species will be apparent. Forty-three days were spent in field work. Most of the work on Parramore, Revel, Hog, and Rogue Islands was done before June 1, with only a few localized spot checks on Parramore and Hog Islands in the summer. The species lists for these two islands particularly will be noticeably lacking in many plants recorded on other islands. Much of this difference is probably due to the season in which the field work was done. Thus, the omission of a species from an island may only reflect the season the author was there rather than the absence of the plant on the island. Similarly, abundance notations may appear inconsistant between islands. Peak productivity of some species was observed on some islands, but the species was less obvious on islands visited at other seasons.

VII. IMAGERY

The vegetation maps were prepared using low altitude infrared transparencies on loan from the Chesapeake Bay Ecological Progarm Office (NASA, Wallops Island, Virginia). This was flown at approximately 9,800 feet in the late morning of June 4, 1974. It was about 2-2½ hours before low tide, on a clear day (Roll W2710101, frames 83-127). Earlier studies have found infrared arial photography to be superior to black and white and natural color imagery for plant community analysis (Anderson 1969, Holman 1974, Taranic 1972). The internal spacial relationships and the plant's leaf morphology vary with each species which allows for a different reflectance from each. In this way, each species reflects its own "spectral signature". Many species, especially larger sized ones, dominants and colonies, can be individually isolated on film this way. Other species are well mixed together in more or less definable and typical communities which are usually identifiable by the spectral signatures of a few dominant species.

Thus, plant communities can be delineated from infrared imagery for mapping and community studies. Variations between and within communities are seen as different tones and textures of red. Using infrared film, more contrast is obvious between communities than with natural color or black and white film.

Differences in such environmental influences as soil factors substrate mobility, elevation, and tidal influence affect the appearance of plant communities on the film. Biological variations such as height, leaf and stem density, growth form, leaf shape and size, dead material, spacial arrangement, dominance and ecotones are also visible. Considerable field checking must be done to insure accurate identification of plant communities and to define significant variations in species dominance and abundance. It cannot be determined initially from the imagery whether such variations are significant.

After localized field checks have been made, relative abundance, density, dominant species, soil moisture, tidal influence, successional trends and environmental influences can be inferred for other areas. Other patterns or tones were atypical and warranted field checking. These include algal blooms, intermittantly flooded areas,

seasonal change in plant condition, and appearance of a highly reflective species in an otherwise typical community. All of these were apparent aberrations of the imagery and were investigated on the ground.

Two main problems were encountered using the infrared imagery. The major one was the vignetting or distortion in color and distance. This distortion increases with distance from the center of the picture. Measuring from the edges of each frame, there are approximately three inches which make photo-interpretation difficult and often undependable. Frames overlap one another by 60%. This practically eliminates the problem laterally. Thus, the main area of the islands were only slightly affected by this problem. However, land areas extending into the top and bottom of the frames were badly distorted. The geographic accuracy of the tracings in these areas is undependable. This includes much of the tidal marsh area, and nearly all of Revel Island, Chimney Pole Marsh, and Rogue Island. Field checking of boundaries and communities above tidal influence has adjusted for photographic aberrations. The tidal marshes on the edges of the maps cannot be further refined using this imagery.

The second difficulty with this imagery, flown at nearly 10,000 feet and relatively early in the growing season, is in differentiating sparsely vegetated areas from unvegetated ones. This difficulty arose primarily in areas adjoining the beach. Very little reflectivity is given in a sparsely vegetated area or one with standing dead grass. Thus, the boundary of beach and dunes or overwash grasslands is often conjectural. This warranted extensive field checking to establish accuracy.

VIII. METHODS

This study has been carried out in five parts:

(1) Preparation of field maps. The roll of infrared transparencies was magnified on a Variscan II to about 1/6,500. Frosted acetate tracings of photo-interpreted mapping units were made and blueprinted at this scale. The blueprinted maps were used in the field for site locations in ground truthing.

(2) Ground truth. Extensive field checking of plant communities, and other mapping units, species, and ecological considerations were carried out throughout the spring and summer.

(a) Mapping units identified on the field maps were ascertained or corrected by spot checking typical areas and by further investigating areas of atypical appearance on the imagery.

(b) Species composition and relative abundance were noted by community and site location.

(c) Ecological factors affecting the mapping units were noted.

(3) Map tracings (1/19,500). Using ground truth information, the corrected mapping units were traced on acetate directly from the aerial transparencies.

(4) Preliminary writeup. After ground truthing each island, field notes were organized into a detailed description of island characteristics, communities, species and variation from typical classifications. These were compiled after the field work on each island. Species card files were also prepared. From the plant species file, the appended species list was compiled. Each species was listed by mapping units and abundance on each island was observed.

(5) Final text preparation.

INTERPRETATION OF MAPPING UNIT ABBREVIATIONS

A : Foredune - Grassland

G : Dense Grassland

AG : Beachgrass Dunes - Dense Grassland Complex

g : Sparse Grassland

Ag : Foredune - Sparse Grassland Complex

At : Open Dunes - Thicket Complex

B : Beach

T : Tall Thicket

AT : Open Dunes - Tall Thicket Complex

t : Low Thicket

J : Juniper Thicket

P : Pine Forest

H : Hardwood Forest

PH : Pine-Hardwood Forest Complex

m : Low Salt Marsh

Mm : Upper Low Salt Marsh

M : Brackish Marsh

s : Salt Flat

F : Fresh Marsh

w : Open Water

dr : Drift

b : Submerged Sand

uw : Underwater Flora (or Fauna)

peat : Peat Outcrops

wf : Wash Flat

mf : Mud Flat

MAPPING UNIT DESCRIPTIONS

The classification system employed shows the main variations in vegetation within the Virginia Coast Reserve. Natural community units are used wherever possible. However, sometimes two or more communities are located within an area too small to isolate. In this case, either a complex was used when these different small communities were mixed in a regular arrangement or the smaller community was included with the nearest, most related community. Some classifications used signify features which are essentially unvegetated.

Because the classification used does not strictly signify natural communities, the term "mapping unit" is more correctly applied (Martin, 1959; Hillestad, 1975). In the following descriptions, the word "community" will be used as appropriate, and the term "mapping unit" will be used for complexes and unvegetated areas. The following mapping unit descriptions include percent cover estimations, and relative abundance of species. The percent cover ranges given are from visual estimation only. The classification scheme was broken first into structural and edaphic categories (xeric-mesic herbaceous, woody, hydric-halophytic herbaceous and essentially non-vegetated mapping units).

The relative abundances were also estimations judged as follows:

Dominant: The most abundant species characterizing the community or mapping unit

Abundant: Plants found in quantity essentially throughout the community

Frequent: Scattered plants or individuals occurring regularly throughout the classification

Occasional: Individuals or colonies occurring infrequently. These may or may not be unusual. In a percent cover sampling, these probably would be noted as "present".

All measurements given are approximations.

1. Xeric-Mesic Herbaceous Mapping Units

Herbaceous communities of xeric or mesic soils are found mostly near the ocean or within the central portion of islands. Grasses, mostly *Ammophila breviligulata* or *Spartina patens*, are the dominant plants, though some shrubs may be found.

The mapping units of the xeric areas are: foredune-grassland, sparse grassland, foredune-sparse grassland complex, open dunes-thicket complex, and beach. The dense grassland may be xeric or mesic, whereas the beachgrass dunes-dense grassland complex contains both. The xeric-mesic herbaceous mapping units are separated by topography, location, origin, species, and density.

Foredune-Grassland (A). A foredune often lines the upper beach of the islands. The grassland behind this either gradually slopes away and may be relatively densely vegetated, or may have scattered, sparsely covered dunes (Figure 1). The dune line is often breached in many places, and even where such openings are no longer found, the influence of overwash is apparent in the grassland.

An abundance of Ammophila breviligulata associated with an oceanside location indicates this classification. Foredunes are usually present and often sparsely vegetated (5-20% cover). The grassland behind the foredunes is densely vegetated (75-100%) cover in most places, but overwash areas have less than 20% cover.

The foredune-grassland complex is a herbaceous community, but occasional shrubs and vines may be found on the rear portions. Some small patches of Juncus roemerianus and Phragmites communis are also present. Low spots, often between dunes, interdune slacks, are frequently encountered here. These have herbaceous species of moist areas and usually a denser growth than the drier parts of this complex.

Alternative mapping units fronting the ocean are similar to the foredune-grassland. The other xeric-mesic herbaceous classifications may actually include a narrow foredune-grassland too small to map. Dead thickets are found in place of "A" on parts of Cedar, Parramore, and Ship Shoal Islands. Where overwash is extreme, backed directly by woody communities, no herbaceous community will front the beach (Figure 6).

Major variations in "A" are found at both ends of Hog and the south end of Parramore Islands.

The following species are generally found in the foredune-grassland community.

Dominant: Ammophila breviligulata

Abundant: Panicum amarum, Spartina patens, Strophostyles helvola

Frequent: Cakile edentula, Calystegia sepium, Carduus spinosissimus, Cenchrus tribuloides, Festuca rubra, Gnaphalium obtusifolium, Lepidium virginicum, Panicum amarulum, Solidago semperivirens

Occasional: Erigeron canadensis var. canadensis, Euphorbia polygonifolia, Gnaphalium purpureum var. purpureum, Salsola kali

Species occurring in the low, moist areas are:

Frequent: Ammophila breviligulata, Fimbristylis spadicea, Scirpus americanus, Setaria geniculata

Occasional: Baccaris halmifolia, Carex festucacea, Juncus scirpoides

Sparse Grassland (g). Dry sandy grasslands with 5-20% cover are isolated as "g" (Figure 2). They occur along the ocean grading with the upper beach and are in early stages of recovery from overwash. The vegetation becomes more dense landward. Many large waterborne shells litter the area. Occasional young dunes are found forming here though in some places more substantial foredunes exist. This is the case at Bungalo Inlet on Smith Island. Within the sparse grasslands, some small low areas of denser grassland are found landward of the foredunes.

Only one exception to the above occurs. This is on the backside of the south end of Smith Island and is described as an exception to the sparse grassland in that island's

Figure 1. Foredune-Grassland (A). A low foredune, sparsely vegetated with Ammophila breviligulata grading into a denser grassland of Ammophila and Spartina patens, generally lines the ocean beach. A broad, sparsely vegetated area characteristic of overwashed areas is visible to the right in this photograph of central Hog Island.

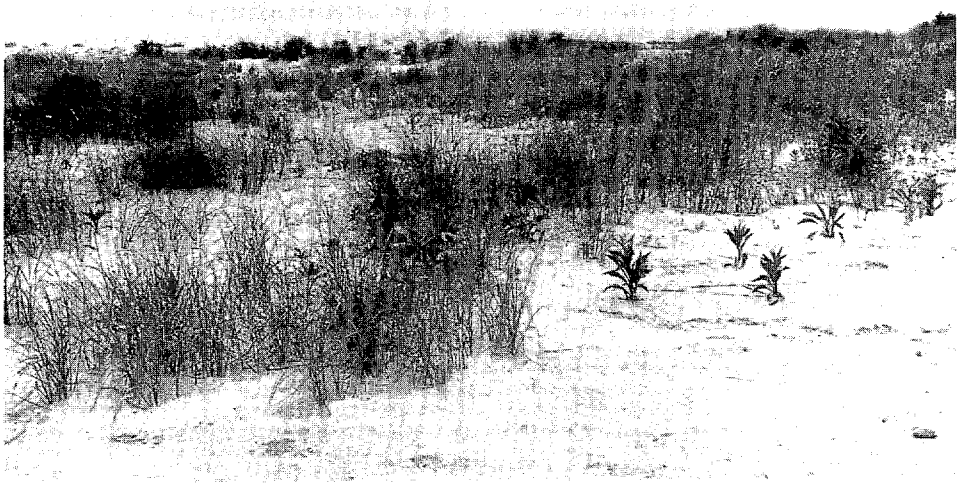

Figure 2. Sparse Grassland (g). Areas recovering from oceanic overwash are usually near the beach and have less than 20% cover. Ammophila breviligulata, Spartina patens, and Solidago sempervirens are some of the more common species as shown on this photograph of Smith Island.

description.

Many of these sparse areas recovering from overwash provide shorebirds with nesting habitat. Black skimmers, oystercatchers, common terns, least terns, and gull-billed terns were all frequent here.

The following plants compose the sparse grassland community:

Dominant: Ammophila breviligulata, Cakile edentula, Solidago sempervirens

Abundant: Spartina patens, Strophostyles helvola

Frequent: Calystegia sepium

Occasional: Atriplex arenaria, Euphorbia polygonifolia, Panicum amarum, Salsola kali, Xanthium strumarium var. strumarium

Foredune-Sparse Grassland Complex (Ag). In places along the ocean where beachgrass dunes are accompanied by sparse overwashed grasslands, the foredune-sparse grassland complex is indicated (Figure 3). As with other complexes, characteristics of both communities are found but the individual areas are too small to map. The beachgrass dune is often sparsely vegetated and breached in many places by storms. There may be low dunes forming in the sparse grassland and occasional areas of more dense vegetation and scattered shrubs are present.

Dominant (A): Ammophila breviligulata

Dominant (g): Spartina patens

Abundant (A): Cakile edentula, Solidago sempervirens

Abundant (g): Erigeron canadensis var canadensis, Ammophila breviligulata, Solidago sempervirens

Frequent (A): Atriplex arenaria, Panicum amarum, Spartina patens

Frequent (g): Calystegia sepium, Strophostyles helvola, Xanthium strumarium var. strumarium

Occasional (A): Euphorbia polygonifolia, Salsola kali

Occasional (g): Salsola kali

Open Dunes - Thicket Complex (At). This complex is found only on the northern end and one-third of the eastern length of Parramore Island. It is an interior open dune system sparsely vegetated by grasses and forbs having thickets, individual shrubs and small trees scattered throughout (Figure 4). Some parts have extensive unvegetated blowouts, whereas other areas are more densely vegetated. Average vegetation cover is 10-50%.

An area of the northeastern section of this complex was planted in 1968 with 1000 Juniperus virginiana and 2000 Pinus taeda seedlings (O'Neal, 1969). The cedars now are less than about three feet tall and are kept well browsed by white-tailed deer. The pines are 8-15 feet tall.

Figure 3. Foredune-Sparse Grassland Complex (Ag). Dunes sparsely covered by Ammophila breviligulata have been breached in many places by storm-driven overwashes. The flattened overwash areas between and behind the remaining dunes have less than 20% cover by such herbs as Spartina patens, Solidago sempervirens, and Cakile Edentula as shown in this view of the south end of Metomkin Island looking towards Cedar Island.

Figure 4. Open Dunes-Thicket Complex (At). An interior system of open dunes with a sparse herbaceous vegetation dominated by Ammophila breviligulata is found only on northeastern Parramore Island. Frequent scattered patches of Juniperus virginiana, Myrica cerifera, and Zanthoxylum clava-hercules are characteristic.

The sparse "At" vegetation is found at the top of most of the "Parramore Mounds" throughout the length of the islands. This is, however, too small to isolate and is included as part of the dominant vegetation (woody communities).

Main plant species of the open dunes-thicket complex are:

Dominant (A): Ammophila breviligulata

Dominant (t): Juniperus virginiana, Myrica cerifera

Abundant (A): Aristida tuberculosa, Cenchrus tribuloides

Frequent: (A): Spartina patens

Frequent (t): Persea palustris, Pinus taeda, Zanthoxylum clava-hercules

Occasional (A): Eupatorium capillifolium, Euphorbia polygonifolia

Occasional (t): Ilex opaca, Prunus serotina

Occasional (low spots): Juncus dichotomus, Juncus scripoides, Myrica pensylvanica

Beach (B). The beaches of most of the Virginia barrier islands are narrow. Wider beaches occur on the north ends of Hog, Cobb, Myrtle, and Ship Shoal Islands, and on the south end of Parramore Island. At other places on these islands, the beach is narrow as it is on the remaining islands.

The upper beach supports sparse vegetation with 0-10% cover (Figure 5). Where the sparse grassland meets the beach, the two merge imperceptibly. Low dunes frequently are found forming on the upper beach where beachgrasses or drift material are present. These dunes are especially conspicuous on accreting beaches.

On the north ends of Cedar and Parramore Islands, dead shrubs line the upper beach where the thicket is frequently overwashed (Figure 6).

Of the existing vegetation, the following abundances can be generalized:

Dominant: Cakile edentula

Abundant: Ammophila breviligulata

Frequent: Salsola kali, Solidago sempervirens, Spartina patens

Occasional: Atriplex arenaria, Panicum amarum, Strophostyles helvola, Xanthium strumarium var. strumarium

Dense Grassland (G). There are several characteristics which represent the dense grassland. They are generally 50-100% vegetated with Spartina patens dominant in a xeric or, more usually, mesic situation (Figure 7). Many herbaceous species are also found here. These grasslands are usually well behind the foredunes. They are often on the interior or back side of the island.

The following characteristics are included in the dense grassland:

(1) Interior disturbed areas (e.g., Coast Guard Station lawns).

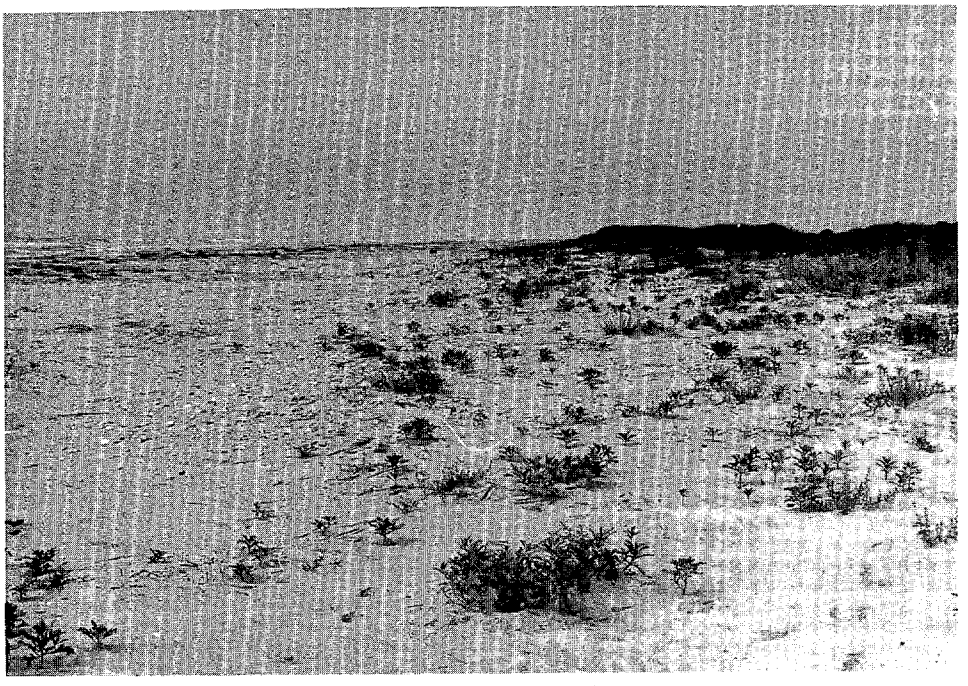

Figure 5. Beach (B). The upper reaches of the beach bear a sparse vegetation dominated by Cakile edentula. This often meets the foredune-grassland (A) as shown here on Smith Island.

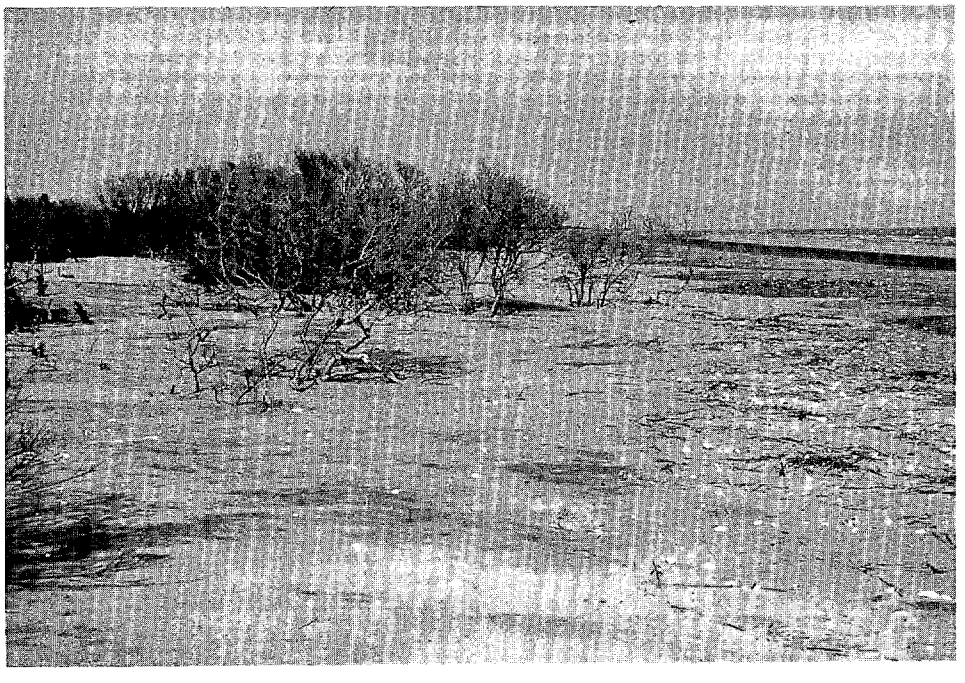

Figure 6. Beach (B). Shrubs and forests bordering the beaches of some islands have been killed as a result of the rising sea level and storm waves. Overwash sand extends beneath these dead Myrica cerifera skeletons on the upper edge of the short beach on Parramore Island.

(2) Interior xeric or mesic grassland areas succeeding to a thicket (0-50% shrub cover) This may be flat or have scattered or rolling dunes.

(3) Mesic grassland areas on elevations above the driftline and Iva frutescens border of salt or brackish marshes. These are generally flat.

(4) Dense, tall Spartina patens grasslands between the foredune grassland and salt marsh. These areas are often moist and usually the plants show the influence of the fresh-brackish water interface. Included are Fimbristylis, Scirpus, Iva, and Borrichia. This grassland type grades imperceptibly on the imagery and ground with the foredune grassland and sometimes with the marshes. They are usually located on barrier flats and frequently have scattered dunes. Ammophila may be frequent. The grasslands nearest the marshes are often similar to brackish marshes.

In all of these types, many shrubs or small thickets may be scattered throughout. Some areas are advanced in their succession toward a low thicket. The dense grassland is one of the more confusing and variable communities treated here because it grades with and resembles adjacent communities.

Many grassland areas are too small to be mapped. These often occur in wooded areas where a small opening in the overstory occurs. Roads especially are examples of such unmarked grasslands.

The dense grasslands shown meeting the beach usually have a narrow beachgrass foredune or a sparse overwash grassland separating the two shown mapping units. This "A" or "g" area is too small to isolate and thus is combined with the dense grassland.

A vegetated driftline often separates the grasslands from the upper low marsh and is considered part of "G". The dense grassland may mix with part of the upper low marsh.

This driftline is a narrow band composed of:

Dominant: Iva frutescens, Spartina patens

Abundant: Borrichia frutescens, Calystegia sepium, Distichlis spicata, Fimbristylis spadicea, Solidago sempervirens

Frequent: Atriplex patula, Baccharis halmifolia, Cakile edentula, Limonium nashii, Salicornia virginica, Scirpus americanus, Setaria geniculata, Spartina alterniflora, Suaeda linearis, Teucrium canadense

Cobb, Hog, and Ship Shoal Islands are dominantly grassland islands. Special noted exceptions in grassland composition are found in the island descriptions of Cedar and Hog Islands.

The most frequently encountered species of the dense-grassland are:

Dominant: Spartina patens

Abundant: Festuca rubra

Frequent: Ammophila breviligulata, Andropogon virginicus, A. virginicus var. abbreviatus, Calystegia sepium, Carduus spinosissimus, Fimbristylis spadicea, Scirpus americanus, Setaria geniculata, Solidago sempervirens, Strophostyles helova, Teucrium canadense

Figure 7. Dense Grassland (G). Spartina patens with many other herbs including Solidago sempervirens and Andropogon virginicus var. abbreviatus cover large interior mesic to xeric areas, as shown on Smith Island.

Figure 8. Beachgrass Dunes-Dense Grassland Complex (AG). An area of dunes covered by Ammophila breviligulata alternates with a dense Spartina patens grassland. Myrica cerifera shrubs are scattered in the grassland shown in the foreground of this photograph of the north end of Hog Island.

Frequently scattered: Baccaris halmifolia, Iva frutescens, Myrica cerifera

Occasional: Achillea millefolium, Eupatorium capillifolium, E. hyssopifolium, E. rotundifolium, Gnaphalium obtusifolium, G. purpureum var. purpureum, Juncus dichotomus, Juncus scirpoides, Monarda punctata, Oenothera laciniata, Penicum amarulum, P. amarum, P. virgatum

Beachgrass Dunes-Dense Grassland Complex (AG). In some places, beachgrass dunes emerge from a dense grassland. The two classifications are so closely mixed that they form a complex of beachgrass dunes and dense grassland (Figure 8).

The dunes are generally rather sparsely vegetated having 10-50% cover. The usual dunegrass species and Andropogon scoparium is often abundant. The grassland is usually mesic (50-100% cover) and has many species characteristic of moist habitats. Fimbristylis and Juncus are common in these areas. The community is sometimes xeric in nature with 15-50% cover. The main places for this complex are Cedar, Hog, and Cobb Islands.

The plants are generally much the same as those found in the two main types composing this complex:

Dominant (A): Ammophila breviligulata, Spartina patens

Dominant (G): Spartina patens

Frequent (A): Andropogon scoparius, A. virginicus, Carduus spinosissimus, Oenothera laciniata, Solidago sempervirens, Strophostyles helvola

Frequent (G): Andropogon virginicus var. abbreviatus, A. virginicus, Festuca rubra, Fimbristylis spadicea, Scirpus americanus, Setaria geniculata

Occasional (A): Juncus dichotomus, Solidago semperiverens

Occasional (G): Juncus scirpoides

Frequently scattered shrubs: Baccharis halmifolia, Iva frutescens, Myrica cerifera

2. Woody Mapping Units

The woody mapping units are mostly inland and towards the backside of the islands. Some are found along the beach due to erosion of the communities' sites formerly between them and the ocean. They are generally on the highest land of the islands.

The shrub communities are dominated by Myrica cerifera. The forest communities vary by island but are mostly composed of Juniperus virginiana, Myrica cerifera, Persea palustris, Pinus taeda, and Prunus serotina.

The various classifications of woody mapping units are separated by height and species composition. They include the tall thicket, low thicket, juniper thicket, pine forest, hardwood forest, and pine-hardwood forest complex.

Tall Thicket (T). Dense thickets of Myrica cerifera (over 10 feet tall) dominate portions of some islands. Often the canopy is so dense that little light penetrates the interior, thus inhibiting growth of a ground layer. In other areas, there is more light filtering through the canopy which allows for a sparse, sometimes moist, ground cover. More herbaceous plants are established when the thicket meets a grassland or marsh. Along fresh, brackish, or salt marshes, the thicket diminishes in stature and the Myrica is replaced by Baccharis halmifolia and often dense Iva frutescens and includes herbs characteristic of the adjacent community.

The tall thickets are usually impenetrable due to the dense tangle of branches and abundant vines. However, within them may be open areas of dense grassland which are too small to isolate at the mapping scale of this project.

These dense thickets are found on Cedar, Parramore, Hog, Wreck, and Smith Islands. On Hog Island, this community is also considered under the "AT" complex where open dunes alternate frequently with the thickets. The island descriptions discuss notable variations in this mapping unit on Cedar and Smith Islands.

Low thickets, "t", have a similar composition but are shorter and often more open.

The main species characterizing the tall thicket are:

Dominant (canopy): Myrica cerifera

Dominant (herb layer): Spartina patens, seedlings of: Myrica cerifera, Parthenocissus quinquefolia, Rhus radicans

Abundant (canopy): (Myrica pensylvanica:Wreck and Cedar Islands), Campsis radicans, Parthenocissus quinquefolia, Rhus radicans, Smilax bona-nox

Abundant (moist edges): Baccharis halmifolia, Iva frutescens, Spartina patens

Abundant (herb layer): Setaria geniculata

Frequent (canopy): Prunus serotina, Vitis aestivalis

Frequent (herb layer): Calystegia sepium, Carduus spinosissimus, Festuca rubra

Occasional (canopy): Ilex opaca, Juniperus virginiana, Pinus taeda

Occasional (herb layer): Andropogon virginicus, Fimbristylis spadicea, Opuntia compressa, Rubus argutus

Open Dunes - Tall Thicket Complex (AT). The classification "AT" represents an open dunes-tall thicket complex and is only found on the north end of Hog Island. Large areas of tall Myrica cerifera thicket alternate with open, sparsely vegetated dunes throughout the interior and backside of the island. The thicket part has the same composition as the typical tall thicket "T" with a dense canopy and 100% cover. The dune portion of the complex exhibits the same species composition as a protected dune area, having sparse herbaceous vegetation (5-20% cover).

Some of the wetter and ecotonal areas of this complex have the vegetative characteristics of the adjacent herbaceous community ("F" fresh marsh, "M" brackish marsh, and "G" dense grassland). The edges of the thicket decrease in height, but not significantly enough to warrent its reclassification as low thicket, "t".

Feral livestock, especially sheep, presently grazing on Hog Island, use the westerly thickets for pasture. Many areas here are relatively clear of dead branches and have a dense, varied and well-cropped herbaceous vegetation. This "pasture" vegetation includes such plants as Poa annua which were probably introduced from hay brought to feed the animals. These species are otherwise not found in thickets.

The main species of this community complex are:

Dominant (A): Ammophila breviligulata

Dominant (T): Myrica cerifera

Abundant (A): Andropogon scoparius, A. virginicus, Carduus spinosissimus, Spartina patens

Abundant (T): Baccharis halmifolia, Parthenocissus quinquefolia

Abundant ("T" grassland ecotone): Andropogon virginicus, A. virginicus var. abbreviatus, Carduus spinosissimus, Fimbristylis spadicea, Setaria geniculata, Spartina patens

Frequent (A): Achillea millefolium, Festuca rubra, Juncus dichotomus, J. scirpoides

Frequent (T edges): Rhus radicans, Rubus argutus, Vitis aestivalis

Frequent (T moist): Festuca rubra, Juncus dichotomus, Hydrocotyle verticillata (?)

Frequent (T pasture): Achillea millefolium, Andropogon virginicus var. abbreviatus Cerastium glomeratum, Geranium carolinianum, Poa annua, Rubus argutus, Rumex acetosella, Setaria geniculata, Spartina patens

Occasional (A): Andropogon virginicus var. abbreviatus, Aristida tuberculosa, Festuca sciurea, Gnaphalium obtusifolium, Solanum carolinense, Solidago microcephala, Zanthoxylum clava-hercules

Occasional (T): Juniperus virginiana, Pinus taeda, Prunus serotina, Salix nigra

Low Thicket (t). The low thicket classification is a variable one including several types of shrub groupings which were discerned on the infrared imagery and classed individually. At times the distinction between the low thickets and the taller thickets or woodlands, and between the low thickets and open shrubby grassland, was not clear cut. Thus, the line defining these units is through the ecotone.

The low shrub thickets are generally composed of shrubs. They are typically in dense aggregations. Included are thickets which are transitional herbaceous community shrubland and have more than 50% shrub cover (Figure 10). In places, the thicket is impenetrable and quite dense (100% cover). This is especially so at the upper edges where it meets taller woody vegetation, and in low, periodically flooded areas. Numerous small thickets are scattered throughout.

The seaside of all thickets and woodlands adjacent to the beach have a "windswept" appearance due to salt pruning. In places on Cedar, Parramore, and Ship Shoal Islands, the thicket edge is overwashed leaving only dead shrubs and trees (Figure 6). Dune species are colonizing the sand beneath them.

Figure 9. Open Dunes-Tall Thicket Complex (AT). On Hog Island, open dunes sparsely covered by various herbs including Ammophila breviligulata and Spartina patens alternate with the tall thicket community characterized by dense stands of Myrica cerifera reaching over ten feet tall.

Figure 10. Low Thicket (t). Myrica cerifera shrubs less than ten feet tall and covering more than 50% of an area generally compose the low thicket. They are often somewhat open with a ground cover of Spartina patens and other plants characteristic of the adjacent herbaceous community. The low thicket shown borders the dense grassland of Cobb Island.

In some marshes ("M", "m", and "Mm"), low thickets of dense Iva frutescens occupy some higher spots of sand or drift deposits above normal high tide levels. Spartina patens and Borrichia frutescens are common here. They may be surrounded by narrow salt flats as they gradually descend to marsh level. Where "t" has an open canopy or meets a herbaceous community, the ground cover has the same composition as that of the adjacent community.

The description of Parramore Island includes several variations of generalized shrub thicket characterization. On Mink Island, a low thicket of Myrica, Baccharis, and Iva surrounds the grassland. This thicket is too small to map, but due to the small area of elevated land on Mink Island, this "advanced" vegetation community deserves special mention.

The main species in the low thicket community type are:

Dominant: Myrica cerifera

Abundant: Borrichia frutescens, Boehemeria cylindrica, Iva frutescens, Pluchea purpurascens, Spartina patens

Frequent: Andropogon virginicus, A. virginicus var. abbreviatus, Calystegia sepium, Juniperus virginiana, Parthenocissus quinquefolia, Rhus radicans, Setaria geniculat

Occasional: Carduus spinosissimus, Festuca rubra, Fimbristylis spadicea, Phragmites communis, Rubus argutus, Scirpus americanus, Solidago semperivirens

Juniper Thicket (J). Juniper thickets occur only on the north ends of Cedar and Parramore Islands, near "Little Beach", and the southern areas of high land on Revel Island. They are located near the marshes and often merge with them through a low shrub border. They appear to be an early stage of forest succession. On Revel Island, the juniper thicket merges with the grassland on the southern end.

This community type has special characteristics on each island. Along the ocean of Cedar Island, the juniper thicket is frequently overwashed, leaving dead shrubs at the high tide line. Rhus radicans survives the overwash. On Parramore Island, many dead junipers are found near the marshes. On Revel Island, this open juniper thicket merges with the marsh on the northern end, and gradually merges with the grassland on the southern end.

Major species of the juniper thicket mapping unit, including important variations by island, are:

Dominant: Juniperus virginiana, (Rhus radicans: Cedar Island)

Abundant: Baccharis halmifolia, Iva frutescens, Myrica cerifera, (Myrica pensylvanica, Parthenocissus quinquefolia: Cedar Island), Spartina patens

Frequent: (Andropogon virginicus, A. virginicus var. abbreviatus: Revel Island). Festuca rubra, (Opuntia compressa: Revel Island), (Phragmites communis: Cedar Island), (Persea palustris, Setaria geniculata, Smilax bona-nox: Parramore Island)

Occasional: (Pinus taeda: Parramore and Revel Islands)

Pine Forest (P). On Parramore Island's interior dune ridges, the dominant plant species is Pinus taeda (Figure 11). It is the only plant appearing on the infrared photos here. A complex of pine and hardwood species, "PH", is more widespread than is the pine forest classification. The dense pine canopy and thick layer of litter is probably responsible for the park-like nature of the forest interior. It is a "pure stand" of pine except in open spots where there is an understory of shrubs and small trees.

The forest on Italian Ridge is between 65 and 85 years old (O'Neal, 1969). Large areas of pine have been killed by the southern pine bark beetle (Dendroctanus frontalis). Some sections near the marshes have been killed assumedly by the rising sea level. Felled trees left by an attempted logging operation are found scattered here especially near the road running the length of Italian Ridge. The open areas which result from these causes contain grasses, forbs, Persea and Myrica.

The central third of Parramore Island has many "mounds" with a pine canopy and a Myrica understory. These "P" mounds are often connected by low shrub thickets of Baccharis, Iva, and Myrica. On these mounds are frequently Persea and Juniperus and occasionally Ilex opaca. Several dead pines are found there.

The major species found in the pine forest of Parramore Island are:

Dominant (canopy): Pinus taeda

Dominant (understory): Myrica cerifera, Persea palustris

Abundant (herb layer): Ammophila breviligulata, Spartina patens, Uniola laxa

Frequent (understory): Juniperus virginiana, Sassafras albidum

Frequent (herb layer): Andropogon scoparius, A. virginicus, Aristida tuberculosa, Eupatorium capillifolium

Occasional (herb layer): Andropogon virginicus var. abbreviatus, Carduus spinosissimus, Mitchella repens, Opuntia compressa

One colony of Liquidambar styraciflua composed of about seven individuals of varying ages was found north of the road across the island.

Hardwood Forest (H). The hardwood forest, "H", makes up much of the woodland area of Parramore and Smith Islands (Figure 12). It is composed of medium-small sized trees or tall shrubs intertwined with vines, forming a dense, nearly impenetrable woodland. They often occupy low, occasionally wet ground. The composition of "H" varies considerably between the two islands. Its impenetrable nature, the abundance of vines, and the presence of hardwood species in addition to Myrica are the main characteristics identifying the community. They are, however, often indistinguishable from the tall thickets on the infrared imagery.

The edges of this forest grade into a lower height and more open arrangement of the same species. It is fringed with Myrica, Baccharis, and Iva and usually is classified a low thicket though it is often too narrow to label. Open places with dense grassland species are also present but are too small to map.

Further descriptions of this community, as it is on both islands, is found in the detailed description of each island. The main species are:

Figure 11. Pine Forest (P). An open park-like forest dominated by Pinus taeda occurs only on interior dune ridges of Parramore Island. Dead pines litter the floor in many places. Other woody plants including Myrica cerifera, Persea palustris, and Ilex opaca are also present.

Dominant: (Juniperus virginiana: Parramore Island), Myrica cerifera, Persea palustris, (Prunus serotina, Robinia pseudoacacia: Smith Island), Smilax bona-nox

Abundant: (Ilex vomitoria: Smith Island), Parthenocissus quinquefolia, Rhus radicans

Abundant (herb layer and open): Festuca rubra, Spartina patens, Uniola laxa

Abundant (edges): Baccharis halmifolia, Iva frutescens

Frequent: (Berchemia scandens: Parramore Island), Campsis radicans, (Prunus serotina: Parramore Island), (Sassafras albidum, Smilax glauca: Smith Island), Smilax rotundifolia, Vitis aestivalis, V. rotundifolia

Frequent (herb layer and open): Andropogon scoparius, A. virginicus, A. virginicus var. abbreviatus, Opuntia compressa

Occasional: Ilex opaca, (Liquidambar styraciflua: Smith Island), Panicum virgatum, (Quercus falcata, Q. stellata, Q. nigra: Smith Island), Salix nigra

Pine - Hardwood Forest Complex (PH). This woodland category is a combination of the "P" and "H" classifications and is only found on Parramore and Smith Islands. Basically, it is a hardwood forest, "H", with many scattered groups or individuals of Pinus taeda throughout (Figure 13). It may occur on old dune ridges although this is not always so. Patches of dead pine trees are conspicuous in this forest. They leave open areas with fallen logs, litter and the understory shrubs of Myrica, Persea, Prunus serotina, and, on Smith Island, Ilex vomitoria. These open areas often have Andropogon scoparius, A. virginicus, Festuca rubra, Opuntia compressa, Spartina patens, and Uniola laxa as ground cover.

The edges of this forest type either grade into "P", "H", or "T" or may ajoin a marsh. As the forest gradually descends in height, the low thicket with Baccharis, Iva, and Myrica is found at the marsh edge. They are included as "PH" when they are inseparable.

The species composition is much the same as "H" with the addition of abundant Pinus taeda in the canopy.

3. Hydric Halophytic Herbaceous Mapping Units

The third main group of mapping units deals with water or salt related communities. These include marshes, open water, and essentially bare areas innundated by storms or tidal water.

The marsh communities are separated by the extent of tidal influence and species composition. They are defined as low salt marsh, upper low salt marsh, salt flat, and fresh marsh. Open water areas shown are only those large enough to label.

Figure 12. Hardwood Forest (H). Myrica cerifera and Persea palustris densely intertwined by Smilax bona-nox are the main components of most of the forest areas. Other tree species are also common. The photograph is of Parramore Island.

Figure 13. Pine-Hardwood Forest Complex (PH). An abundance of Pinus taeda in the hardwood forest (Figure 12) composes this mapping unit. Broadleaf trees other than those mentioned above are common and include Prunus serotina. Occasional grassy areas are to be found such as that shown by this road across Parramore Island.

Low Salt Marsh (m). The low salt marsh covers vast areas behind all islands of this barrier chain. They are almost exclusively vegetated by Spartina alterniflora. Ground cover ranges from 75-100%. The daily tidal flux drains and refills most of this area twice daily. Mazes of meandering creeks interlace the marshland (Figure 14).

Spartina alterniflora has classes of various heights. Two forms are recognized by Klemas et al. (1974) in the Delaware marshes. A tall form, up to two meters in height, lines the creeks, and a short form, as short as fifteen centimeters covers the remaining low marsh. Holman (1974) cites three height classes, a short (50-99 centimeters), medium (100-149 centimeters), and tall (150-199 centimeters) form. He also notes that density decreases as height increases. Holman's criteria seem generally applicable to the Virginia barrier island marshes though the heights estimated here are shorter than his. The short form is 15-25 centimeters; medium form is 25-91 centimeters; and the tall form is 91-167 centimeters. The densities here also were greater with the shorter regime of Spartina alterniflora.

Such a size breakdown is possible using infrared aerial imagery (Klemas et al. 1974). However, the marshes on the flight used were in the vignetted portion of the frames. Therefore, classifications of these marshes was not further refined except for portions of upper low marsh, "Mm", and mud flats. The breakdowns of "Mm" and "mf" in this area of marsh have been photo-interpreted but were not ground truthed. Density differences within the salt marsh cordgrass are also visible on the imagery, but were not differentiated.

The substrate of the marsh changes as one goes from the island proper towards the channel. The marshes are growing atop a thick layer of organic material, commonly referred to as peat. Higher elevations are generally located closer to the island, or midway between creeks. They usually have a firm organic substrate and short, often dense, Spartina alterniflora (15-25 centimeters). This grades into the upper low marsh "Mm" which receives little daily inundation. In places with more daily flooding, silty deposits cover the peat. This silt becomes deeper closer to the creeks. These areas generally support the taller regime of salt marsh cordgrass and are inundated most of the time.

The upper parts of the marsh are frequently characterized by drift deposits, mud flats and salt flats. They may also include up to a 20% cover of Salicornia virginica and other halophytes.

There usually exists a band of upper low marsh, "Mm", between the pure Spartina alterniflora marsh and the main island. When very narrow, this fringe is included with the low salt marsh.

On most of the islands, regions can be found where overwashes, salt flats, or spit development have connected beach, dunegrass, or sparse grasslands with the low salt marsh. Some places of incongruous mixing are found where low marsh and upland plants mingle. Usually vegetated driftlines marked by Borrichia and Iva separate the low marsh "m" and "Mm" from other herbaceous mapping units.

Though often not isolated from the larger adjacent classification on these maps, vegetation surrounds several interior salt ponds, salt flats, and creek extensions.

Metomkin, Revel, Chimney Pole Marsh, Rogue, Ship Shoal, Myrtle, and Mink are dominantly marsh islands. All except Godwin are fronted by narrow sandy beaches which often wash over onto the marsh. The oceanside islands named above, as well as Cobb, Little Cobb, and Smith have many peat exposures protruding seaward from the beaches (Figure 20).

Figure 14. Low Salt Marsh (m). Vast areas of Spartina alterniflora marsh extend behind all of the islands. The Chesapeake Bay Bridge-Tunnel is visible to the right on the horizon in this view of the Smith Island marsh.

Figure 15. Upper Low Salt Marsh (Mm). A mixture of short Spartina alterniflora and Salicornia virginica on a firm substrate is found on the upper edge of most of the low salt marshes. Other halophytes are also common here though not present in this photograph of Smith Island.

The marsh is a highly productive component of the barrier island system. The salt marsh is the primary producer of nutrients for estuarine and marine life. The amount of marsh production indicates the quantity of plant material available to these organisms. Thus, not only the acreage, but also the height and density of Spartina alterniflora directly affect marsh production. The Eastern Shore's wide tidal range flushes over a large area with great force releasing nutrients to the estuarine system.

The main species of the low marsh are:

Dominant: Spartina alterniflora

Frequent (upper reaches): Salicornia virginica

Frequent (usually submerged): Aghardiella tenera, Enteromorpha lensa, Fucus vesiculosis, Gracilaria verrucosa, Polysiphonia denudata, Ulva lactuca

The higher parts may also contain species of salt flats, "s", upper low marsh, "Mm", and drift, "dr".

Upper Low Salt Marsh (Mm). A dense (50-100%) halophytic community usually flooded by only a few inches of salt water during each tidal cycle borders the upper edge of the low salt marsh (Figure 15). It is considered as part of the low marsh in this report due to its daily tidal inundation, but the species composition is that usually composing a high marsh. It is rather distinctly separated from other communities on the infrared imagery. The upper low salt marsh usually occurs on a firm substrate. A driftline border frequently vegetated by Borrichia, Distichlis, Iva, and Spartina patens usually separates it from the dense grassland or woody mapping units. It grades with the brackish marshes, "M", as the upper low salt marsh increases in abundance of Distichlis and Spartina patens. Thus, the line dividing these types defines an ecotone. Where "Mm" is too small to isolate, it is combined as part of the low marsh, "m".

The upper low marsh classification also contains small mudflats, salt flats, salt ponds, drift mats and some scattered elevated shrub patches. "Mm" also surrounds thickets found within the low marsh proper. Where overwashes extend onto the marshes, they are frequently sparsely vegetated by "Mm" species. Many upper low marsh patches are isolated on the outer marshes.

The main species found in the upper low marsh community are:

Dominant: Salicornia virginica, Spartina alterniflora (12-20 centimeters)

Abundant: unicellular algae and sulfur bacteria

Abundant (upper edges): Borrichia frutescens, Distichlis spicata, Iva frutescens, Spartina alterniflora

Frequent: Limonium nashii, Salicornia europaea

Occasional: Atriplex patula, Bassia hirsuta, Salicornia bigelovii, Spergularia marina, Suaeda linearis

Occasional (upper edges): Atriplex arenaria, Fimbristylis spacicea, Scirpus americanus, S. robustus, Solidago sempervirens

Brackish Marsh (M). Brackish marshes cover a large area on Cedar, Parramore, Hog, and Smith Islands (Figure 16). Smaller ones occur on some of the other islands. They are slightly influenced by salt water. This is particularly so near the creeks. This influence dissipates gradually as the marsh extends toward the interior of the island. They are frequently wet, though they do not appear to be much affected by monthly spring tides. They have 100% cover of dense grasses dominated by Distichlis spicata and Spartina patens. The brackish marshes gradually merge with other herbaceous communities especially the upper low marsh, "Mm", fresh marshes, "F", and dense grassland, "G".

The distinction between community types is vague. Characteristics of the adjacent zones integrade with the brackish marsh considerably. The gradation between brackish and fresh marshes is truly imperceptible in both the field and from the imagery. The interior ends of "M" probably are actually fresh. The presence of Distichlis or Iva indicates whether the unit is classified "M" or "F". The low end of the brackish marsh is often separated from the low marsh by a storm drift line. The marsh-side border of the woody communities usually has a band of dense Iva with Spartina patens beneath it.

Occasional small salt flats exist in the lower parts of the brackish marsh. Numerous small salty and brackish ponds and pools are scattered throughout. Most of these ponds and salt flats are too small to map.

Throughout the marshes are small thickets usually of Baccharis, Iva, and Myrica. Some low Iva thickets are found on higher parts of this marsh in large stands with a dense ground cover of Spartina patens. Many Iva thickets form on storm drift deposits.

The main species generally found in the brackish marsh are:

Dominant: Distichlis spicata, Spartina patens

Abundant (interior): Iva frutescens, Pluchea purpurascens, (Typha angustifolia: Parramore Island)

Frequent (interior): Kosteletskya virginica, Mikania scandens, Scirpus americanus, Hibiscus moscheutos ssp. moscheutos, Juncus dichotomus, J. roemerianus (approximately 30 yards diameter colonies), J. gerardi, Phragmites communis (30-60 yards diameter colonies), Samolus parviflorus, Scirpus robustus

Scattered thickets and marsh edges:

Dominant: Iva frutescens, Spartina patens

Abundant: Baccharis halmifolia, Borrichia frutescens, Festuca rubra, Setaria geniculata

Frequent: Kosteletskya virginica

Occasional: Hibiscus moscheutos ssp. moscheutos

Salt Flat (s). Salt flats of various sizes are found on all the islands (Figure 17). They are usually located in the upper low marsh region, though they are frequently also found within the low and brackish marshes. Many of these are too small to map. They are not stable features. Some may become vegetated or be covered by new drift. Other salt flats will appear as present drift mats are relocated.

Figure 16. Brackish Marsh (M). Lush meadows extend well to the interior of some low salt marshes. They have a dense cover of Spartina patens and Distichlis spicata. The lower region is somewhat salty whereas the inner parts are nearly fresh. They are usually lined by Iva frutescens on their borders. In this photograph of Smith Island dune ridges with Myrica cerifera are visible on the edges of the marsh.

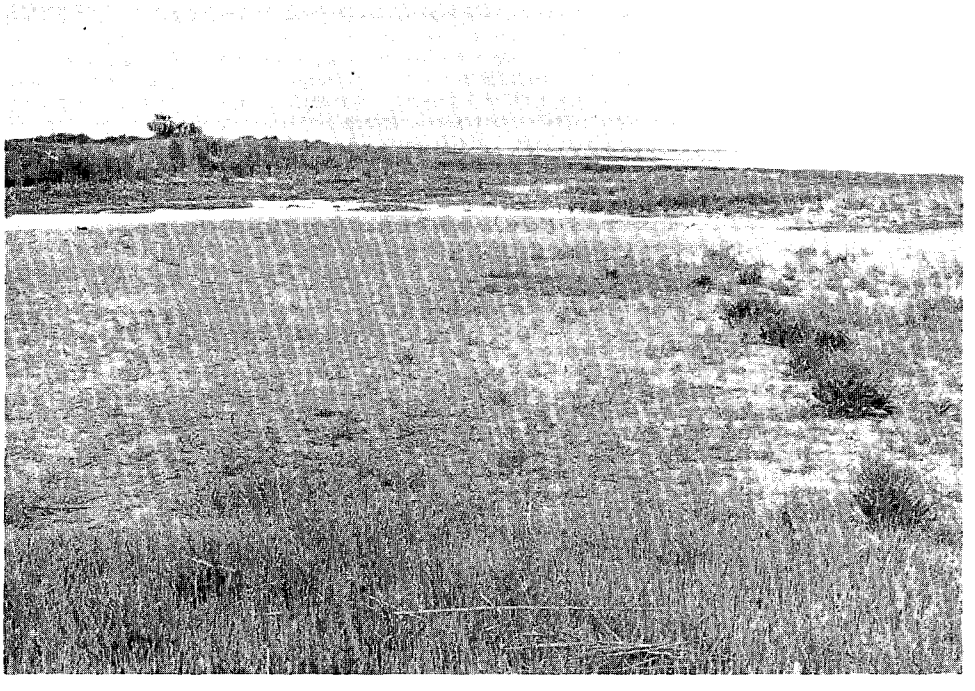

Figure 17. Salt Flat (s). Low areas where accumulations of salt water evaporate leave essentially unvegetated flats. The sparse vegetation is concentrated mostly on the edges and consists dominantly of such halophytes as Distichlis spicata and Salicornia virginica as shown in this photograph of Smith Island.

Some of the largest salt flats are of beach origin on the north end of Hog Island. The largest is located behind a dune field in the middle of the island. Others lie seaward of this and also between the dune ridges.

Salt flats are areas of virtually bare, firm sand with a high salt concentration and a layer of unicellular algae on the surface. They have less than 15% cover. Most of this is on the edges of the flat although scattered plants do exist in the center. The salt flats are differentiated in the field from the similar classifications of mud flats and wash flats by the presence of a layer of unicellular algae on the surface, a gray-caked appearance, and by the sparse halophytic vegetation.

A large shallow pond near Little Beach in central Parramore Island has abundant salt flat vegetation surrounding it and may itself become a salt flat when dry. On many islands, narrow salt flats line the upper edge of the upper low marsh, "Mm", or are adjacent to the drift lines, "dr", on the backside of the islands. Many are too narrow to isolate and are included with the adjacent "Mm", "m", or "dr" classification.

The salt flats are caused by sea water frequently accumulating and evaporating, leaving behind increasing concentrations of salt. Their location and nature is determined in several ways:

(1) Tidal ponds may be left by a ridge and runnel system as a beach accretes in front of the ridge. Inlets to the sea may be closed, but allow intermittent flooding, thereby trapping salt water which evaporates. This is most obvious at the northern end of Hog Island.

(2) Overwash areas which are devoid of vegetation may be salt water from adjacent low marshes or creeks. Overwashes spreading a layer of sand over a previous marsh may start revegetation as salt flats, later becoming marshes. The south end of Cedar Island shows this pattern.

(3) Shallow ponds in flat or low backside areas may receive salt water from spring and storm tides which is entrapped until it finally evaporates. This is in process in central Parramore Island.

(4) Drift mat relocation on the upper low marsh edge may leave a lower, unvegetated area where tidal water accumulates and evaporates. Ship Shoal Island has flats where this has occurred.

Of the existing vegetation, the following species are most common:

Dominant: *Salicornia virginica*, sulfur bacteria, unicellular algae

Abundant: *Salicornia bigelovii*, *S. europaea*

Frequent: *Distichlis spicata*, *Limonium nashii*, *Spartina alterniflora*, *Spergularia Marina*

Occasional: *Atriplex arenaria*, *Bacopa monnieri*, *Bassia hirsuta*, *Solidago sempervirens*, *Suaeda linearis*

Occasional (edges): *Borrichia frutescens*, *Iva frutescens*, *Spartina patens*

Fresh Marsh (F). Fresh marshes are inland wetlands with wet soil or standing water which is fresh or slightly brackish (Figure 18). They often surround an area of open

Figure 18. Fresh Marsh (F). Interior wet areas of some islands are dominated by Typha angustifolia, though some marsh areas may have other dominants. A Pinus taeda forest meets this cattail marsh with a characteristic border of Myrica cerifera and Baccharis halmifolia on Parramore Island.

water. The fresh marshes gradually extend above the main salt water influence found in the brackish marsh. The two marsh types overlap. Fresh marshes are only located on Parramore, Hog, and Smith Islands.

The fresh marshes often continue under the adjacent shrub thickets, forming pocosin-like areas. The thickets, usually of Baccharis, Myrica, and Iva are usually dense with a wet mucky bottom vegetated by Boehemeria, Hydrocotyle, Polygonum, Samolus and other species. These pocosins are considered part of the thicket community.

In some areas dead Baccharis shrubs are prevalent with Spartina patens dominant beneath. They may have been drowned by a rising water level. This is found in the northeastern marsh of Parramore Island. As in the brackish marshes, small thickets of Baccharis and Myrica are scattered in the fresh marshes.

The main species of the fresh marshes are:

Dominant: (Panicum dichotomiflorum: northeast Parramore Island), Spartina patens, (Typha angustifolia: Parramore Island)

Abundant: Boehemeria cylindrica, Eleocharis palustris, Lippis lanceolata, Pluchea purpuranscens, Kosteletskya virginica, filamentous algae

Frequent: Eleocharis acicularis, Hydrocotyle verticillata, Mikania scandens, Phragmites communis (30-60 yards diameter colonies), (Typha angustifolia: Hog and Smith Islands)

Occasional: Apocynum cannabinum, Carex festucacea, Hibiscus moscheutos ssp. moscheutos, Juncus roemerianus (30 yards diameter colonies), Ptilimnium capillaceum, Samolus parviflorus, (Typha latifolia: Parramore Island)

The edges are usually composed of:

Dominant: Baccharis halmifolia

Frequent: Myrica cerifera

Occasional: Iva frutescens

Open Water (w). Fresh, brackish, or salt water ponds are found on most of the islands. They are usually surrounded by one of the marsh categories, though many ponds occur in the Cobb Island grassland. Some of the marsh areas around ponds may represent succession from a previously more open pond. Bodies of open water nearest creeks are quite saline, while those further inland are brackish or fresh. Tidal ponds on the outer beach formed by a ridge and runnel system on an accreting beach are also classified as "w". Some of the larger creeks extending within the marshes are labeled "w" in order to assist interpretation.

Many open pools that were too small to map comprise a considerable area of open water when their surface areas are combined. Other unmapped wet areas occur on the edges of the marshes under shrub thickets.

The ponds may be permanent or intermittent. Some are quite shallow and may form salt flats if dry. On the other hand, some of the fresh marshes and salt flat areas were inundated when visited, though dry on the imagery or during other visits. Thus, some intermittent ponds are labeled "F" or "s". Northeastern Parramore Island "F" and Hog

Island main salt flats are especially noted in this report.

Many of the ponds appear scummy in the summer. They have a dense growth of filamentous algae on the surface and attached to the grasses drooping over their edges.

Plants of the ponds and edges are:

Dominant (within): filamentous algae

Abundant (within): Ruppia maritima

Dominant (edges): Distichlis spicata, Spartina patens

Abundant (edges): Pluchea purpurascens

Frequent (edges): Scirpus americanus

Occasional (edges): Hibiscus moscheutos ssp. moscheutos, Kosteletskya virginica, Samolus parviflorus

Halophytes characteristic of the salt flats, "s", and upper low marsh, "m", surround the salty ponds near the low marshes.

4. Other Mapping Units

These are essentially bare or non-terrestrial areas outlined on the maps. They are separated by origin, location, plant species, and substrate composition. They include drift, submerged sand, underwater flora or fauna, peat outcrops, wash flats, and mud flats.

Drift (dr). Within the marshes, and more consistantly on the upper edge of the marshes bordering the grasslands, are often found large essentially bare areas of drift material (Figure 19). These are composed dominantly of dead Spartina alterniflora stems with an array of other flotsam. Also near the drift mat often are mud flats or salt flats where drift mats had been previously. All of these are transient, unstable features. The drift moves with sufficiently high tides, leaving marsh, salt flat or mud flat in its place and, in turn, covers up other places. It appears that the origin and succession of salt flats, mud flats, and upper low marshes may be related to the position of present or previous drift mats.

The sparse vegetation associated with the drift includes:

Abundant: Cakile edentula

Abundant (upper edge): Baccharis halmifolia, Borrichia frutescens, Calystegia sepium, Distichlis spicata, Fimbristylis spadicea, Iva frutescens, Solidago sempervirens, Spartina patens

Frequent: Distichlis spicata, Limonium nashii, Salicornia virginica, Solidago sempervirens, Spartina alterniflora, S. patens, Suada lineris

Occasional: Atriplex arenaria, A. patula, Salicornia bigelovii, Salsola kali, Xanthium strumarium var. strumarium

Occasional: (upper edge): Chenopodium ambrosioides, Scirpus americanus, Teucrium canadense, Zanthium strumarium var. strumarium

Figure 19. Drift (dr). Large deposits of drift accumulate along the upper edges of the salt marsh. These mats consist primarily of dead Spartina alterniflora stems. Drift mats may shift location when influenced by high tides and winds.

Figure 20. Peat Outcrops (peat). As islands recede westward, they often expose organic peat substrates. These deposits represent former marshland which has been buried by sand overwash from the island's base. As the island continues its westerly retreat, the peat is exposed seaward of the beach.

Submerged Sand (b). There are shoal areas which are visible on the infrared imagery. They are usually subsurface accumulations of sand near a spit or an inlet and are covered by water throughout most of the tidal cycle. They are unvegetated. The submerged sand areas have been isolated on Metomkin, the south end of Parramore, Chimney Pole Marsh, and north end of Cobb, Little Cobb, Ship Shoal, and Wreck Islands.

Underwater Flora (or fauna) (uw). The imagery shows darkened patches on what appear to be shallow areas in the open water behind the islands. They are usually rather close to the marsh edge. They were not sampled, but may be oyster beds, algal growth, or human artifacts. One area near the south end of Hog Island was examined at low tide and consisted of oysters, sponges, and *Ulva lactuca*. Algae collected at some locations near the creek edge of a marsh may also compose this underwater classification. Species collected include: *Aghardiella tenera*, *Enteromorpha lensa*, *Fucus vesiculosis*, *Gracilaria verrucosa*, *Polysiphonia denudata*, and *Ulva lactuca*.

It is possible that *Zostera marina* may occur in some of these areas near the more southern islands. Drifted leaves of *Zostera* were found on the ocean beach of Smith Island only.

Peat Outcrops (peat). In several locations, peat outcrops are labeled on the ocean or inlet beach (Figure 20). They have been mapped though their presence may change depending on storm activity and erosion. They are mapped on Metomkin, the south end of Cobb, Ship Shoal, Myrtle, and Smith Islands.

During major storms, sand is washed across the island and deposited atop interior plant communities, usually grasslands and marshes. With time, the sand becomes revegetated, though possibly by a different community than was previously there. For example, a grassland may initially revegetate sand on top of a former low marsh. A marsh, once overwashed, eventually is beneath a beach and becomes exposed in the surf zone (Godfrey, 1970). Thus, the peat outcrops are witness to this migration of the islands.

The peat outcrops are unvegetated, though within the peat are roots of *Spartina alterniflora* and *S. patens*. Occasionally on the surface of the peat are green thalli of *Ulva lactuca*.

Wash Flat (wf). In overwash areas or regions of ephemeral inlets, essentially bare, beach-like sand is found on the backside of the island. The wash flats may be separated from the ocean by sparse grasslands or may be continuous with the beach (Figure 21). They extend onto low marshes or to creek edges. This "rear beach" lacks the abundance of oceanborne shells found on the ocean beach or in the sparse grasslands. It is mostly sand and the rear parts may be tidally flooded.

On the backside of the island, near the tidal influence of the creeks, a sparse growth of *Spartina alterniflora* (0-10% cover) indicates marsh formation. Small, more densely covered (10-50%) low marsh patches may also be found on the wash flats. The outer edges of the wash flats may actually integrade with mud flat classification. Those extending only to the upper edge of the low marsh appear to be succeeding to salt flat vegetation. The distinction between the two is that the wash flat lacks the algae and salt-caked surface characteristic of the salt flat.

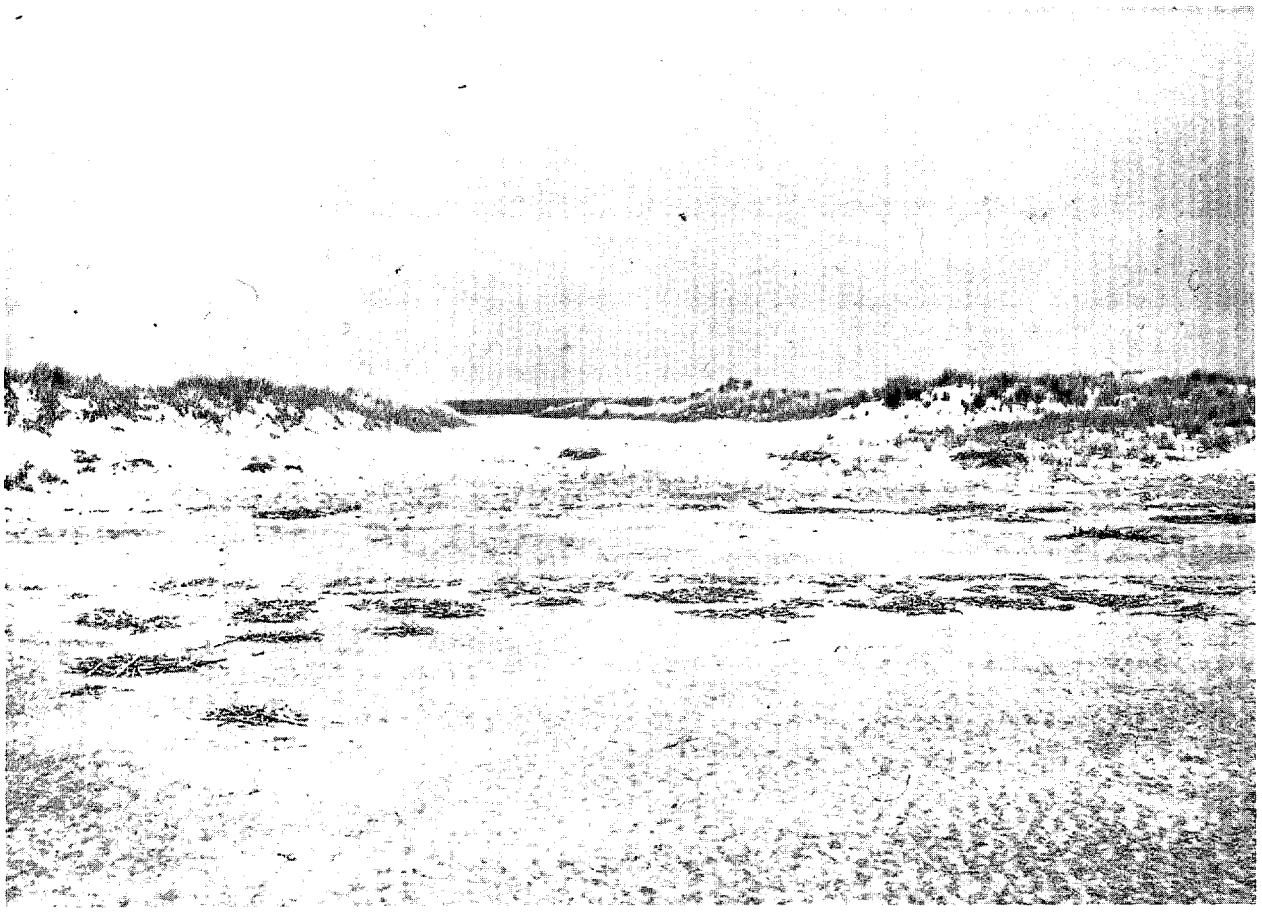

Figure 21. Wash Flat (wf). Overwash areas extending across the breadth of an island may remain essentially unvegetated. They appear to be a "rear beach" behind the remaining dunes, but lack the abundance of shells found on the ocean beach. Storm water from the backside of the island may inundate this low area. The wash flat is in the foreground. An overwash channel connecting the ocean beach and the wash flat is obvious between the beachgrass dunes shown here on southern Hog Island.

These wash flat areas, especially where they are contiguous with the beach or sparse grasslands, provide bird nesting sites. Species present included black skimmers, common terns, gull-billed terns, oystercatchers, Wilson's plovers, and occasionally nighthawks.

Plant species which may be found on the wash flat are:

Dominant: Spartina alterniflora

Frequent: Atriplex arenaria, Salicornia europaea, S. virginica, Suaeda linearis

Occasional: Atriplex patula, Bassia hirsuta, Borrichia frutescens, Cakile edentula, Distichlis spicata, Fimbristylis spadicea, Juncus bufonius, Pluchea purpurascens, Salicornia bigelovii, Spartina patens, Spergularia marina

Mud Flat (mf). Areas classified as mud flat have a muddy surface and are essentially devoid of vegetation. They are in three locations which are extensions of marsh islands grading into creeks which appear only flooded two to two and one half hours before low tide; within low marsh or upper low marsh areas which are muddy and essentially unvegetated; and extensions of overwashes into water of an island's backside which have accumulated silt and are tidally inundated.

Many of the mud flats of the upper low marsh are too narrow to isolate from the marsh community. The formation of mud flats in the low marsh areas may have resulted from drift mats which had covered live plants. The mat then floated off after the underlying vegetation died. Those near the outer edges of the low marsh are accumulations of esturarine sediments building onto the marsh.

Mud flats are generally successional to the low marsh. On some they are so advanced that they are considered low marsh and have 20-50% cover of Spartina alterniflora. This is evident on some parts of the former Bungalow Inlet on Smith Island.

Of the existing sparse vegetation, the following species may be found:

Dominant: Spartina alterniflora, unicellular algae, sulfur bacteria

Abundant (upper edges); Borrichia frutescens, Iva frutescens, Spartina patens

Frequent: Salicornia europaea

Occasional: Atriplex arenaria, Cakile edentula, Salicornia bigelovii, Ulva lactuca

ISLAND DESCRIPTIONS AND DISCUSSION

Previously various mapping units have been described for typical areas. These descriptions are widely applicable. However, variations within several classifications are found on each island. The following section of the report includes a generalized description of the island's communities for each island and their locations, (Appendix E). Notes on variations and unusual vegetation within each community can be found in Appendix F.

I. METOMKIN ISLAND (Figure 22)

Metomkin Island, composed of at least three island segments, is better termed "an island complex". It is quite narrow, averaging about 2000 feet wide with about 200 feet above the daily tidal range. It is mostly an overwash and marsh island. Most of that which is not salt marsh reflects the influence of frequent, extensive deposits of storm-driven water and sand.

The backside of the Metomkin Island Complex is composed of low salt marsh and upper low marsh areas. The low salt marshes continue, broken by several creeks and channels, a short distance to the mainland. The rest of the island is sparse grassland, "g", sometimes accompanied by a broken foredune grassland. The northern segment of this island complex has a narrow dense grassland or brackish marsh band behind the dunegrass-sparse grassland complex. The two southern segments have many wash flat areas continuing behind the sparse grasslands. Little woody growth is found on any of the island segments except as scattered shrubs.

II. CEDAR ISLAND (Figure 23)

Cedar Island is a relatively narrow island which is widest on its north end. This end supports most of the island's plant diversity. A narrow wooded area is found on the northern end. It differs from thickets on other islands in that the dominant species here are Juniperus virginiana, Myrica pensylvanica, and Rhus radicans. The two latter species usually do not assume a dominant status in thickets. This thicket fronts the ocean beach with dead shrubs where erosion and overwash are active (Figure 6). A similar thicket of Juniperus surrounded by an Iva, Spartina patens brackish marsh is behind the main thicket on a marsh separated from the main island by a small creek.

A brackish marsh similar to that on Parramore and Smith Islands covers a large part of the rear of this part of the island. Low salt marshes lie behind the northern half of the island.

The beachfront along the length of the island generally is an overwashed area. It consists of a sparse grassland, "g" or foredune-sparse grassland, "Ag". This type of area covers a large portion of the southern half of the island. The five foot duneline is breached in many places.

In most locations along the whole island, the sparse grassland type of vegetation grades in with a narrow band of dense grassland, "G", on the backside before meeting the marsh. Occasional low thickets are found in this dense grassland especially near the southern end.

A large salt flat with marsh and sparse grassland vegetation on the edges is situated about one and a half miles from the southern tip. It is apparently an overwash lobe.

LEGEND

INTERPRETATION OF MAPPING UNIT ABBREVIATIONS

A : Foredune - Grassland

G : Dense Grassland

AG : Beachgrass Dunes - Dense Grassland Complex

g : Sparse Grassland

Ag : Foredune - Sparse Grassland Complex

At : Open Dunes - Thicket Complex

B : Beach

T : Tall Thicket

AT : Open Dunes - Tall Thicket

t : Low Thicket

J : Juniper Thicket

P : Pine Forest

H : Hardwood Forest

PH : Pine-Hardwood Forest Complex

m : Low Salt Marsh

Mm : Upper Low Salt Marsh

M : Brackish Marsh

s : Salt Flat

F : Fresh Marsh

w : Open Water

dr : Drift

b : Submerged Sand

uw : Underwater Flora (or Fauna)

peat : Peat Outcrops

wf : Wash Flat

mf : Mud Flat

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III. PARRAMORE ISLAND (Figure 24)

Parramore Island has been called "The Crown Jewel of the Virginia Barrier Islands". It is indeed a naturalist's paradise and has a wide variety of plant communities. It is the widest of the islands presently studied, and the one with the most upland acreage.

A foredune-grassland system lines the inlet and seaside of the island except where dead trees and shrubs connect the forest with the beach (Figure 6). A large, interior, open dune area curves around inside the northern end and continues in a narrow band down the northern third of the island's oceanside. This area, in large part, has sparse herbaceous vegetation and scattered groups of trees and shrubs. Some plantings of Pinus taeda and Juniperus virginiana were done on the northeast part of this area in 1968. This interior open dune area is unique to Parramore Island (Figure 4).

On the northern third of the island, Italian Ridge, there are old dune ridges dominate by a pine forest. Most of the remaining area of this end of the island supports not only pine forests but also dense hardwood forests, and mixtures of the two.

Two "islands" of trees and tall thickets are located on the rear of the central third of the island including "Little Beach". They are on dunes in a line with "Italian Ridge" and support a similar vegetation.

Tall thickets of Myrica cerifera are found on the northeast corner and along the oceanside of the central third of Parramore Island. Juniper thickets are present mostly on the upper edge of the brackish marshes lining the island's backside.

Vast brackish marshes of Spartina patens extend well inland on the northern part of the island and dominate its central section. Within the marsh of this central section are many slightly elevated shrub thickets with sparsely vegetated centers. These are referred to as the "Parramore Mounds" (Figure 25), and will be described later in this report.

Many salty ponds are also scattered throughout these brackish marshes. The brackish marshes grade into fresh marshes at their interior end (Figure 18). These fresh marshes are dominated by Typha angustifolia, though other fresh marshes on Parramore Island are dominated by Spartina patens or Panicum dichotomiflorum.

Near "Little Beach" are some large, shallow ponds with halophytes on the edges. These could become salt flats when dry. An area of salt flats is located on the south end of the island behind the foredune-grassland.

Large areas of upper low salt marsh extend behind the main part of the island and grade into the low salt marsh areas beyond.

IV. REVEL ISLAND (Figure 24)

Revel Island is situated west of the southern tip of Parramore Island. It is covered by low salt marsh except for two main elevated regions where trees occur. A juniper thicket grading into grassland dominates the southeastern part, whereas a pine-hardwood forest complex covers the western ridge. This westerly forest is on a line with "Little Beach" and Italian Ridge of Parramore Island. All are on dune ridges and have similar vegetative composition. This suggests a different position and orientation of a historical "Parramore Island". Brackish marsh and upper low salt marsh types surround both wooded areas of Revel Island. Scattered low thickets of Iva with some Baccharis and Juniperus are found in the marsh on this eastern part of the island.

Figure 25. Parramore Mound. The grouping of trees and shrubs to the fore is a small Parramore mound and is similar in external appearance to other such mounds which dot the marshes of central Parramore Island. This one shows Juniperus virginiana, Pinus taeda, Persea palustris, and Myrica cerifera. The brackish marsh of Spartina patens encircles the mound as in the foreground.

LEGEND

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AT : Open Dunes - Tall Thicket

t : Low Thicket

J : Juniper Thicket

P : Pine Forest

H : Hardwood Forest

PH : Pine-Hardwood Forest Complex

m : Low Salt Marsh

Mm : Upper Low Salt Marsh

M : Brackish Marsh

s : Salt Flat

F : Fresh Marsh

w : Open Water

dr : Drift

b : Submerged Sand

uw : Underwater Flora (or Fauna)

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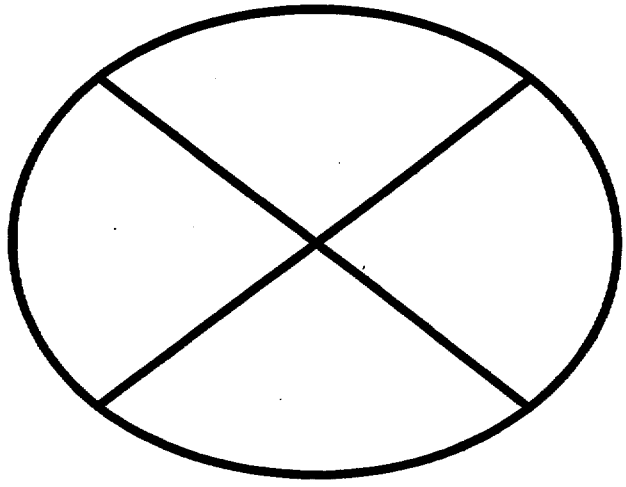

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V. "CRESCENT" ISLAND (Figure 24)

"Crescent" Island is a small crescent-shaped island southwest of the lower end of Parramore Island. It has formed since the most recent topographical maps (1968) and hydrological charts (August 10, 1974). It is about 1700 feet along its long axis. A shoal area presently extending north of "Crescent" Island may add to its land mass. Its existence is tenuous due to its low elevation and sparse stabilizing vegetation.

Most of the island is an unvegetated beach of fine sand, shells, and drift. It has a relatively sparse herbaceous cover, and some low marsh forming on its lee side. If it accretes, a denser and more diversified vegetation should be expected to develop.

VI. CHIMNEY POLE MARSH

Chimney Pole Marsh lies directly west of Quinby Inlet. It is mostly low marsh, but has some higher land. The lobe on the north has a salt pond surrounded by low marsh and salt flat vegetation between two elevated areas. A beach and a dunegrass ridge lie seaward of this pond, and a grassland with low shrubs is on the mainland side.

VII. HOG ISLAND (Figure 27)

Hog Island is rather neatly divided into an accreting northern portion and an overwashing southern section. The northern part has a widening beach with young dunes forming in the upper reaches. Two ponds were isolated here as the beach has built out beyond them. The eastern lengthwise part of this part of the island has a broad area of sparse dunes and dense grassland. A vast interior salt flat lies in the north central third. It is intermittently flooded and has typical halophytes at its edges. Several other more advanced salt flats are located between the dunes seaward of this one.

Westward of this salt flat is a dense grassland which meets a tall thicket of Myrica cerifera. Many sandy beachgrass dunes alternate with shrub thicket patches. The north-south center of the island has two marshes. One is brackish and the other is fresh. The southern half of Hog Island extends beyond the end of the thicket area. It is dominated by the influence of oceanic overwash. It has a wide beach with scattered beachgrass and cordgrass dunes and an essentially bare wash flat extending behind the dun to the channel. Much of the southern end of the island is a sand spit with a curving dune line. Near the abandoned Coast Guard Station is a grassland with a few naturally occurring and planted shrub thickets.

VIII. ROGUE ISLAND (Figure 27)

Rogue Island is located west of the channel opposite the south end of Hog Island and is geographically analagous to Revel Island further north. Low marshes cover most of the island, but there is an inland salt to brackish pond surrounded by a dense grassland with many shrubs. The northeastern side of Rogue Island is lined with a high area of low shrubs and grasses. This part was probably formed by drift and sand deposits. It supports an advanced driftline vegetation with mixed characteristics of the upper low salt marsh, brackish marsh, Iva thicket, and dense grassland. Former occupants planted beach plum near a house which was on the island when Broadwater was an active town on Hog Island. A fire swept the island around 1950.

IX. COBB ISLAND (Figure 28)

Cobb Island is mostly a dense grassland. Tall Spartina patens in this mesic environment

covers two-thirds of the high land. Xeric dune ridges of sparse Andropogon scoparius are found within the grassland.

A sparse grassland lies between the beach and the dense grassland along the whole length of the island. No significant foredunes line the shore except near Sand Shoal Inlet at the south.

The south end is separated from the grassland section by a narrow, 400 feet overwashed neck. A hook of low and upper low salt marsh makes up most of the south end of the island.

X. LITTLE COBB ISLAND (Figure 28)

South of Cobb Island is small Little Cobb Island. There is very little vegetation there. Most of the island is bare sand beach and shoals which are exposed at low tide. The northern half of the island is a sparse grassland, "g", of the usual species. On the backside of the east end is a fair sized Spartina alterniflora low marsh, "m", including the algae, Ulva lactuca and Fucus vesticulosa. Behind the southern portion is a wash flat presently being colonized by Spartina alterniflora. The plant communities of the island are typical with the above exceptions.

XI. WRECK ISLAND

Wreck Island is a small island covered mostly by dense Ammophila breviligulata. The usual vegetated driftline separates the grassland from the upper low salt marsh. A typical tall Myrica thicket is centrally located on the island. A normal low salt marsh extends westward from the island.

XII. SHIP SHOAL ISLAND (Figure 30 & 31)

Ship Shoal is largely a marsh island. Its beach continually overwashes onto the marsh and grassland behind it. Outcrops of marsh peat extend seaward from the beach. The area mapped as submerged shoal, "b", appears to have built up adding a large area of beach to the northernmost end of the island in the past year (1974-1975). The south end of Ship Shoal Island has a large dense grassland and a ridge of beachgrass foredune grassland.

XIII. GODWIN ISLAND (Figure 30 & 31)

Godwin Island is completely low salt marsh with intertwining creeks. The vegetation is consistantly Spartina Alterniflora.

XIV. MYRTLE ISLAND (Figure 30 & 31)

Myrtle Island exhibits one of the most developed foredune systems within the Virginia Coast Reserve system. The main dry-land communities are the foredune-grassland and a mesic to dry dense grassland. The northeast end of the island has ten foot, densely covered dunes. These communities meet the low marsh at a vegetated Iva driftline and some salt flat vegetation. At the northeastern end of the island is a wide beach. The southwestern end of the island parallels Little Inlet. It has a short beach backed by a beachgrass ridge.

XV. MINK ISLAND (Figure 30 & 31)

Mink Island is almost exclusively a marsh island except for an area on the northeastern sector which has two small sections of higher ground. They are vegetated mostly by dense grasslands surrounded with a band of Baccharis and Iva. An upper low salt marsh and driftline surrounds them. One salt flat is behind the southeast grassland.

LEGEND

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mf : Mud Flat

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XVI. SMITH ISLAND (Figure 32)

Smith Island is one of the most diverse islands of the Virginia Coast Reserve. It is equaled in this regard only by Parramore Island. It has two connected sections: a northern part which is much influenced by overwash, and a main, southern section of alternating wooded dune ridges and brackish marshes.

The northern part is similar to Metomkin Island with its overwashed nature. Bungalow Inlet was formerly open about one-third of the way from the north end of the island. It is now sealed. This former inlet area now has a beach, wash flat, and patches of sparse grassland. Large areas of young vigorous marsh are found in this vicinity on recent mud flat or wash flat sediments. Another narrow area which represents a former inlet is at the junction of the narrow northern section and the main southern part of the island.

The most diverse part of Smith Island is the southern end. It is nearly a mile wide and almost two miles long. A series of dune ridges are oriented in a nearly east-west direction along this part of the island. They are densely vegetated by a hardwood forest and tall Myrica thicket. The hardwood forest is quite different from that of Parramore Island. It is dominated by Myrica cerifera, Prunus serotina, and Robinia pseudoacacia. It also has abundant Ilex vomitoria. Smith Island is the only portion of the Virginia Coast Reserve on which oak trees were seen. Many individuals of Quercus falcata, Q. stellata, and Q. nigra are found on the northern half of the main body. Two individuals of Quercus virginiana were seen near the beach.[1/] This is the northernmost extension of this species on any barrier island. Relatively few individuals of Juniperus virginiana were seen on Smith Island.

The ridges to the south have tall Myrica cerifera thickets similar to those on Hog Island. Further south, the stature and density of the thickets decreases.

Between the wooded ridges lie brackish marshes. These are dominated by a lush growth of Distichlis spicata. Though they have a simple composition and description, they are a very significant community here. Much of the island's acreage is brackish marsh.

The only botanical paper concerning Smith Island was by Clovis published in 1968. He describes the vegetation of the southern (main) part of the island and lists some species found in the major communities. Several are noteworthy.

The dune ridges (Ridge Areas) have advanced successionally from a dominance of shrubs to a hardwood forest on the northern ridges. He lists Ilex opaca, Persea borbonia, (P. palustris of the present report), Pinus taeda, Aralia spinosa, Diospyros virginiana, Juniperus virginiana, and Quercus falcata occurring there. In the present field work, the first three species (Ilex, Persea, and Pinus) were frequent or abundant. The last four were occasional. Few individuals of Aralia and Diospyros were found. Quercus falcata is slightly more common. Noteably, few Juniperus were found on the whole island.

In the description of the foredune-grassland (Dune Strand), Spartina alterniflora on the seaside dunes, along with other plants presently found, were listed. This may be misleading. When S. alterniflora has been located near seaside dunes on some islands, it has always been located near salt flats, wash flats, or in heavily overwashed areas. This plant may have been seen in this zone, but was probably an exception either at the southern tip of the island or at the junction of the main body and the narrow northern part of the island.

1/ Two specimens were collected by Louis Cullipher of the U.S. Soil Conservation Service, Prince George, Virginia in May, 1975.

Clovis includes "large clumps of Juncus balticus" in the marsh areas, but does not mention J. roemerianus. Since the coastal range for J. balticus is from Canada to Long Island, it is suspected that J. roemerianus was the plant forming "large clumps" as it does today.

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peat : Peat Outcrops

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FUTURE STUDY NEEDS

The present vegetation analysis is a relatively cursory inventory of the main communities and most common species characteristic of each one. Many variations exist on each island. The time allowed for this project was insufficient to cover many important aspects of the vegetation and ecology of these islands.

The Virginia Coast Reserve is virtually a botanical terra incognito. Many relatively common plants of these islands are not recorded for Accomack or Northampton Counties because few papers have been written about the area and few specimens are in herbaria. Many plants reach their northern or southern limits on these islands, but a comprehensive list and location of the present limit has not been created. No papers on ecological relationships or on salt marsh characteristics and productivity of these islands are in the literature.

Several features here are ideal for studies presently of academic significance but with possibilities for applicability to future coastal management. Some less involved studies of more immediate applicability may be useful for understanding and managing the islands.

This report is only a start on the research potential of this important coastal area. The islands will prove to be of increasing importance for future research on natural areas in solving problems relating to human manipulation of other east coast barrier islands.

Eleven items to be considered for future study follow:

(1) A complete species list for all the islands is desirable. It should be compiled by a team of botanists in the field from April through November for at least one year. It should include species at their range limit and location of this limit; "new" county records; and rare, endangered, threatened, or nearly extinct species encountered. Voucher specimens deposited in a major institution are important.

(2) A study delineating definite boundaries of tidal wetlands should be done, and should include studies of environmental parameters needed for such determinations.

(3) A more detailed salt marsh analysis including variations in height regimes and density of Spartina alterniflora, substrate composition, marsh elevation, productivity, and acreage should be performed.

(4) Ecological studies involving sampling, environmental parameters and successional relationships would expand the present analysis. In some respects (e.g., succession) they may add information useful for management of specific areas.

(5) Repetition of a mapping project and field reconnaissance similar to the present one (for 9-12 months) should be done about five years from now. This would help monitor effects of succession in areas important to wildlife (e.g., fresh marsh succession to thicket; loss of grasslands to erosion or thicket succession; extensions of Phragmites or Juncus colonies), to study the success of recolonization on overwash areas, and to focus attention on new or continually critical areas.

(6) Studies of marsh succession rates on wash flats and mud flats may be desired.

(7) Studies of the succession of salt flats and the relationship between salt flats, mud flats, wash flats, drift mats, and salt marshes can be done here on ideal locations.

(8) Investigations of areas which may profit from grass plantings and recommendations in this regard may be desirable in the near future.

(9) Brief research on the forests of Parramore Island may be desirable to determine forest succession potential, availability of seed dispersal, soil nutrient and moisture availability, and the local ecology of the southern pine park beetle. (APPENDIX G)

(10) A more directed brief study on the effects of deer browsing on Parramore and Smith Islands is needed.

(11) Desirability of controlled burns in forest or marsh areas to increase wildlife food, habitat or to reduce fire danger or germination inhibition should be investigated.

SUMMARY

A chain of barrier islands lines the coast of Virginia north of the Chesapeake Bay. Approximately fifty miles of this coastline is administered by The Nature Csnservancy.

Many plant communities from tidal areas to wooded dune ridges are found on these islands. They generally have a narrow beach backed by a foredune and grassland or an overwashed grassland area. Behind this is usually a thicket, and in some cases, forest. Brackish and fresh marshes are located in the interior of some islands. Vast salt marshes extend behind all islands.

Using infrared aerial imagery, a map of the main plant communities and complexes was created. Twenty-three mapping units were used to designate the various recognizable plant communities, complexes, and significant unvegetated areas. These mapping units are distributed within the following main groupings: xeric-mesic herbaceous vegetation, woody vegetation, hydric-halophytic vegetation, and essentially non-vegetated mapping units.

The mapping units usually represent communities or complexes of small communities. They all have uniform characteristics, but variations within the mapping units occur on all the islands. Each island has its own unique features. Range limits of many typically northern and southern plants are met here.

These islands have been relatively undisturbed and presently have few permanent structures. Erection of permanent structures outside of the most protected areas is not advisable.

The Virginia Barrier Islands are some of the last natural islands remaining on the middle and northern part of the east coast. Though they have been treated very little in the scientific literature, many important facts and relationships are to be learned from them. They will become increasingly important in our understanding of natural coastal processes and ecological relationships.

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Fauna

VERTEBRATE ZOOGEOGRAPHY OF THE VIRGINIA COAST RESERVE

by

Raymond D. Dueser
William C. Brown
Sue Ann McCuskey
Gregory S. Hogue

Department of Environmental Sciences
University of Virginia
Charlottesville, Virginia 22903

INTRODUCTION

The terrestrial vertebrates of the Virginia Barrier Islands have received comparatively little scientific attention. There are few published studies of the mammals, birds, amphibians and reptiles of these islands. With increased interest in management activities related to these islands, however, there are several substantial reasons for examining vertebrate population ecology and zoogeography in this nearshore archipelago:

1. No biological survey of a natural area is complete without consideration of these generally inconspicuous, but ubiquitous species;

2. These species reflect the extent to which the ecology of these islands resembles the ecology of the adjacent Delmarva Peninsula;

3. These species, many resident on the islands year-round, comprise an abundant, diverse consumer group, capable of directly influencing other components of the island biota, including both colonies of ground-nesting sea and shore birds and patches of early successional vegetation;

4. Since these species are, as a rule, very responsive to habitat alterations, terrestrial vertebrate populations should be considered *a priori* in island land use or management schemes; and,

5. This particular barrier island complex provides an exceptional opportunity for examining the dynamic aspects of island zoogeography, species niche relationships and isolation-induced population differentiation.

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OBJECTIVES

This study was designed to provide baseline population and zoogeographic information for the terrestrial vertebrate species occurring on the Virginia Barrier Islands owned by The Nature Conservancy. Specific objectives included:

1. Comparison of vertebrate species composition and relative abundances between island habitats and similar habitats on the adjacent mainland;

2. Comparison of species composition and relative abundances between islands of different size, configuration and vegetation characteristics; and,

3. Description of the ecological distribution of each species among the habitats available on each island.

Examination of species composition and relative abundances on selected islands will outline the overall pattern of vertebrate zoogeography in this barrier island complex. Information on species distributions may isolate specific locations in which either a) the activities of vertebrates as consumers might be of particular significance for other components of the biota (e.g., ground-nesting sea or shore birds) or b) the vertebrate populations themselves might be particularly susceptible to disruption of the physical environment.

Two groups of vertebrates, land birds and small mammals, received particular attention. The land birds included species from the orders Falconiformes (diurnal birds of prey), Galliformes (fowl), Columbiformes (pigeons and doves), Cuculiformes (cuckoos), Strigiformes (owls), Caprimulgiformes (whip-poor-wills and nighthawks), Apodiformes (swifts), Piciformes (woodpeckers), and Passeriformes (song birds). Species of sea and shore birds were not included in this study. (Ed. note see Williams et al. An Analysis of Past and Present Status of the Beach Nesting and Colonial Birds of the Virginia Coast Reserve in this Volume). The small mammals included species from the orders Rodentia (mice, voles, rats and squirrels) and Insectivora (shrews and moles). Intensive systematic sampling procedures were used for these taxa. Other mammals, and reptiles and amphibians, were observed as encountered. There were no observations for bats.

STUDY AREAS

Study areas were located at nine mainland locations within five miles of Wachapreague, Virginia, and on 10 islands (Table 1). The mainland study areas encompassed the range of coastal habitats found in the central Delmarva Peninsula. The 10 islands included five large seaward barrier islands owned wholly or in part by The Nature Conservancy (Parramore, Hog, Cobb, Myrtle and Smith), one barrier island owned by the Commonwealth of Virginia (Wreck), two small backside islands owned by The Nature Conservancy (Revel and Mink) and two additional small, privately-owned islands (Skidmore and Raccoon). The five large islands were studied because of their geographical, ecological and historical dominance of the Eastern Shore island complex. The small backside islands were studied as ecological "stepping stones" both between the mainland and the seaward islands and between the seaward island themselves. Total sampling effort on each study area was roughly proportional to the size and vegetation-type (habitat) diversity of that study area.

METHODS

I. STUDY TRANSECTS

Systematic sampling of mammals and birds in most study areas was concentrated on a transect through the area (Table 1).

TABLE 1

MAINLAND AND ISLAND STUDY AREAS FOR SYSTEMATIC CENSUSING OF SMALL MAMMALS AND LAND BIRDS

Study Area	Transect No.	Mammal Census	Bird Census
Mainland	1	X	X
" "	2	X	X
" "	3	X	
" "	4	X	X
" "	5	X	
" "	6	X	X
" "	7	X	X
" "	8	X	X
" "	9	X	
Parramore	10	X	X
Revel	16	X	X
Hog	11	X	X
Cobb	15	X	X
Smith	12	X	X
Skidmore	14	X	X
Raccoon	13	X	X
Wreck			X
Myrtle			X
Mink			X

The location and orientation of each island transect were determined from inspection of detailed vegetation and topographic maps. Each transect was located to intersect representative units of both the extensive vegetation types, as described in the McCaffrey (1975) vegetation survey, (Ed. note see Vegetation Section of this Volume for further treatment) and the conspicuous topographic features of the study area. Since the island vegetation types generally occur as sharply-bounded zones running parallel to the length of the island, a transect from backside to seaside, perpendicular to the beach, intersected several vegetation types. No transect was established on the three smallest islands on which the birds, but not the mammals, were censused.

Each transect was surveyed with pocket transit, steel tape and pacing, and a permanent station was marked every 15 meters with a numbered wire stake flag. Each transect was surveyed as straightly as possible, given the occasionally dense undergrowth, along a predetermined compass bearing. The Parramore transect included 200 stations along one straight line. The other transects included variable numbers of stations (Table 2), but each doubled back from the seaside to provide two parallel crossings of the island. In addition, a side loop of two parallel rows of five stations 15 meters apart extended from each main transect, to intensify sampling effort for any particularly narrow or seldom-encountered vegetation type and/or topographic feature. The transect stations served both as small mammal trap sites and as bird-habitat observation points.

TABLE 2

STUDY DATES AND NUMBERS OF TRAP NIGHTS FOR MAINLAND AND ISLAND STUDY AREA TRANSECTS

Study Area	Transect No.	Study Dates (1975)	No. of Stations	No. of Nights	Trap Nights
Mainland	1	6/ 9-6/12	40	4	160
" "	2	6/ 9-6/12	7	4	28
" "	3	6/14-6/17	21	4	84
" "	4	6/14-6/17	20	4	80
" "	5	6/18	20	1	20
" "	6	6/18-6/21	18	4	63
" "	7	6/18-6/21	22	4	88
" "	8	6/18-6/21	42	4	168
" "	9	6/24-6/25	50	2	100

TABLE 2 CONTINUED

Study Area	Transect No.	Study Dates (1975)	No. of Stations	No. of Nights	Trap Nights
Parramore	10	6/26-6/29	200	4	863*
" "	10	7/03-7/06	190	4	844*
" "	10	8/28-8/29	188	2	408*
Revel	16	7/31-8/ 2	100	3	330*
Hog	11	7/10-7/13	165	4	652+
Cobb	15	7/24-7/26	124	3	367+
Smith	12	7/18-7/20	165	3	495
Skidmore	14	7/20-7/21	20	2	40
Raccoon	13	7/20-7/21	20	2	40

*Several transect stations had multiple traps.
+Several trap nights were lost to malfunctioning traps.

II. POPULATION SAMPLING

Small mammal species composition and relative abundances were determined using mark-and-release live-trapping procedures on the transects and from observations of free-ranging individuals and identifiable signs (e.g. tracks). Table 2 summarizes the study dates and numbers of trap nights for each transect. Each transect station had one large rigid Sherman live-trap of either aluminum or galvanized iron. Approximately every tenth station also had one large wire live-trap for spot sampling of medium size mammals such as raccoons. Each trap was cleaned, adjusted and baited with dry rolled oats; bait was added as necessary during a trapping period. This mundane bait was used to reduce the lure effect associated with "noisey" baits such as peanut butter. All traps were run both morning and evening. Trapped animals were determined to sex, weight, examined for physical and reproductive condition, marked for permanent individual identification and released at the capture site. Capture information for each individual was recorded on a standardized keypunch data form.

Land bird species composition and relative abundances were determined from systematic observations at each transect station. Table 3 summarizes the study dates and numbers of hours of observation for each study area. Most transects were walked slowly both morning and evening for at least two days. Bird work typically began on the day that the traps were dropped, with subsequent censusing twice daily until it became apparent that the birds had been "mapped" along the transect. This sampling was aided by the fact that many of the species observed were nesting and/or territorial during the study and were, therefore, relatively sedentary. Individuals within 10 meters of the transect were identified to species and, where possible, to sex by appearance and song. The number of singing individuals heard, but not seen

was recorded separately. Behavioral activity, time of day, date, transect station and vegetation type were recorded for any individual observed visually. Systematic observations also were made on three very small islands for which there were no transects (Wreck, Myrtle and Mink). Sampling on these islands consisted of walking the entire area systematically at least once, noting essentially every individual on the island.

TABLE 3

STUDY DATES AND NUMBERS OF HOURS OF
BIRD OBSERVATIONS FOR MAINLAND AND ISLAND STUDY AREAS

Study Area	Transect No.	Study Dates (1975)	No. of Bird Walks	Hours of Observation
Mainland	1	6/ 9-6/13		
" "	2	and 6/16	8	8.0
" "	4	6/17-6/18	2	1.5
" "	5	6/18	1	1.0
" "	6	6/17-6/19	5	5.0
" "	7	6/17-6/19	5	5.0
" "	8	6/18-6/19	3	2.0
Parramore	10	6/26-6/29	7	18.6
Revel	16	6/ 5-6/ 6	4	14.9
Hog	11	7/ 9-7/11	3	4.5
Cobb	15	7/24-7/26	3	2.8
Smith	12	7/17-7/20	4	7.3
Skidmore	14	7/19-7/20	2	2.5
Raccoon	13	7/19-7/20	2	2.3
Myrtle		7/16	1	2.0
Mink		7/16	1	1.8
Wreck		7/16	1	4.0

Additional systematic observations were taken occasionally for specific purposes for both mammals and birds. For example, the grounds of the Parramore Beach Coast Guard Station, including the garbage dump, were trapped briefly specifically to provide information on the mammal fauna associated with current human habitation. Also, since the bird work proceeded faster than the mammal work, there was time to observe the land birds on the three additional small islands for which no systematic mammal work was undertaken.

Taxa other than small mammals and land birds were observed as encountered. Field records for these species generally included date and vegetation type.

III. SPECIES-HABITAT ASSOCIATIONS

Vegetation type was noted for each transect station, in the terminology of the McCaffrey (1975) vegetation maps. The vegetation of each station was easily classified because of the sharp zonation and conspicuous differentiation of types. Vertebrate species-habitat (i.e., species-vegetation type) associations were determined on each transect from the cumulative records for each species in each of the vegetation types represented. Detailed species microhabitat preferences were determined from quantitative multivariate descriptions of the transect stations where individuals of each species were observed.

Species-habitat associations are treated here in two ways. First, these associations are summarized and discussed for four principal, easily distinguished vegetation (habitat) types, each of which includes several of the McCaffrey vegetation types (Table 4). This lumping of McCaffrey types was accepted for economy of presentation, since it facilitates direct comparisons between islands with no substantial loss of information. A particular transect might not intersect several of the McCaffrey vegetation types, even though each principal type was represented by one or more of its included McCaffrey types; thus, these principal types are more frequently observed than are the individual McCaffrey types. Second, species-habitat associations at the fine-scaled level of the McCaffrey vegetation types are summarized in appendices. These associations are mentioned in the text only where they provide substantially increased resolution for a species.

TABLE 4

LISTING OF THE McCAFFREY VEGETATION TYPES INCLUDED IN EACH OF THE MAJOR VEGETATION TYPES RECOGNIZED IN THIS REPORT

Grassland-Dunes	Woodland-Thicket	Tidal Marsh	Nontidal Marsh
A	AT	m	M
AG	H	Mm	F
Ag	J	S	
At	P	W	
B	PH		
G	T		
g	t		

RESULTS

I. MAMMAL FAUNA

A. Species Composition

The mammal species composition reported for each study area incorporates four sources of information: trapped individuals, free-ranging individuals, identified signs (e.g., muskrat dens) and confirmed reports during the study period from other biologists working on the islands. Biosystematic nomenclature for mammals follows Handley and Patton (1947). Appendix H gives the scientific and common name for each species reported here. Seven mammal species are reported for the nine mainland study areas in the Wachapreague vicinity (Table 5). Only two species, the white-tailed deer and eastern cottontail, were observed without trapping. One deer and several cottontails were observed on transect 1. Most species, the white-footed mouse and eastern harvest mouse, were trapped on several transects. With the conspicuous exception of transect 1, most transects yielded only one or two species. There is no obvious relationship between the intensity of trapping effort on a given transect and the number of species observed on that transect. This mainland species list undoubtedly is conservative; the mammal fauna of the Wachapreague vicinity probably includes several additional species not reported here.

TABLE 5

SUMMER 1975 MAMMAL SPECIES REPORT FOR THE MAINLAND STUDY AREAS (T - trapped, O - observed).

Species	Mainland Study Areas (Transects)								
	1	2	3	4	5	6	7	8	9
Blarina brevicauda	T								
Microtus pennsylvanicus	T								T
Odocoileus virginianus	O								
Oryzomys palustris									T
Peromyscus leucopus	T	T	T	T		T	T		
Reithrodontomys humulis				T	T			T	
Sylvilagus floridanus	O								

Sixteen species are reported for nine islands (Table 6). This list does not include the two most frequently observed mainland species, the white-footed mouse and eastern harvest mouse; these two species were neither trapped nor observed on any island. The white-footed mouse has been reported as common in all habitats except salt marshes and pine stands on Assateague Island (Paradiso and Handley, 1965). This list does include two livestock species and nine wildlife species not reported on the mainland. Feral cows and sheep are established on Hog Island, and sheep on Revel Island. The wildlife species include

the California jackrabbit, river otter, house mouse, mink, muskrat, raccoon, Norway rat, gray squirrel and red fox. Six of these nine species -- excluding the intentionally-introduced California jackrabbit on Cobb Island -- almost certainly occur locally on the peninsula, even though they were not reported during this study period (Wass, 1972).

TABLE 6

SUMMER 1975 MAMMAL SPECIES REPORT FOR THE ISLAND STUDY AREAS
(T - trapped, O - observed, S - sign observed, R - confirmed report)

	Island Study Areas								
Species	Parramore	Revel	Hog	Cobb	Wreck	Myrtle	Smith	Skidmore	Raccoon
Blarina brevicauda									T
Bos taurus			O						
Lepus californicus				O					
Lutra canadensis	O						O		
Microtus pennsylvanicus	T	T							
Mus musculus	T		T				T		
Mustela vison							O		
Odocoileus virginianus	O	O	R			O	O		
Ondatra zibethica	S	S	S		R	R	O		
Orysomys palustris	T	T	T	T			T	T	
Ovis sp.		O	O						
Procyon lotor	T	O	R	R			R		
Rattus norvegicus	T	T							
Sciurus carolinensis	O						R		
Sylvilagus floridanus	O		O				S		
Vulpes fulva			O						

Three small mammal species were observed on three or fewer islands. While the short-tailed shrew was abundant in the pine forest on mainland transect 1, the total observations for this species on the islands consist of one capture of one individual in a brackish marsh within 30 meters of the pine forest on Raccoon Island, at the southern tip of the Delmarva Peninsula. Although this one capture does little more than establish the presence of this shrew on Raccoon Island, it is interesting to note that this species was found only on the island which was most recently connected by dry land to the peninsula. Raccoon Island was created from a spur of the peninsula with the comparatively recent opening of the Intracoastal Canal. Since the habitat in which this shrew occurs on both the mainland and Raccoon Island is available on other islands in the complex, it seems likely that the island distribution of this species is determined primarily by its inability to disperse from the mainland. The meadow vole was found on only two islands, Parramore and Revel. This native species is very commonly found on islands along the northern and central Atlantic coast (Youngman, 1967; Crowell, 1973). The house mouse, one of the most commonly observed introduced species on Atlantic coast islands, was trapped on Parramore, Hog and Smith.

Six other wildlife species were found on only one or two islands. One mink was sighted one time on Smith Island. The observed restricted distribution of the mink probably reflects simply the inherent difficulty of observing this elusive aquatic species. The total observations for the gray squirrel include only one sighting of one individual on each of two forested islands. There was one sighting in the pine forest on Parramore and one in the deciduous forest on Smith. Given the amount of observor time spent on these two islands, these squirrel populations must have been at very low densities during the study period for there to be only one observation per island, with no sightings of nests. Squirrels were not found on Revel Island, even though this island has extensive pine forest. The California jackrabbit was observed only on Cobb Island, where it was introduced intentionally for hunting (John W. Bowen, Exmore, Virginia, pers. comm.). Two red fox were observed together on Hog Island. The cottontail was present but not abundant on Parramore and Hog Islands. Judging from the density of rabbit pellets on the front grassland-dune, this species is probably abundant on Smith Island. The Smith Island cottontail is recognized as a distinct subspecies (Mearns, 1911; Handley and Patton, 1947). There was a single confirmed sighting of the river otter on each of two islands, Parramore and Smith.

Four wildlife species occurred on several islands. The deer and raccoon were abundant on several islands, including islands at least as small as Myrtle. There were at least two deer sightings per independent observer-day on Parramore and Revel Islands. Reports from Wachapreague residents indicate that deer frequently are observed crossing backside marshes and swimming the channels, passing between islands and between the islands and mainland. No such crossings were observed during the study period. Data from five adult specimens collected during this study period indicate that the deer on Parramore are light-weight for their age by comparison with mainland specimens. Also, these specimens carried

stomach parasite loads higher than expected for a healthy deer population (Fairfax Settle, Virginia Division of Game and Inland Fisheries, Richmond, Virginia, pers. comm.). Both of these observations raise a question about the extent to which these island deer populations really are open to migration. (Ed. note. Specific information gathered about the relative fitness, parasite load and age structure of the Parramore Island deer herd was gathered in autumn, 1975. The analysis of this data has not been completed at this time. Independent analysis by four separate investigators [McCaffrey, 1975, Williams, 1975, Steirly, 1975, Folk, 1975] indicates overbrowsing of the island's vegetation.) Raccoons also were frequently observed on Parramore and Revel, with several individuals frequently within view at the same time. Fourteen raccoons were observed on Parramore Beach at dusk one evening from the end of the Parramore transect. A muskrat was actually observed only on Smith Island, where what appeared to be the same individual was sighted on three different occasions at the same den in a tidal marsh. There were, however, conspicuous signs of this aquatic species on several other islands. The rice rat was the most widely distributed small mammal species. This semi-aquatic species has dispersed throughout the island complex; Raccoon Island was the only transect on which it was not trapped. The rice rat previously has been reported from Assateague Island (Paradiso and Handley, 1965) and from Wreck and Smith Islands (Goldman, 1918).

Even discounting the feral livestock on Revel and Hog Islands, introduced species comprise a conspicuous element of the mammal fauna of several islands. The jackrabbit is abundant and conspicuous on Cobb Island. The house mouse is the only mouse species reported for the island complex, and the Norway rat seems to have resident populations on at least Parramore and Revel Islands. Although the jackrabbit was recently introduced to Cobb intentionally for hunting, the house mouse and the Norway rat clearly reflect the historic human occupation of these islands.

Although no statistical treatment has been attempted, it appears from inspection of Table 6 that the number of species increases with island size, elevation and vegetation complexity. This is particularly true for the trappable small mammal species. Parramore Island is the highest, most complex island sampled, and it yielded five small mammal species. The other intensively-sampled islands could be ranked qualitatively in descending order of complexity as Revel, Smith, Hog and Cobb. These Islands yielded three, three, two and one small mammal species, respectively. Complete analysis of this aspect of the vertebrate zoogeography of the barrier islands would require quantitative measures of island size, elevation and isolation.

Tables 5 and 6 support five general conclusions about mammal species composition:

1. Some species common on the mainland are absent (e.g., white-footed mouse and eastern harvest mouse) or uncommon (e.g., short-tailed shrew) on the islands. Conversely, some species present on the islands are absent or at least uncommon on the mainland (e.g., house mouse, Norway rat, meadow vole and rice rat). Small mammal species composition, in particular,

differs conspicuously both between the mainland and islands and among the islands.

2. Several species are widely distributed through the island complex (e.g., deer, raccoons, muskrats and rice rats). Conversely, several species are restricted in their distributions among the islands, probably reflecting the habitat preferences and/or dispersal ability of these species (e.g., gray squirrel and short-tailed shrew).

3. The species most widely distributed in the complex are either large and highly mobile (e.g., deer and raccoons) or small and at least semi-aquatic (e.g., muskrats and rice rats).

4. Several introduced species of small and large mammals occur in the island complex (i.e., California jackrabbit, house mouse, Norway rat, cows and sheep). There is no evidence that the introduced species are able to disperse unassisted between islands; the occurrence of each species on any particular island is easily explained as the result of a direct introduction, either accidental or intentional.

5. For those islands which were most intensively sampled (i.e., Parramore, Revel, Hog, Cobb and Smith), the number of species appears to increase with island elevation, vegetation complexity, and, perhaps, size.

B. Species Abundances

Abundances for species observed, but not trapped (e.g., deer and raccoons) were summarized cursorily in the preceding section. The most reliable quantitative information on abundances is for those species subject to live-trapping. Three related aspects of this information are summarized here: total live-trap captures of each species in each study area; captures, and numbers of animals, for the identified individuals of each species in each study area; and, projected captures of identified individuals of each species per 100 trap nights in each study area. These data have not been tested statistically.

There were 101 total captures for the five small mammal species live-trapped in 791 trap nights on the mainland (Table 7). The percentage of these captures accounted for by each species was: white-footed mouse 66%, eastern harvest mouse 16%, meadow vole 8%, short-tailed shrew 6% and rice rat 4%. The average percent trapping success for the nine mainland transects was 12.8% (range 4.8 to 20.6%). There were 634 total captures for the five small mammal species live-trapped in 4,039 trap nights on the islands (Table 8). The percentage of these captures accounted for by each species was: rice rat 51%, meadow vole 28%, house mouse 17%, Norway rat 4% and short-tailed shrew 1%. The average percent trapping success for the seven island transects was 15.7% (range 2.5 to 20.0%). Based on these results, the mainland and island small mammal faunas appear to very dissimilar in both species composition and relative abundances. There was no consistent relationship between trapping effort (i.e., number of trap nights) and percent trapping success.

TABLE 7

TOTAL CAPTURES AND PERCENT TRAPPING SUCCESS
[(no. of captures/no. of trap nights) x 100%]
FOR THE SMALL MAMMAL SPECIES OF THE MAINLAND STUDY AREAS

Species	Mainland Study Areas (Transects)									Species Totals
	1	2	3	4	5	6	7	8	9	
Blarina brevicauda	6									6
Microtus pennsylvanicus	1								7	8
Oryzomys palustris									4	4
Peromyscus leucopus	26	4	9	8		5	15			67
Reithrodontomys humulis				6	2			8		16
Study Area Totals	33	4	9	14	2	5	15	8	11	101
No. of Trap Nights	160	28	84	80	20	63	88	168	100	791
% Trapping Success	20.6	14.3	10.7	17.5	10.0	7.9	17.0	4.8	11.0	12.8

TABLE 8

TOTAL CAPTURES AND PERCENT TRAPPING SUCCESS
[no. of captures/no. of trap nights) x 100%]
FOR THE SMALL MAMMAL SPECIES OF THE ISLAND STUDY AREAS

Species	Island Study Areas							Species Totals
	Parramore	Revel	Hog	Cobb	Smith	Skidmore	Raccoon	
Blarina brevicauda							1	1
Microtus pennsylvanicus	172	8						180
Mus musculus	5		37		64			106
Oryzomys palustris	72	56	109	75	5	6		323
Rattus norvegicus	22	2						24

TABLE 8 CONTINUED

Species	Island Study Areas							
	Parramore	Revel	Hog	Cobb	Smith	Skidmore	Raccoon	Species Totals
Study Area Totals	271	66	146	75	69	6	1	634
No. of Trap Nights	2,115	330	652	367	495	40	40	4,039
% Trapping Success	12.8	20.0	22.4	20.4	13.9	15.0	2.5	15.7

Most live-trapped animals were marked for permanent identification and were assigned an individual identification number in the capture records. Some animals, however, escaped while being handled, without being individually identified. Tables 7 and 8 summarized total captures by species and study area, including captures of both identified and unidentified individuals. Tables 9 and 10 summarize both the numbers of captures of identified animals and the numbers of individuals for the small mammal species of the mainland and islands respectively. Most individuals were captured only once. The conspicuous exceptions are the white-footed mouse on the mainland (average of 1.9 captures per individual) and the meadow vole (1.4), house mouse (1.3) and rice rat (1.3) on the islands.

Since the study areas were not sampled with equal effort (Table 2), the most convenient measure by which the abundances of these small mammal species can be compared on and between study areas is simply the projected or expected number of captures of identified individuals per 100 transect trap nights, based on the observed capture frequencies. This measure of estimated abundance is calculated simply as [(no. of captures of identified individuals on a transect/no. of trap nights on that transect) x 100]. Assuming that the species are equally susceptible to trapping, these estimated abundances are directly comparable between transects, islands and species. This assumption generally is questionable for short-term (2-4 days) trapping records (Webb, 1965), but there is no hard evidence available here to suggest that these particular species differ greatly in their susceptibility to trapping.

The white-footed mouse was by far the most abundant species on the mainland, in terms of both where it occurred and its numerical abundance on each transect (Table 11). Most species were found in low abundance in both these respects. Only the eastern harvest mouse had similar estimated abundances on all transects where observed. The rice rat was by far the most abundant species on the islands (Table 12). With the exception of the infrequently observed Norway rat and short-tailed shrew, species abundances were highly variable between islands. Only the house mouse and rice rat were ever observed at abundances greater than ten captures per 100 trap nights. Interestingly, these

two species were the most frequently consumed mammals in a large sample of barn owl pellets collected on Fisherman's Island, near Smith Island at the southern tip of the peninsula (Blem and Pagels, 1973). The meadow vole previously has been reported to be the most numerous mammal on Assateague Island (Paradiso and Handley, 1965). As discussed below, most species exhibited restricted distributions among the vegetation types sampled in each study area. These types were not sampled with equal intensity.

TABLE 9

CAPTURES OF IDENTIFIED INDIVIDUALS
(i.e., ear-tagged or trap-dead) for the small mammal species of the mainland study areas (no. of captures/no. individuals)

Species	Mainland Study Areas (Transects) 1	2	3	4	5	6	7	8	9	Species Totals
Blarina brevicauda	5/5									5/5
Microtus pennsylvanicus	1/1								7/5	8/6
Orysomys palustris									4/4	4/4
Peromyscus leucopus	23/10	3/2	9/4	8/3		5/4	14/9			62/32
Reithrodontomys humulis				5/4	1/1			8/8		14/13
Study Area Totals	29/16	3/2	9/4	13/7	1/1	5/4	14/9	8/8	11/9	93/60

TABLE 10

CAPTURES OF IDENTIFIED INDIVIDUALS
(i.e., ear-tagged or trap-dead)
FOR THE SMALL MAMMAL SPECIES OF THE ISLAND STUDY AREAS
(No. captures/no. individuals)

Species	Island Study Areas							Species Totals
	Parramore	Revel	Hog	Cobb	Smith	Skidmore	Raccoon	
Blarina brevicauda							1/1	1/1
Microtus pennsylvanicus	168/116	8/8						176/124
Mus musculus	4/4		37/29		64/47			105/80
Oryzomys palustris	71/53	56/42	106/74	75/58	5/5	6/6		319/238
Rattus norvegicus	19/15	2/2						21/17
Study Area Totals	262/188	66/52	143/103	75/58	69/52	6/6	1/1	622/460

TABLE 11

ESTIMATED ABUNDANCES OF THE MAINLAND SMALL MAMMAL SPECIES,
MEASURED AS THE NUMBER OF CAPTURES OF IDENTIFIED INDIVIDUALS PER 100
TRAP NIGHTS ON THE MAINLAND STUDY AREAS

Species	Mainland Study Areas (Transects)								
	1	2	3	4	5	6	7	8	9
Blarina brevicauda	3.0								
Microtus pennsylvanicus	0.6								7.0
Oryzomys palustris									4.0
Peromyscus leucopus	14.4	10.7	10.7	10.0		7.9	15.9		
Reithrodontomys humulis				6.3	5.0			4.8	

TABLE 12

ESTIMATED ABUNDANCES OF THE ISLAND SMALL MAMMAL SPECIES, MEASURED AS THE NUMBER OF CAPTURES OF IDENTIFIED INDIVIDUALS PER 100 TRAP NIGHTS ON THE ISLAND STUDY AREAS

Species	Island Study Areas						
	Parramore	Revel	Hog	Cobb	Smith	Skidmore	Raccoon
Blarina brevicauda							2.50
Microtus pennsylvanicus	7.9	2.4					
Mus musculus	0.2		5.7		12.9		
Oryzomys palustris	3.4	16.9	16.3	20.4	1.0	15.0	
Rattus norvegicus	0.9	0.6					

Therefore, much of the apparent variability in species abundance undoubtedly reflects variability in the vegetation composition of the study areas. This point is considered again below.

These results support five general conclusions about mammal species relative abundances:

1. Some species observed frequently on the islands (e.g., deer and raccoons) were seldom or never observed on the mainland, even though they must occur on the mainland. Although there is no absolute measure of abundance for these species, it is apparent that they are more abundant and/or more easily observed on the islands.

2. Those species which were most abundant on the mainland during this field season were absent from the islands. Conversely, those species which were most abundant on the island were absent or present in relatively low abundances on the mainland.

3. There was substantial variation among islands in the abundance of those species found on two or more islands. Much of this variation must reflect variation in the vegetation composition of the islands.

4. For the small mammal species, each island fauna seems to be dominated by a single species, with one or two additional species occurring in much lower abundance.

5. Mainland and island mammal faunas appear to be very dissimilar, in terms of both species composition and relative abundances.

C. Habitat Associations

The vegetation at each point where a mammal was observed was classified by the scheme used for the McCaffrey (1975) vegetation maps of the islands. Mammal species-habitat associations were determined from the cumulative observations for a species by vegetation type and study area (Appendix I). For economy of presentation, these associations are discussed here for only the four principal vegetation types discussed above in connection with Table 4. Instances in which information has been lost by this lumping of the McCaffrey vegetation types includes in any particular principal vegetation type are mentioned below with reference to Appendix I. Table 13 summarizes the small mammal trapping effort in each principal vegetation type for each area.

Only the white-footed mouse and rice rat are reported from more than one of the three principal vegetation types sampled on the mainland (Table 14.) As is commonly observed, the white-footed mouse occurred in pine and deciduous forests, shrub thickets and grass fallow-fields. The rice rat occurred in tidal marsh and adjacent shrub-thickets. Each of the other small mammal species occurred in only one vegetation type: short-tailed shrew in pine forest, meadow vole in tidal marsh, and eastern harvest mouse in grass fallow-field. It is important to note both that the rice rat was never captured in tall shrub thicket or forest and that the meadow vole was never captured in the woodland-thicket type, even when this type was immediately adjacent to the tidal marsh where it was captured. The deer and cottontail rabbit undoubtedly would have been observed in several vegetation types had they been recorded for more than one transect.

Most of the island species occurred in multiple vegetation types (Table 15). Two relatively large species, the deer and raccoon, were found in all four of the principal vegetation types. These species are highly mobile and are likely to encounter a variety of vegetation types in the course of their daily activities. Deer were observed particularly often in pine forest and nontidal marsh meadow. In contrast to their mainland distributions, the meadow vole and rice rat also occurred in all four of the principal vegetation types on the islands. Both of these species were trapped in locations varying from wet tidal marsh and beach dune through mature pine forest. The house mouse, which was never observed on the mainland, also occurred in all four vegetation types.

The Norway rat was captured in three types, but always within 50 meters of the woodland-thicket type. Although it is not reflected in Table 15, there were 8 captures of Norway rats in 30 trap nights on the grounds of the Parramore Beach Coast Guard Station, the only persistent human habitation in the island complex. As might be expected, the muskrat occurred in both nontidal and tidal marshes; this aquatic species was absent from upland vegetation types. The short-tailed shrew was trapped only once, in a brackish marsh at a trap station within 30 meters of the pine forest on Raccoon Island. The gray squirrel occurred in mature pine forest on Parramore and in mixed deciduous-broadleaf evergreen forest on Smith. It was not reported for the pine forest on Revel

Island or the tall shrub thicket on Hog. Given the limited forest development in the island complex, it is apparent that the distributions of the shrew and squirrel ultimately are influenced by the availability of suitable habitat.

TABLE 13

APPROXIMATE PERCENTAGE DISTRIBUTION OF TOTAL TRAP NIGHTS IN EACH STUDY AREA AMONG THE VEGETATION TYPES CROSSED BY THE TRANSECT IN THAT STUDY AREA

Study Area	Transect No.	No. of Trap Nights	Approx. % of Trap Nights Per Type			
			Grassland-Dunes	Woodland-Thicket	Tidal Marsh	Nontidal Marsh
Mainland	1	160	20.0	77.5	2.5	
" "	2	28		100.0		
" "	3	84		100.0		
" "	4	80	100.0			
" "	5	20	60.0	40.0		
" "	6	63		100.0		
" "	7	88		100.0		
" "	8	168	100.0			
" "	9	100		34.0	66.0	
Parramore	10	2,115	8.3	54.0	13.9	23.8
Revel	16	330		54.0	46.0	
Hog	11	652	49.0	29.7	15.8	5.5
Cobb	15	367	75.0	9.7	15.3	
Smith	12	495	43.6	16.4	3.0	37.0
Skidmore	14	40	5.0	90.0	5.0	
Raccoon	13	40		50.0	50.0	

TABLE 14

MAMMAL SPECIES REPORTED FOR EACH OF THE PRINCIPAL VEGETATION TYPES ON THE MAINLAND (T - trapped, O - observed)

Species	Principal Vegetation Types		
	Grassland-Dunes	Woodland-Thicket	Tidal Marsh
Blarina brevicauda		T	
Microtus pennsylvanicus			T
Odocoileus virginianus		O	
Oryzomys palustris		T	T
Peromyscus leucopus	T	T	
Reithrodontomys humulis	T		
Sylvilagus floridanus		O	

TABLE 15

MAMMAL SPECIES REPORTED FOR EACH OF THE PRINCIPAL VEGETATION TYPES ON THE ISLANDS (T - trapped, O - observed, S - sign observed)

Species	Principal Vegetation Types			
	Grassland-Dunes	Woodland-Thicket	Nontidal Marsh	Tidal Marsh
Blarina brevicauda			T	
Bos taurus	O	O		
Lepus californicus	O			
Microtus pennsylvanicus	T	T	T	T
Mus musculus	T	T	T	T
Mustela vison				O
Odocoileus virginianus	O	O	O	O
Ondatra zibethicus			S	O

TABLE 15 CONTINUED

Species	Principal Vegetation Types			
	Grassland-Dunes	Woodland-Thicket	Nontidal Marsh	Tidal Marsh
Oryzomys palustris	T	T	T	T
Ovis sp.	O	O		O
Procyon lotor	O	O	O	O
Rattus norvegicus		T	T	T
Sciurus carolinensis		O		
Sylvilagus floridanus	O	O		

TABLE 16

CAPTURES OF IDENTIFIED INDIVIDUALS IN EACH OF THE PRINCIPAL VEGETATION TYPES AND PERCENTAGE OF SPECIES CAPTURES PER TYPE, FOR THE MAINLAND SMALL MAMMAL SPECIES

Species	Principal Vegetation Types		
	Grassland-Dunes	Woodland-Thicket	Tidal Marsh
	Transect 1		
Blarina brevicauda		5 (100.0)	
Microtus pennsylvanicus			1 (100.0)
Peromyscus leucopus	1 (4.3)	22 (95.7)	
	Transect 2		
Peromyscus leucopus		3 (100.0)	
	Transect 3		
Peromyscus leucopus		9 (100.0)	
	Transect 4		
Peromyscus leucopus	8 (100.0)		
Reithrodontomys humulis	5 (100.0)		
	Transect 5		
Reithrodontomys humulis	1 (100.0)		
	Transect 6		
Peromyscus leucopus		5 (100.0)	

TABLE 16 CONTINUED

Species	Principal Vegetation Types		
	Grassland-Dunes	Woodland-Thicket	Tidal Marsh
	Transect 7		
Peromyscus leucopus		14 (100.0)	
	Transect 8		
Reithrodontomys humulis	8 (100.0)		
	Transect 9		
Microtus pennsylvanicus			7 (100.0)
Oryzomys palustris		2 (50.0)	2 (50.0)

These species-habitat associations can be better appreciated with quantitative treatment of species distributions. Table 16 summarizes the captures of identified animals for each species in each principal vegetation type for the mainland small mammal species. The important point, as indicated by the percentage of species captures per vegetation type, is that each species exhibited a distinct association with one principal type. The short-tailed shrew was found in pine forest, the meadow vole in tidal marsh, the rice rat in tidal marsh or immediately adjacent shrub thicket, the eastern harvest mouse in grassy fallow-fields and the white-footed mouse predominantly in forest.

Table 17 summarizes the comparable results for the island mammal populations. The Norway rat was captured most often in the woodland-thicket type, with occasional captures in marshes. Altogether, 90% of the Norway rat captures were in association with woody vegetation, generally tall shrub thicket or forest. Fifty-three percent of the captures for this species on Parramore were in pine-hardwood forest (Appendix I). This is comparable to the distribution observed for this species on Assateague Island (Paradiso and Handley, 1965). The house mouse was captured only in the seaside grassland-dunes on Parramore, and this species was most abundant in the grassland-dunes type on the other two islands where it occurred. Altogether, 83% of the house mouse captures were in association with this type, and within this type most captures were in association with either densely vegetated dunes or dense grassland (Appendix I). This is in contrast with the distribution of this species on Assateague, where it has been reported to be abundant and to occur in a variety of habitats not including the sparsely vegetated dunes near the ocean beach (Paradiso and Handley, 1965).

In contract to their mainland distributions, both the meadow vole and the rice rat were fairly abundant in multiple vegetation types. Altogether, the meadow vole captures were 2% grassland-dunes, 45% woodland-thicket, 47% nontidal marsh, and 6% tidal marsh. This species generally was found in brackish and fresh water marshes and in adjacent short-to-tall shrub thicket, but voles were also frequently captured in

the pine-hardwood forest on Parramore (Appendix I). This occurrence in association with a variety of island habitats, including mature forest, parallels the ecological distributions reported for this species on many other islands, both in lakes (e.g., Manville, 1951; Webb, 1965) and in coastal island complexes (e.g., Grant, 1971; Crowell, 1973). Altogether, 37% of the rice rat captures were in grassland-dunes, 13% in woodland-thicket, 7% in nontidal marsh and 43% in tidal marsh. Eleven percent of the rice rat captures on Parramore were in pine-hardwood forest (Appendix I). Along the central Atlantic coast, this species previously has been reported from the wetter portions of fresh and salt marshes on Assateague Island (Paradiso and Handley, 1965) and from salt marshes on Chincoteague Island (Hamilton, 1946).

TABLE 17

CAPTURES OF IDENTIFIED INDIVIDUALS IN EACH OF THE PRINCIPAL VEGETATION TYPES AND PERCENTAGE OF SPECIES CAPTURES PER TYPE, FOR THE ISLAND SMALL MAMMAL SPECIES

Species	Principal Vegetation Types			
	Grassland-Dunes	Woodland-Thicket	Nontidal Marsh	Tidal Marsh
	Parramore Island			
Microtus pennsylvanicus	3 (1.8)	75 (44.6)	82 (48.8)	8 (4.8)
Mus musculus	4 (100.0)			
Oryzomys palustris	1 (1.4)	15 (21.1)	7 (9.9)	48 (67.6)
	Revel Island			
Microtus pennsylvanicus		5 (62.5)		3 (37.5)
Oryzomys palustris		2 (3.6)		54 (96.4)
Rattus norvegicus		1 (50.0)		1 (50.0)
	Hog Island			
Mus musculus	26 (70.3)	9 (24.3)		2 (5.4)
Oryzomys palustris	70 (66.0)	10 (9.4)	13 (12.3)	13 (12.3)
	Cobb Island			
Oryzomys palustris	48 (64.0)	8 (10.7)		19 (25.3)
	Smith Island			
Mus musculus	57 (89.1)	2 (3.1)	5 (7.8)	
Oryzomys palustris		1 (20.0)	2 (40.0)	2 (40.0)
	Skidmore Island			
Oryzomys palustris		4 (67.7)	2 (33.3)	
	Raccoon Island			
Blarina brevicauda			1 (100.0)	

Since the four principal vegetation types were not sampled with equal effort on any given island (Table 13), the capture records summarized in Tables 16 and 17 do not necessarily provide an unbiased, comparative measure of species-habitat associations. This measure of abundance must be adjusted for sampling effort in each vegetation type. The most convenient measure by which species-habitat associations can be compared on and between islands is simply the projected or expected number of captures of identified individuals per 100 trap nights per vegetation type. As discussed above, this measure of abundance assumes the species to be equally susceptible to trapping. Also, interpretation of this measure for a species requires due consideration for the number of observations on which the measure is based.

This adjusted estimate of abundance does not alter the mainland species-habitat associations, since each species occurred primarily in association with one principal vegetation type (Table 18). This adjusted estimate does, however, provide a more realistic view of these associations on the islands (Table 19). The Norway rat still is associated with the woodland-thicket type, but even here it occurred in very low abundance, relative to the other species. The apparent absence of this species from the other wooded islands, including Hog, Smith and Raccoon, seems unlikely to be due to habitat restriction. The continued presence of human occupation on Parramore may play a significant part in the relative success of the Norway rat on Parramore. The house mouse still is associated with the grassland-dune type, with much lower abundances in the other types. The absence of this mouse from Cobb Island seems unlikely to be due to habitat restriction. This adjusted measure of species-habitat association describes the meadow vole as a primarily nontidal marsh species, rather than as nontidal/tidal marsh species. To the extent that this vole really prefers nontidal marsh, it is possible that its distribution in the island complex may be affected by habitat availability. The rice rat, on the other hand, is primarily a tidal marsh species. This habitat association is consistent with the findings of Negus et al. (1961) and Goertz and Lang (1973) for this species. Also, within tidal marsh, upper low salt marsh (Mm) seems to be preferred over low salt marsh (m) (Appendix).

The results suggest seven general conclusions about mammal species-habitat associations:

1. The mainland species tend to be restricted to a single principal vegetation type and to show pronounced species-habitat associations. Most of the island species, on the other hand, occur in a variety of vegetation types, including types from which they are conspicuously absent on the mainland (e.g., the house mouse in island grassland and the Norway rat in island forest).

2. Most species exhibit marked expansion of the habitats occupied on the islands, relative to their customary mainland distributions (e.g., the meadow vole and rice rat in pine forest on the islands). This habitat expansion probably reflects differences between the mainland and island communities in community composition and in interspecific competetive relationships.

TABLE 18

ESTIMATED ABUNDANCES OF THE MAINLAND SMALL MAMMAL SPECIES IN THE PRINCIPAL VEGETATION TYPES, MEASURED AS THE NUMBER OF CAPTURES OF IDENTIFIED INDIVIDUALS PER 100 TRAP NIGHTS

Species	Principal Vegetation Types		
	Grassland-Dunes	Woodland-Thicket	Tidal Marsh
	Transect 1		
Blarina brevicauda		4.0	
Microtus pennsylvanicus			25.0
Peromyscus leucopus	3.1	17.7	
	Transect 2		
Peromyscus leucopus		10.7	
	Transect 3		
Peromyscus leucopus		10.7	
	Transect 4		
Peromyscus leucopus	10.0		
Reithrodontomys humulis	6.3		
	Transect 5		
Reithrodontomys humulis	8.3		
	Transect 6		
Peromyscus leucopus		7.9	
	Transect 7		
Peromyscus leucopus		15.9	
	Transect 8		
Reithrodontomys humulis	4.8		
	Transect 9		
Microtus pennsylvanicus			10.6
Oryzomys palustris		5.9	3.0

TABLE 19

ESTIMATED ABUNDANCES OF THE ISLAND SMALL MAMMAL SPECIES IN THE PRINCIPAL VEGETATION TYPES, MEASURED AS THE NUMBER OF CAPTURES OF IDENTIFIED INDIVIDUALS PER 100 TRAP NIGHTS

Species	Principal Vegetation Types			
	Grassland-Dunes	Woodland-Thicket	Nontidal Marsh	Tidal Marsh
	Parramore Island			
Microtus pennsylvanicus	1.7	6.6	16.3	2.7

TABLE 19 CONTINUED

Species	Principal Vegetation Types			
	Grassland-Dunes	Woodland-Thicket	Nontidal Marsh	Tidal Marsh
	Parramore Island Continued			
Mus musculus	2.3			
Oryzomys palustris	1.0	1.3	1.4	16.3
Rattus norvegicus		1.6	1.0	
	Revel Island			
Microtus pennsylvanicus		2.8		2.0
Oryzomys palustris		1.1		35.5
Rattus norvegicus		1.0		1.0
	Hog Island			
Mus musculus	8.2	4.6		1.9
Oryzomys palustris	21.9	5.2	36.1	12.6
	Cobb Island			
Oryzomys palustris	17.5	22.2		33.9
	Smith Island			
Mus musculus	26.4	2.5	2.7	
Oryzomys palustris		1.2	1.1	13.3
	Skidmore Island			
Oryzomys palustris		10.0	5.0	
	Raccoon Island			
Blarina brevicauda			2.5	

3. The larger mammal species, such as deer and raccoon, do not exhibit conspicuous species-habitat associations. This is a predictable observation for these relatively mobile species.

4. There are only two small mammal species consistently associated with tidal marshes, the muskrat and rice rat. This is typical habitat for these species elsewhere.

5. There are only two small mammal species consistently associated with nontidal marshes, the meadow vole and rice rat. On Parramore Island, where both species were observed frequently, the meadow vole was more abundant in nontidal marsh, the rice rat in tidal.

6. There are only two small mammal species consistently associated with grassland-dunes, the house mouse and rice rat. On the two islands having the most extensive grassland-dunes, the rice rat was most abundant in this type on one (Hog) and the house mouse

was most abundant in this type on the other (Smith). There is no obvious explanation for this relationship.

7. These results corroborate the earlier suggestion that the number of species increases with island size, elevation and vegetation complexity. The addition of woody vegetation to an island appears to significantly increase the species variety for that island. Forested islands have more species than those with thicket vegetation, and the latter have more species than those with grassland.

II. AVIAN FAUNA

A. Species Composition

The avian species composition reported for each study area incorporates two sources of information: individuals observed on the transect and individuals observed in the vicinity of the transect. The presence of species such as starlings and house sparrows, which congregate in areas of human habitation, is noted here even though there is no corresponding measure of abundance. Because of the seasonality of avian species composition, it is impossible to compare the species lists reported here with any other information available for the Delmarva Peninsula. At the least, however, the species reported here are representative of the summer avifauna of the mainland and islands. These species represent nine orders of land birds. Biosystematic nomenclature follows the fifth edition of the American Ornithologists' Union Check-List for North American Birds (1957). Appendix J gives the scientific and common names for each species.

Thirty-four species of land birds were observed on seven mainland transects, including species from seven orders (Table 20). The order Apodiformes (swifts) was observed only on the mainland. Most orders were represented by only one or two species, but there were 35 species of passerines. Twenty-six species occurred on only one transect, 12 on two, 3 on three and 3 on four. The six most ubiquitous species were the bobwhite, yellow-billed cuckoo, cardinal, redwing blackbird, indigo bunting and rufous-sided towhee. Eleven species reported for the Wachapreague vicinity, including the blue jay, mockingbird, starling and house sparrow, were never observed on a transect. Transects 1, 2 and 6, 7 had the greatest avian diversity, with 17 and 21 species reported, respectively. Transects 4, 5 and 8 had five, seven and seven species, respectively. This uneven distribution of species among transects reflects both variation in sampling effort (Table 3) and, probably even more importantly, variation in vegetation composition. This point is considered further below.

Forty-five species are reported for the 10 island study areas, including species from eight orders (Table 21). While the order Apodiformes (swifts) was observed only on the mainland, orders Falconiformes (diurnal birds of prey) and Strigiformes (owls) were observed only on the islands. Otherwise, the mainland and islands had the same recorded avian orders, and they shared 22 of the 57 species observed altogether on the transects.

There were species differences within several orders, however. For example, in the order Passeriformes, family Mimidae is often represented by the mockingbird on the mainland and by the catbird on the islands. Similarly, in the family Corvidae, the common crow is most often observed on the mainland and the fish crow on the islands. Most island species were observed on more than one transect. Seventeen species occurred on only one island, 8 on two, 8 on three and 12 on four or more. The twelve most ubiquitous species were the osprey, mourning dive. barn swallow, house wren, Carolina wren, catbird, yellow-throated warbler, eastern meadowlark, redwing blackbird, boat-tailed grackle, seaside sparrow and song sparrow. In this list, only the redwing blackbird was also considered to be widely distributed on the mainland.

TABLE 20

SUMMER 1975 BIRD SPECIES REPORT FOR THE MAINLAND STUDY AREAS AND THE WACHAPREAGUE VICINITY ("Other" study area) (O - species observed)

Species	Mainland Study Areas (Transects)					
	1,2	4	5	6,7	8	Other
Order Galliformes						
Colinus virginianus	O	O		O	O	
Order Columbiformes						
Zenaidura macroura	O			O		
Order Cuculiformes						
Coccyzus americanus		O		O	O	
Order Caprimulgiformes						
Caprimulgus carolinensis						O
Caprimulgus vociferus						O
Chordeiles minor						O
Order Apodiformes						
Chaetura pelagica						O
Archilochus colubris			O			
Order Piciformes						
Dendrocopos pubescens				O		
Colaptes auratus	O					

TABLE 20 CONTINUED

Species	Mainland Study Areas (Transects)					
	1,2	4	5	6,7	8	Other
Order Passeriformes						
Family Tyrannidae						
Tyrannus tyrannus	0	0				
Myiarchus crinitus			0			0
Contopus virens	0					
Family Hirundinidae						
Irodoprocne bicolor	0					0
Hirundo rustica	0					0
Progne subis				0		
Family Corvidae						
Cyanocitta cristata						0
Corvus brachyrhynchos		0			0	
Family Paridae						
Parus carolinensis				0		
Family Troglodytidae						
Troglodytes aedon				0		
Thryothorus ludovicianus	0			0		
Family Mimidae						
Mimus polyglottos						0
Toxostoma rufum	0					0
Family Turdidae						
Turdus migratorius						0
Sialia sialis	0					

TABLE 20 CONTINUED

Species	Mainland Study Areas (Transects)					
	1,2	4	5	6,7	8	Other
Family Sylviidae						
Polioptila caerulea				0		
Family Sturnidae						
Sturnus vulgaris						0
Family Vireonidae						
Vireo griseus				0		
Vireo gilvus				0	0	
Family Parulidae						
Dendroica dominica				0		
Seiurus aurocapillus				0		
Geothlypis trichas	0			0		
Icteria virens				0		
Family Ploceidae						
Passer domesticus						0
Family Icteridae						
Agelaius phoeniceus	0	0		0	0	0
Icterus spurius						0
Quiscalus quiscula	0	0				
Molothrus ater				0		
Family Thraupidae						
Piranga rubra			0	0		

TABLE 20 CONTINUED

Species	Mainland Study Areas (Transects)					
	1,2	4	5	6,7	8	Other
Family Fringillidae						
Richmondena cardinalis	0			0		0
Passerina cyanea	0	0	0	0		
Spinus tristis	0				0	
Pipilo erythrophthalmus			0	0	0	
Spizella passerina	0					
Melospiza melodia						0

TABLE 21

SUMMER 1975 BIRD SPECIES REPORT FOR THE ISLAND STUDY AREAS (O - species observed)

Species	Island Study Areas									
	Parramore	Revel	Hog	Cobb	Wreck	Myrtle	Mink	Smith	Skidmore	Raccoon
Order Falconiformes										
Buteo jamaicensis	O	O								
Pandion haliaetus	O	O		O				O	O	O
Order Galliformes										
Phasianus colchicus			O	O						
Order Columbiformes										
Zenaidura macroura	O							O	O	O
Order Cuculiformes										
Coccyzus americanus	O									
Order Strigiformes										
Bubo virginianus	O									
Tyto alba								O		
Order Caprimulgiformes										
Caprimulgus carolinensis	O									
Caprimulgus vociferus	O									
Chordeiles minor					O					
Order Piciformes										
Dendrocopus pubescens	O									
Colaptes auratus	O									

TABLE 21 CONTINUED

Species	Island Study Areas									
	Parramore	Revel	Hog	Cobb	Wreck	Myrtle	Mink	Smith	Skidmore	Raccoon
Order Passeriformes										
Family Tyrannidae										
Tyrannus tyrannus	0	0						0		
Myiarchus crinitus	0									
Contopus virens	0									
Family Alaudidae										
Eremophila alpestris				0						
Family Hirundinidae										
Iridoprocne bicolor	0	0	0							
Hirundo rustica	0		0	0				0	0	
Family Corvidae										
Cyanocitta cristata	0	0								
Corvus brachyrhynchos			0						0	
Corvus ossifragus	0		0					0		
Family Paridae										
Parus bicolor	0	0								
Family Troglodytidae										
Troglodytes aedon	0	0	0					0	0	0
Thryothorus ludovicianus	0	0	0		0			0	0	0
Family Mimidae										
Dumetella carolinensis	0	0	0		0			0	0	0
Toxostoma rufum	0									

TABLE 21 CONTINUED

Species	Island Study Areas									
	Parramore	Revel	Hog	Cobb	Wreck	Myrtle	Mink	Smith	Skidmore	Raccoon
Family Turdidae										
Turdus migratorius	0									
Hylocichla mustelina	0									
Family Sylviidae										
Polioptila caerulea	0	0								0
Family Vireonidae										
Vireo griseus	0	0								0
Family Parulidae										
Dendroica dominica	0									
Dendroica pinus	0	0								
Dendroica discolor	0	0	0							
Seiurus aurocapillus	0	0								0
Geothlypis trichas	0	0	0	0	0		0	0	0	0
Family Icteridae										
Sturnella magna			0	0			0	0		
Agelaius phoeniceus	0	0	0	0	0		0	0	0	0
Cassidix mexicanus	0	0	0	0	0	0	0			0
Quiscalus quiscula		0								
Family Fringillidae										
Richmondena cardinalis	0							0		
Pipilo erythrophthalmus	0		0					0		

TABLE 21 CONTINUED

Species	Island Study Areas									
	Parramore	Revel	Hog	Cobb	Wreck	Myrtle	Mink	Smith	Skidmore	Raccoon
Ammospiza caudacuta		O				O				
Ammospiza maritima		O	O	O	O	O	O	O		O
Melospiza georgiana	O									
Melospiza melodia	O	O	O	O	O	O	O	O	O	

Parramore Island had the greatest avian diversity, with 36 of the 45 total species reported for the islands. These 36 species included 13 which were seen on no other island, including several forest-dwelling species such as the yellow-billed cuckoo, great horned owl, downy woodpecker, yellow-shafted flicker, brown thrasher and wood thrush. These results reflect the fact that Parramore is one of the largest and most complex islands studied, both topographically and vegetationally. More than 50% of the Parramore transect passed through the woodland-thicket vegetation type. Also, Parramore was the most intensively sampled island. Revel Island, which is adjacent to the mainland side of Parramore, had 21 species, 18 of which also were found on Parramore. The common grackle was found only on Revel. The total number of species and the number of unique species for the eight remaining islands were: Hog (16 total, 0 unique), Smith (16, 1), Raccoon (12, 0), Cobb (9, 1), Skidmore (10, 0), Wreck (8, 1), Mink (6, 0) and Myrtle (4, 0). The barn owl was found only on Smith, the horned lark only on Cobb and the common nighthawk only on Wreck. The introduced pheasant was observed only on Hog; pheasant feathers were found on Cobb. Although this species is not included in Table 21 because there were no confirmed sightings, a rooster was heard crowing shortly after dawn one morning on Hog Island. Since this island was last occupied about 1943 (John W. Bowen, Exmore, Virginia, pers. comm.), any chickens there today probably represent a feral population at least 30 years old.

Tables 20 and 21 suggest seven general conclusions about avian species composition:

1. Birds of prey, including hawks, ospreys and owls, are more commonly observed on the islands than on the mainland. This is particularly true for ospreys, which are observed frequently on the islands.

2. Several species common on the mainland are absent (e.g., the bobwhite and indigo bunting) or uncommon (e.g., the cardinal)

on the islands. Conversely, several species common on the islands are absent or at least uncommon on the mainland (e.g., the osprey, barn swallow, house wren and Carolina wren). Since the overlap is only about 45% for the 62 total species observed, the mainland and island avian faunas are very different in species composition during the summer.

3. Some families are represented by one species on the mainland and by a different, but closely related species on the islands (e.g., the mockingbird on the mainland and the catbird on the islands).

4. Several species are widely distributed through the island complex (e.g., the osprey, Carolina wren, yellow-throated warbler and song sparrow). Conversely, several species are restricted in their distributions among the islands (e.g., the common nighthawk, downy woodpecker, yellow-shafted flicker and swamp sparrow). For many of these species, this restricted distribution must be related to the limited availability of suitable habitat.

5. The widely distributed island species include both large and small species. In general, differences in species dispersal ability probably have little influence on island avian species composition, particularly by comparison to the mammals. On the other hand, it is likely that some species having a short flight radius are absent from the islands because of limited over-water dispersal ability (e.g., bobwhite).

6. Although there may be feral chickens on Hog, the pheasant on Hog and Cobb is the only conspicuous introduced species on the islands. Even the introduced starling and house sparrow, both of which are abundant in the Wachapreague vicinity, were absent from the islands.

7. Avian species number appears to increase with island elevation, vegetation complexity and, perhaps size.

B. Species Abundances

There were 133 observations for 34 species on the seven mainland transects (Table 22). Most species were observed very infrequently; 19 of the species together were represented by less than 2% of the total observations. Even most of the species recorded on multiple transects were seldom observed. Conspicuous exceptions are the redwing blackbird and bobwhite, which accounted for 17% and 10.5% of the total observations, respectively. Most transects provided relatively few cumulative observations. Transects 1, 2 and 6, 7 accounted for 44%, and 32% of the total observations, respectively.

There were 1,439 observations for 45 species on the 10 islands censused (Table 23). As on the mainland, most species were observed infrequently; 29 of the species together were represented by less than 1% of the total

observations. The percentages of the observations accounted for by the seven most common species were: redwing blackbird 22%, catbird 9%, song sparrow 9%, house wren 8%, yellow-throated warbler 7%, boat-tailed grackle 6% and barn swallow 5%. The percentages of the observations accounted for by the individual islands were: Parramore 40%, Revel 16%, Smith 13%, Cobb 13%, Hog 12%, and the five smallest islands, with less than 3% each.

Since the study areas were not sampled with equal effort, the most convenient measure by which the abundances of these avian species can be compared on and between study areas is simply the expected number of observations per 10 transect-hours of observation, based on the observed encounter-frequencies. This measure of estimated abundance is calculated simply as [(no. of observations for a species on a transect/no. of hours of observation on that transect) x 10]. This measure is analogous to that used above for comparing small mammal abundances, except that the number of individual animals involved in the calculation is not known for the birds. This measure assumed that the species are equally observable on the transects. Table 24 summarizes the number of bird walks and the total number of hours of observation per transect.

Most mainland species were observed less than once per hour, on the average (Table 25). The two most abundant of those species observed on multiple transects were the bobwhite and redwing blackbird. Altogether there were approximately five observations per hour on transect 5, seven each on transects 8 and 1, 2, and nine each on transects 4 and 6, 7. These small numbers reflect the fact that the observations were restricted to a corridor within 10 meters of the transect. Also, these transects were sampled during the period when the avian sampling procedures were being developed. Most island species also were observed less than once per hour, on the average (Table 26). Several species, however, were conspicuously abundant on each of several islands (e.g., the barn swallow, house wren, catbird, redwing blackbird and song sparrow). The osprey seemed surprisingly abundant on several islands, particularly since other data indicate that island osprey populations are declining (Byrd, 1975). Altogether, there were approximately 10 observations per hour on Raccoon, 14 on Skidmore, 16 on Revel, 26 on Smith, 31 on Parramore, 37 on Hog and 64 on Cobb. Quantitative records would have been difficult to keep on most islands without the use of a portable cassette tape recorder. Species abundance as measured by observations per unit of time clearly is not a simple function of island size or complexity. Parramore is much larger and more complex vegetationally than Cobb, but the latter produced nearly twice as many observations per hour.

Tables 25 and 26 suggest four general conclusions about avian species relative abundances:

1. Several of the species most abundant on the mainland were seldom or never observed on the islands. This was particularly true for "domestic" species such as the blue jay, starling and house sparrow. Conversely, several of the species most abundant on the islands were seldom observed on the mainland. This was perhaps most obvious for the birds of prey, particularly the osprey.

TABLE 22

TOTAL OBSERVATIONS FOR THE LAND BIRD SPECIES OF THE MAINLAND STUDY AREAS

Species	Mainland Study Areas (Transects) 1,2	4	5	6,7	8	Species Totals
Order Galliformes						
Colinus virginianus	8	1		3	2	14
Order Columbiformes						
Zenaidura macroura	2			2		4
Order Cuculiformes						
Coccyzus americanus		2		2	1	5
Order Apodiformes						
Archilochus colubris			1			1
Order Piciformes						
Dendrocopus pubescens				2		2
Colaptes auratus	4					4
Order Passeriformes						
Family Tyrannidae						
Tyrannus tyrannus	4	1				5
Myiarchus crinitus			1			1
Contopus virens	3					3
Family Hirundinidae						
Iridoprocne bicolor	1					1
Hirundo rustica	8					8
Progne subis				2		2
Family Corvidae						
Corvus brachyrhynchos		3			1	4

TABLE 22 CONTINUED

Species	Mainland Study Areas (Transects) 1,2	4	5	6,7	8	Species Totals
Family Paridae						
Parus carolinensis				1		1
Family Troglodytidae						
Troglodytes aedon				3		3
Thryothorus ludovicianus	1			6		7
Family Mimidae						
Toxostoma rufum	1					1
Family Turdidae						
Sialia sialis	1					1
Family Sylviidae						
Polioptila caerulea				1		1
Family Vireonidae						
Vireo griseus				1		1
Vireo gilvus				2	1	3
Family Parulidae						
Dendroica dominica				2		2
Seiurus aurocapillus				1		1
Geothlypis trichas	4			1		5
Icteria virens				1		1
Family Icteridae						
Agelaius phoeniceus	10	4		4	5	23
Quiscalus quiscula	3	2				5
Molothrus ater				2		2
Family Thraupidae						
Piranga rubra			1	3		4

TABLE 22 CONTINUED

Species	Mainland Study Areas (Transects) 1,2	4	5	6,7	8	Species Totals
Family Fringillidae						
Richmondena cardinalis	2			2		4
Passerina cyanea	2	1	1	1		5
Spinus tristis	1				1	2
Pipilo erythrophthalmus	2		1	1	2	6
Spizella passerina	1					1
Study Area Totals	58	14	5	43	13	133

TABLE 23

TOTAL OBSERVATIONS FOR THE LAND BIRD SPECIES OF THE ISLAND STUDY AREAS

Species	Island Study Areas: Parramore	Revel	Hog	Cobb	Wreck	Myrtle	Mink	Smith	Skidmore	Raccoon	Species Totals
Order Falconiformes											
Buteo jamaicensis	1	3									4
Pandion haliaetus	2	17		2				15	2	2	40
Order Galliformes											
Phasianus colchicus			2								2
Order Columbiformes											
Zenaidura macroura	2							2	6		10
Order Cuculiformes											
Coccyzus americanus	1										1

TABLE 23 CONTINUED

Species	Island Study Areas										Species Totals
	Parramore	Revel	Hog	Cobb	Wreck	Myrtle	Mink	Smith	Skidmore	Raccoon	
Order Strigiformes											
Bubo virginianus	1										1
Tyto alba								3			3
Order Caprimulgiformes											
Caprimulgus carolinensis	1										1
Caprimulgus vociferus	1										1
Chordeiles minor					1						1
Order Piciformes											
Dendrocopos pubescens	2										2
Colaptes auratus	9										9
Order Passeriformes											
Family Tyrannidae											
Tyrannus tyrannus	16	15						3			34
Myiarchus crinitus	4										4
Contopus virens	12										12
Family Alaudidae											
Eremophila alpestris				1							1
Family Hirundinidae											
Iridoprocne bicolor	1	10	16								27
Hirundo rustica	24		7	26				18	2		77
Family Corvidae											
Cyanocitta cristata	1	1									2
Corvus brachyrhynchos			2						1		3
Corvus ossifragus	2		8					6			16

TABLE 23 CONTINUED

Species	Island Study Areas										Species Totals
	Parramore	Revel	Hog	Cobb	Wreck	Myrtle	Mink	Smith	Skidmore	Raccoon	
Family Paridae											
Parus bicolor	11	2									13
Family Troglodytidae											
Troglodytes aedon	70	16	12					8	5	2	113
Thryothorus ludovicianus	51	7	2					7		2	69
Family Mimidae											
Dumetella carolinensis	82	22	10		2			9	3	3	131
Toxostoma rufum	3										3
Family Turdidae											
Turdus migratorius	5										5
Hylocichla mustelina	4										4
Family Sylviidae											
Polioptila caerulea	9	3								1	13
Family Vireonidae											
Vireo griseus	12	1								1	14
Family Parulidae											
Dendroica dominica	1										1
Dendroica pinus	9	2									11
Dendroica discolor	47	4	4								55
Seiurus aurocapillus	7	1								2	10
Geothlypis trichas	35	8	20	16	1		1	22	2	2	107

TABLE 23 CONTINUED

Species	Island Study Areas										Species Totals
	Parramore	Revel	Hog	Cobb	Wreck	Myrtle	Mink	Smith	Skidmore	Raccoon	
Order Passeriformes (cont.)											
Family Icteridae											
Sturnella magna			6	8			1	1			16
Agelaius phoeniceus	103	57	28	44	2		4	61	11	3	313
Cassidix mexicanus	6	23	28	15	4	1	2			3	82
Quiscalus quiscula		2									2
Family Fringillidae											
Richmondena cardinalis	11							1			12
Pipilo erythrophthalmus	8		1					1			10
Ammospiza caudacuta		1				2					3
Ammospiza maritima		4	14	31	1	5	3	14		1	73
Melospiza georgiana	1										1
Melospiza melodia	24	33	5	37	1	3	5	16	3		127
Study area totals	579	232	165	180	12	11	16	187	35	22	1439

TABLE 24

APPROXIMATE PERCENTAGE DISTRIBUTION OF TOTAL HOURS OF BIRD OBSERVATIONS AMONG THE VEGETATION TYPES CROSSED BY EACH TRANSECT.

Study Area	Transect No.	Hours of Observation	Approx. % of Hours per Type			
			Grassland-Dunes	Woodland-Thicket	Tidal Marsh	Nontidal Marsh
Mainland	1,2	8.0	17.0	81.0	2.0	
" "	4	1.5	100.0			
" "	5	1.0	60.0	40.0		
" "	6,7	5.0		100.0		
" "	8	2.0	100.0			
Mainland totals		17.5	31.8	67.2	1.0	
Parramore	10	18.6	11.0	52.5	13.5	23.0
Revel	16	14.9		54.0	43.0	3.0
Hog	11	4.5	49.0	30.0	16.0	5.0
Cobb	15	2.8	75.0	10.0	15.0	
Smith	12	7.3	44.0	16.0	3.0	37.0
Skidmore	14	2.5	5.0	90.0	5.0	
Raccoon	13	2.3		50.0	50.0	
Island totals		52.9	28.3	38.1	15.8	17.8

TABLE 25

ESTIMATED ABUNDANCES OF THE MAINLAND BIRD SPECIES, MEASURED AS THE EXPECTED NUMBER OF OBSERVATIONS FOR EACH SPECIES IN 10 HOURS OF OBSERVATION ON EACH OF THE MAINLAND TRANSECTS.

Species	Mainland Study Areas (Transects)				
	1,2	4	5	6,7	8
Order Galliformes					
Colinus virginianus	10.0	6.7		6.0	10.0
Order Columbiformes					
Zenaidura macroura	2.5			4.0	
Order Cuculiformes					
Coccyzus americanus		13.3		4.0	5.0
Order Apodiformes					
Archilochus colubris			10.0		
Order Piciformes					
Dendrocopus pubescens				4.0	
Colaptes auratus	5.0				
Order Passeriformes					
Family Tyrannidae					
Tyrannus tyrannus	5.0	6.7			
Myiarchus crinitus			10.0		
Contopus virens	3.8				
Family Hirundinidae					
Iridoprocne bicolor	1.3				
Hirundo rustica	10.0				
Progne subis				4.0	

TABLE 25 CONTINUED

Species	Mainland Study Areas (Transects)				
	1,2	4	5	6,7	8
Order Passeriformes (cont.)					
Family Corvidae					
Corvus brachyrhynchos		20.0			5.0
Family Paridae					
Parus carolinensis				2.0	
Family Troglodytidae					
Troglodytes aedon				6.0	
Thryothorus ludovicianus	1.3			12.0	
Family Mimidae					
Toxostoma rufum	1.3				
Family Turdidae					
Sialia sialis	1.3				
Family Sylviidae					
Polioptila caerulea				2.0	
Family Vireonidae					
Vireo griseus				2.0	
Vireo gilvus				4.0	5.0
Family Parulidae					
Dendroica dominica				4.0	
Seiurus aurocapillus				2.0	
Geothlypis trichas	5.0			2.0	
Icteria virens				2.0	

TABLE 25 CONTINUED

Species	Mainland Study Areas (Transects)				
	1,2	4	5	6,7	8
Order Passeriformes (cont.)					
Family Icteridae					
Agelaius phoeniceus	12.5	26.7		8.0	25.0
Quiscalus quiscula	3.8	13.3			
Molothrus ater				4.0	
Family Thraupidae					
Piranga rubra			10.0	6.0	
Family Fringillidae					
Richmondena cardinalis	2.5			4.0	
Passerina cyanea	2.5	6.7	10.0	2.0	
Spinus tristis	1.3				5.0
Pipilo erythrophthalmus	2.5		10.0	2.0	10.0
Spizella passerina	1.3				

TABLE 26

ESTIMATED ABUNDANCES OF THE ISLAND BIRD SPECIES, MEASURED AS THE EXPECTED NUMBER OF OBSERVATIONS FOR EACH SPECIES IN 10 HOURS OF OBSERVATION ON EACH OF THE ISLAND TRANSECTS

Species	Island Study Areas						
	Parramore	Revel	Hog	Cobb	Smith	Skidmore	Raccoon
Order Falconiformes							
Buteo jamaicensis	0.5	2.0					
Pandion haliaetus	1.0	11.4		7.1	20.5	8.0	8.6
Order Galliformes							
Phasianus colchicus			4.4				
Order Columbiformes							
Zenaidura macroura	1.0				2.7	24.0	
Order Cuculiformes							
Coccyzus americanus	0.5						
Order Strigiformes							
Bubo virginianus	0.5						
Tyto alba					4.1		
Order Caprimulgiformes							
Caprimulgus carolinensis	0.5						
Caprimulgus vociferus	0.5						
Order Piciformes							
Dendrocopos pubescens	1.0						
Colaptes auratus	4.8						

TABLE 26 CONTINUED

Species	Island Study Areas						
	Parramore	Revel	Hog	Cobb	Smith	Skidmore	Raccoon
Order Passeriformes							
Family Tyrannidae							
Tyrannus tyrannus	8.6	10.0			4.1		
Myiarchus crinitus	2.1						
Contopus virens	6.4						
Family Alaudidae							
Eremophila alpestris				3.5			
Family Hirundinidae							
Iridoprocne bicolor	0.5	6.7	35.5				
Hirundo rustica	12.9		15.5	92.8	24.6	8.0	
Family Corvidae							
Cyanocitta cristata	0.5	0.6					
Corvus brachyrhynchos			4.4			4.0	
Corvus ossifragus	1.0		17.7		8.2		
Family Paridae							
Parus bicolor	5.9	1.3					
Family Troglodytidae							
Troglodytes aedon	37.6	10.7	26.6		10.9	20.0	8.6
Thryothorus ludovicianus	27.4	4.6	4.4		9.5		8.6

TABLE 26 CONTINUED

Species	Island Study Areas						
	Parramore	Revel	Hog	Cobb	Smith	Skidmore	Raccoon
Order Passeriformes (cont.)							
Family Mimidae							
Dumetella carolinensis	44.0	14.7	22.2		12.3	12.0	13.0
Toxostoma rufum	1.6						
Family Turdidae							
Turdus migratorius	2.6						
Hylocichla mustelina	2.1						
Family Sylviidae							
Polioptila caerulea	4.8	2.0					4.3
Family Vireonidae							
Vireo griseus	6.4	0.6					4.3
Family Parulidae							
Dendroica dominica	0.5						
Dendroica pinus	4.8	1.3					
Dendroica discolor	25.2	2.6	8.8				
Seiurus aurocapillus	3.7	0.6					8.6
Geothlypis trichas	18.8	5.3	44.4	57.1	30.1	8.0	8.6

TABLE 26 CONTINUED

Species	Island Study Areas						
	Parramore	Revel	Hog	Cobb	Smith	Skidmore	Raccoon
Order Passeriformes (cont.)							
Family Icteridae							
Sturnella magna			13.3	28.5	1.3		
Agelaius phoeniceus	55.3	38.2	62.2	157.1	83.5	44.0	13.0
Cassidix mexicanus	3.2	15.4	62.2	53.5			13.0
Quiscalus quiscula		1.3					
Family Fringillidae							
Richmondena cardinalis	5.9				1.3		
Pipilo erythrophthalmus	4.3		2.2		1.3		
Ammospiza caudacuta		0.6					
Ammospiza maritima		2.6	31.1	110.7	19.1		4.3
Melospiza georgiana	0.5						
Melospiza melodia	12.9	22.1	11.1	132.1	21.9	12.0	

2. There was substantial intraspecific variation in abundance for those species found on two or more islands. Much of this variation must reflect variation in the vegetation composition of the islands.

3. There was substantial variation in bird abundance among the islands, measured as the number of bird sightings per hour. There was no obvious relationship between island size and complexity and average overall abundance.

4. Mainland and island avian faunas appear to be very dissimilar during the summer, in terms of both species composition and relative abundances.

C. Habitat Associations

The vegetation at each transect station where a species was observed was classified by the scheme used for the McCaffrey (1975) vegetation maps of the islands. Avian species-habitat associations were determined from the cumulative observations for a species by vegetation type (Appendix K). As for the mammals, these associations are discussed here only for the four principal vegetation types discussed above in connection with Table 4. Instances in which information has been lost by this lumping of the McCaffrey vegetation types included in any particular principal vegetation type are mentioned below with reference to Appendix K.

Most of the 34 species on the mainland transects occurred in only one of the three principal vegetation types sampled (Table 27). No species occurred in all three types and only 10 of the 34 occurred in two types. Fourteen species were observed in the grassland-dunes vegetation type, 29 in woodland-thicket and one species, the barn swallow, in tidal marsh. This last type was sampled very lightly (Table 24). Four species, including the ruby-throated hummingbird, tree swallow, common crow and common grackle, were observed only in the grassland-dunes types. Twenty species, including all of the passerines, were observed only in the woodland-thicket type; these 20 species include the chickadees, wrens, thrashers, bluebirds, gnatcatchers, vireos and wood warblers.

Most of the 45 island species were observed in more than one of the four principal vegetation types (Table 28). Seven species, including the osprey, tree swallow, barn swallow, redwing blackbird, eastern kingbird, seaside sparrow and song sparrow, were observed in all four types. Twenty-two species were observed in the grassland-dunes type, 40 in woodland-thicket, 12 in nontidal marsh and 18 in tidal marsh. The common nighthawk was observed only in the grassland-dunes type, the common grackle and horned lark only in nontidal marsh, and the swamp sparrow only in tidal marsh. Fifteen species, including forest-dwelling species such as the yellow-billed cuckoo, great horned owl, barn owl, downy woodpecker, yellow-shafted flicker, great crested flycatcher and pine warbler, were observed only in woodland-thicket. Most of the species observed in only one of the principal vegetation types actually occurred in several McCaffrey types within that principal type (Appendix K).

These species habitat associations can be better appreciated with quantitative treatment of species distributions. Since the four principal vegetation types were not sampled with equal effort on any given island (Table 24), the most convenient measure by which species-habitat associations can be quantified is simply the expected number of observations per 10 transect hours of observation. This measure is similar to that used for comparing species abundances, except that it is weighted for unequal hours of observation per vegetation type, and is calculated simply as [(no. of observations for a species in a vegetation type/no. of hours of observation in that vegetation type) x 10]. This measure assumes that the species are equally observable in the different vegetation types. This value is calculated for each species overall, but not for each study area separately.

TABLE 27

BIRD SPECIES REPORTED FOR EACH OF THE PRINCIPAL VEGETATION TYPES ON THE MAINLAND (O - species observed)

Species	Principal Vegetation Types		
	Grassland-Dunes	Woodland-Thicket	Tidal Marsh
Order Galliformes			
Colinus virginianus	O	O	
Order Columbiformes			
Zenaidura macroura	O	O	
Order Cuculiformes			
Coccyzus americanus		O	
Order Apodiformes			
Archilochus colubris	O		
Order Piciformes			
Dendrocopus pubescens		O	
Colaptes auratus	O	O	
Order Passeriformes			
Family Tyrannidae			
Tyrannus tyrannus	O	O	
Myiarchus crinitus		O	
Contopus virens		O	
Family Hirundinidae			
Iridoprocne bicolor	O		
Hirundo rustica	O		O
Progne subis		O	
Family Corvidae			
Corvus brachyrhynchos	O		

TABLE 27 CONTINUED

Species	Principal Vegetation Types		
	Grassland-Dunes	Woodland-Thicket	Tidal Marsh
Family Paridae			
Parus carolinensis		0	
Family Troglodytidae			
Troglodytes aedon		0	
Thryothorus ludovicianus		0	
Family Mimidae			
Toxostoma rufum		0	
Family Turdidae			
Sialia sialis		0	
Family Sylviidae			
Polioptila caerulea		0	
Family Vireonidae			
Vireo griseus		0	
Vireo gilvus		0	
Family Parulidae			
Dendroica dominica		0	
Seiurus aurocapillus		0	
Geothlypis trichas		0	
Icteria virens		0	
Family Icteridae			
Agelaius phoeniceus	0	0	
Quiscalus quiscula	0		
Molothrus ater		0	

TABLE 27 CONTINUED

Species	Principal Vegetation Types		
	Grassland-Dunes	Woodland-Thicket	Tidal Marsh
Family Thraupidae			
Piranga rubra	0	0	
Family Fringillidae			
Richmondena cardinalis		0	
Passerina cyanea	0	0	
Spinus tristis	0	0	
Pipilo erythrophthalmus	0	0	
Spizella passerina		0	

TABLE 28

BIRD SPECIES REPORTED FOR EACH OF THE PRINCIPAL VEGETATION TYPES ON THE ISLANDS (0 - species observed)

Species	Principal Vegetation Types			
	Grassland-Dunes	Woodland-Thicket	Nontidal Marsh	Tidal Marsh
Order Falconiformes				
Buteo jamaicensis		0	0	
Pandion haliaetus	0	0	0	0
Order Galliformes				
Phasianus colchicus		0		
Order Columbiformes				
Zenaidura macroura		0	0	
Order Cuculiformes				
Coccyzus americanus		0		

TABLE 28 CONTINUED

Species	Principal Vegetation Types			
	Grassland-Dunes	Woodland-Thicket	Nontidal Marsh	Tidal Marsh
Order Strigiformes				
Bubo virginianus		0		
Tyto alba		0		
Order Caprimulgiformes				
Caprimulgus carolinensis				
Caprimulgus vociferus		0		
Chordeiles minor	0			
Order Piciformes				
Dendrocopos pubescens		0		
Colaptes auratus		0		
Order Passeriformes				
Family Tyrannidae				
Tyrannus tyrannus	0	0	0	0
Myiarchus crinitus		0		
Contopus virens		0		0
Family Alaudidae				
Eremophila alpestris				0
Family Hirundinidae				
Iridoprocne bicolor	0	0	0	0
Hirundo rustica	0	0	0	0
Family Corvidae				
Cyanocitta cristata	0	0		
Corvus brachyrhynchos	0	0		
Corvus ossifragus	0	0	0	0

TABLE 28 CONTINUED

Species	Principal Vegetation Types			
	Grassland-Dunes	Woodland-Thicket	Nontidal Marsh	Tidal Marsh
Family Paridae				
Parus bicolor		0	0	
Family Troglodytidae				
Troglodytes aedon	0	0	0	
Thryothorus ludovicianus	0	0	0	
Family Mimidae				
Dumetella carolinensis	0	0	0	
Toxostoma rufum	0	0		
Family Turdidae				
Turdus migratorius		0		
Hylocichla mustelina		0		
Family Sylviidae				
Polioptila caerulea		0		
Family Vireonidae				
Vireo griseus		0		
Family Parulidae				
Dendroica dominica		0		
Dendroica pinus		0		
Dendroica discolor	0	0		
Seiurus aurocapillus		0		
Geothlypis trichas	0	0	0	
Family Icteridae				
Sturnella magna	0	0		
Agelaius phoeniceus	0	0	0	0
Cassidix mexicanus	0	0		0
Quiscalus quiscula				0

TABLE 28 CONTINUED

Species	Principal Vegetation Types			
	Grassland-Dunes	Woodland-Thicket	Nontidal Marsh	Tidal Marsh
Family Fringillidae				
Richmondena cardinalis	0	0	0	
Pipilo erythrophthalmus	0	0	0	
Ammospiza caudacuta		0		
Ammospiza maritima	0	0	0	0
Melospiza georgina			0	
Melospiza melodia	0	0	0	0

As indicated previously, most of the mainland species occurred in only one of the principal vegetation types (Table 29). Most species were present in low abundance overall in any particular type. Conspicuous exceptions include the bobwhite and redwing blackbird in grassland-dunes and the barn swallow in tidal marsh. No single species was abundant in more than one vegetation type. In contrast to the mainland species, most of the island species occurred in two or more of the principal vegetation types (Table 30). In general, the abundances in each type were greater on the islands than on the mainland, even for those species which occurred in both places. Several island species were comparatively numerous in two or more types (e.g., the osprey, eastern kingbird, barn swallow, yellowthroat, boat-tailed grackle and song sparrow). As might be expected, these species also occurred on more islands than those species which were restricted to only one or two vegetation types. Conversely, several species were comparatively rare, even though they occurred in multiple vegetation types (e.g., the common crow, brown thrasher, cardinal and rufous-sided towhee). Each of these species occurred on three or fewer islands.

The most direct indications of strict species habitat preferences were for those species which occurred in a single principal vegetation type, but which were comparatively abundant in that type. For example, the yellow-shafted flicker, blue-grey gnatcatcher, white-eyed vireo, ovenbird and pine warbler all were abundant in woodland-thicket. These species all were most abundant in hardwood, juniper, pine or pine-hardwood forest (Appendix K), and they occurred only on forested islands.

Twelve of the 22 species observed on both the mainland and the islands occupied a broader range of vegetation types on the islands than on the mainland. The eastern wood pewee, common crow and brown thrasher each expanded from one to two vegetation types. For each of these species, however, there was only a single observation in each of the new types.

The house wren, Carolina wren, yellowthroat and cardinal each expanded from woodland-thicket to occupy in addition grassland-dunes and nontidal marsh. The tree swallow expanded from grassland-dunes on the mainland to all four types on the islands. The rufous-sided towhee expanded from grassland and woodland to occupy also nontidal marsh. The eastern kingbird, barn swallow and redwing blackbird each expanded from two to four types. For each of these species which expanded into two or more additional vegetation types on the islands, there were generally several observations in each of the new types. These species provide the best evidence of habitat expansion. Even with these expansions, however, none of these species changed the vegetation type in which it was most common.

TABLE 29

ESTIMATED ABUNDANCES OF THE MAINLAND BIRD SPECIES IN THE PRINCIPAL VEGETATION TYPES, MEASURED AS THE NUMBERS OF SIGHTINGS PER 10 HOURS OF OBSERVATION TIME IN EACH VEGETATION TYPE

Species	Principal Vegetation Types		
	Grassland-Dunes	Woodland-Thicket	Tidal Marsh
Order Galliformes			
Colinus virginianus	17.9	3.4	
Order Columbiformes			
Zenaidura macroura	1.8	2.6	
Order Cuculiformes			
Coccyzus americanus		4.3	
Order Apodiformes			
Archilochus colubris	1.8		
Order Piciformes			
Dendrocopus pubescens		1.7	
Colaptes auratus	1.8	2.6	
Order Passeriformes			
Family Tyrannidae			
Tyrannus tyrannus	5.4	1.7	
Myiarchus crinitus		0.9	
Contopus virens		2.6	

TABLE 29 CONTINUED

Species	Principal Vegetation Types		
	Grassland-Dunes	Woodland-Thicket	Tidal Marsh
Family Hirundinidae			
Iridoprocne bicolor	1.8		
Hirundo rustica	8.9		150.0
Progne subis		1.7	
Family Corvidae			
Corvus brachyrhynchos	7.1		
Family Paridae			
Parus carolinensis		0.9	
Family Troglodytidae			
Troglodytes aedon		2.6	
Thryothorus ludovicianus		3.4	
Family Mimidae			
Toxostoma rufum		0.9	
Family Turdidae			
Sialia sialis		0.9	
Family Sylviidae			
Polioptila caerula		0.9	
Family Vireonidae			
Vireo griseus		0.9	
Vireo gilvus		2.6	
Family Parulidae			
Dendroica dominica		1.7	
Seiurus aurocapillus		0.9	
Geothlypis trichas		4.2	
Icteria virens		0.9	

TABLE 29 CONTINUED

Species	Principal Vegetation Types		
	Grassland-Dunes	Woodland-Thicket	Tidal Marsh
Family Icteridae			
Agelaius phoeniceus	33.9	3.4	
Quiscalus quiscula	8.9		
Molothrus ater		1.7	
Family Thraupidae			
Piranga rubra	1.8	2.6	
Family Fringillidae			
Richmondena cardinalis		3.4	
Passerina cyanea	3.6	2.6	
Spinus tristis	1.8	0.9	
Pipilo erythrophthalmus	5.4	2.6	
Spizella passerina		0.7	

TABLE 30

ESTIMATED ABUNDANCES OF THE ISLAND BIRD SPECIES IN THE PRINCIPAL VEGETATION TYPES, MEASURED AS THE NUMBERS OF SIGHTINGS PER 10 HOURS OF OBSERVATION TIME IN EACH VEGETATION TYPE

Species	Principal Vegetation Types			
	Grassland-Dunes	Woodland-Thicket	Nontidal Marsh	Tidal Marsh
Order Falconiformes				
Buteo jamaicensis		1.5	1.2	
Pandion haliaetus	8.1	10.5	7.1	11.7
Order Galliformes				
Phasianus colchicus		0.9		
Order Columbiformes				
Zenaidura macroura		4.5	1.2	

TABLE 30 CONTINUED

Species	Principal Vegetation Types			
	Grassland-Dunes	Woodland-Thicket	Nontidal Marsh	Tidal Marsh
Order Cuculiformes				
Coccyzus americanus		0.5		
Order Strigiformes				
Bubo virginianus		0.5		
Tyto alba		0.5		
Order Caprimulgiformes				
Caprimulgus carolinensis		0.5		
Caprimulgus vociferus		0.5		
Order Piciformes				
Dendrocopos pubescens		1.0		
Colaptes auratus		4.5		
Family Tyrannidae				
Tyrannus tyrannus	5.4	9.5	3.6	4.3
Myiarchus crinitus		1.9		
Contopus virens		5.5		1.0
Family Alaudidae				
Eremophila alpestris				1.0
Family Hirundidae				
Iridoprocne bicolor	8.1	3.9	1.2	7.5
Hirundo rustica	31.5	3.5	15.5	10.6
Family Corvidae				
Cyanocitta cristata	0.7	0.5		
Corvus brachyrhynchos	0.7	1.0		
Corvus ossifragus	4.0	1.5	7.1	

TABLE 30 CONTINUED

Species	Principal Vegetation Types			
	Grassland-Dunes	Woodland-Thicket	Nontidal Marsh	Tidal Marsh
Family Paridae				
Parus bicolor		5.9	1.2	
Family Troglodytidae				
Troglodytes aedon	2.0	53.2	3.6	
Thryothorus ludovicianus	0.7	32.3	3.6	
Family Mimidae				
Dumetella carolinensis	2.7	62.7	1.2	
Toxostoma rufum	0.7	1.0		
Family Turdidae				
Turdus migratorius		2.5		
Hylochichla mustelina		1.9		
Family Sylviidae				
Polioptila caerulea		6.5		
Family Vireonidae				
Vireo griseus		7.0		
Family Parulidae				
Dendroica dominica		0.5		
Dendroica pinus		5.5		
Dendroica discolor	4.0	24.4		
Seiurus aurocapillus		4.9		
Geothlypis trichas	18.1	38.8	2.4	
Family Icteridae				
Sturnella magna	8.7	1.5		
Agelaius phoeniceus	57.1	69.2	90.5	12.8
Cassidix mexicanus	20.1	22.9		6.4
Quiscalus quiscula				2.1

TABLE 30 CONTINUED

Species	Principal Vegetation Types			
	Grassland-Dunes	Woodland-Thicket	Nontidal Marsh	Tidal Marsh
Family Fringillidae				
Richmondena cardinalis	0.7	4.5	2.4	
Pipilo erythrophthalmus	1.3	2.9	2.4	
Ammospiza caudacuta		0.5		
Ammospiza maritima	32.2	3.9	9.5	9.6
Melospiza georgiana			1.2	
Melospiza melodia	36.2	29.4	15.5	1.1

Seven of the species observed on both the mainland and the islands were found only in the woodland-thicket type in both places. These species include forest-dwelling species such as the yellow-billed cuckoo, downy woodpecker, great crested flycatcher and warbling vireo. The mourning dove switched from a primarily grassland species on the mainland to a woodland species on the islands. The common grackle switched from grasslands to tidal marsh, but it was never abundant on the islands. The yellow-shafted flicker actually contracted from grassland-dunes and woodland-thicket on the mainland to woodland only on the islands. Given the number of observations for this species, this contraction appears to be real rather than a simple sampling artifact.

Tables 27 through 30 suggest seven general conclusions about avian species-habitat associations:

1. Most of the mainland species appear to be restricted to a single principal vegetation type. Although there are few observations overall for most of these species, the fact that this same pattern was observed for so many species certainly supports this conclusion. Most of the island species, on the other hand, occur in a variety of vegetation types, frequently including types from which they are conspicuously absent on the mainland.

2. Of those 22 species which occurred on both the mainland and the islands, most exhibited some degree of habitat expansion on the islands. Many of the reported expansions are based on many observations from each vegetation type. None of the expansions appear to have been accompanied by a conspicuous shift in the species preferred vegetation type.

3. There was a strong, direct relationship between the relative abundance of a species in multiple vegetation types and the distribution of that species among islands. Species which were comparatively abundant in several vegetation types also occurred on several islands. Conversely, species which were comparatively scarce, even if found in several vegetation types, occurred on few islands.

4. The best evidence of strict species habitat preferences is for several species which occurred in only one vegetation type, but which were comparatively abundant in that type. For several species, this observation provides good evidence of habitat availability determining species distributions among the islands.

5. The woodland-thicket vegetation type supported approximately twice as many species as any other type. The addition of tall shrub thicket or forest to an island greatly increases the potential of the island to support greater avian species diversity. The actual effect of increased vegetation complexity is confounded with the related effects of island size and isolation.

6. Overall bird abundance or density seems not to be directly related to vegetation complexity. This may reflect fundamental behavioral and ecological differences between the species found in comparatively simple habitats and those found in comparatively complex habitats.

7. A factor related to vegetation complexity, but requiring separate mention, is the effect of vegetation transition zones on island species diversity. Vegetation complexity increases through the addition of woody vegetation and increased vegetation mass, but it also increases through zonation of vegetation types across an island. Part of the great increase in avian diversity on wooded islands undoubtedly reflects the influence of increased zonation of vegetation, with increased edge. It appears that the pattern of zonation on an island is an important determinant of species composition and diversity on that island.

III. HERPETOFAUNA

There were no sightings of island amphibians and few of reptiles, probably because the field work did not begin until hot summer weather had set in. Thanks to Dr. Roger Conant, however, there is considerable information available on species composition of the herpetofauna of the entire Virginia Barrier Island complex. Dr. Conant has collected reptiles and amphibians on these islands several times during the past 30 years. For this report he has prepared a summary of known species distributions, updated through his field work on Smith Island on June 11, 1975 (Table 31). Biosystematic nomenclature follows Conant (1975). Appendix L gives the scientific and common names for each species reported here.

The only sightings during this study period were three northern diamondback terrapins and five rough green snakes on Parramore, and numerous northern diamondback terrapins, one common snapping turtle, one eastern box turtle, one black rat snake, one northern water snake and three eastern kingsnakes on Smith. There are no population or comparative abundance data for these species, but there did seem to be a relatively high density of snakes around the abandoned Smith Island Coast Guard Station. Two kingsnakes, one kingsnake skin and one northern water snake were encountered in two days of activity in this small area. Inspection of Table 31 suggests that forested islands tend to have more species of reptiles and amphibians than do islands with less complex vegetation. Although we recorded no snakes or turtles on Hog Island, Brady (1924, reference from Table 31) reported several species of snakes and turtles to be abundant on Hog in June, 1924. At that time, Hog supported an extensive forest which has since disappeared (Gerard J. Hennessey, The Nature Conservancy, pers. comm.).

TABLE 31

REPTILES AND AMPHIBIANS OF THE VIRGINIA BARRIER ISLANDS,
INCLUDING SEVERAL ISLANDS NOT EXAMINED IN THE PRESENT STUDY
(X - species reported; * - voucher specimen available)
PREPARED BY DR. ROGER CONANT FROM PERSONAL COLLECTIONS AND LITERATURE REFERENCES
June 25, 1975

	Virginia Barrier Islands									
Species	Assateague	Chincoteague	Wallops	Parramore	Revel	Hog	Pig*	Cobb	Myrtle	Smith
	Turtles									
Chelydra s. serpentina	X	X		X*		X				X
Kinosternon s. subrubrum	X*	X	X	X*		X*				X*
Clemmys guttata	X	X				X*				X*
Terrapene c. carolina										X*
Malaclemys t. terrapin	X	X*		X*		X*		X	X	X
Chrysemys rubriventris	X									
Chrysemys p. picta	X	X								
Caretta c. caretta	X					X				
Chelonia m. mydas	X					X				
	Lizards									
Sceloporous u. hyancinthinus	X									X*
Leiolopisma laterale										X*

TABLE 31 CONTINUED

Species	Virginia Barrier Islands									
	Assateague	Chincoteague	Wallops	Parramore	Revel	Hog	Pig*	Cobb	Myrtle	Smith
Snakes										
Natrix s. sipedon	X*		X	X		X				X*
Storeria d. dekayi				X*		X*				
Virginia v. valeriae						X		X		
Didophis punctatus ssp		X*								
Heterodon platyrhinos	X*	X*	X			X				
Coluber c. constrictor	X*		X			X				X*
Opheodrys aestivus	X*		X	X*	X*	X	X			X*
Elaphe o. obsoleta	X*									X
Lampropeltis g. getulus										X
Salamanders										
Plethodon cinereus		X*								
Toads and Frogs										
Bufo woodhousei fowleri	X*	X*		X*						X*
Hyla cinerea	X*									
Rana utricularia	X*	X*								

Principal References: Conant (personal collections)
Brady (Copeia. 1924. No. 136: 110-111)
Fowler (Copeia. 1925. No. 146: 65-67)
Lee (Bull. Md. Herp. Soc., No. 8 (4): 90-95)

*[Ed. note. Pig Island no longer exists. It was formerly a large circular island, seaward of the northern end of the present day Cobb Island. It was a dune, grassland area].

DISCUSSION

The terrestrial vertebrate communities of the Virginia Barrier Islands appear to differ substantially from those on the adjacent Delmarva Peninusla. Species composition differs conspicuously between the mainland and islands for both mammals and land birds. Overlap was approximately 43% for trappable small mammals; only three of the seven mammal species trapped during the summer occurred in both places. Overlap was approximately 45% for land birds; only 28 of the 62 species observed occurred in both places. These estimates of overlap probably are conservative, particularly for the mammals, since the mainland sampling was restricted to a relatively small vicinity. Nevertheless, the observed faunal differences between the mainland and islands are sufficiently pronounced to indicate very real differences between the two places. Although these differences appear to be reflected also in species abundances, this point is much more difficult to establish conclusively.

There are conspicuous faunal differences also among the ten islands studied. Parramore, the highest and most complex island and one of the largest, supported a complement of at least nine mammal species, including four trappable small mammal species. The other islands, lower and less complex than Parramore, supported from one to eight species each, including from one to three small mammal species. Average overlap in mammal species composition between islands was approximately 35%. A similar overall pattern of island differences is discernible for the land birds. Parramore supported at least 36 species during the summer. The other islands supported from 6 to 21 species each. Average overlap between islands was very low because of great differences in species numbers, but most island avifaunas were simply a subset of the Parramore fauna. This pattern does not apply to the barrier island herpetofauna. Hog and Smith Islands have many more species of reptiles and amphibians than any of the other islands examined.

An obvious question--with no single obvious answer--arises from these conclusions: why are the island vertebrate faunas so dissimilar from those on the mainland? That is, what are the principal ecological determinants of zoogeographic patterns in this near-shore archipelago? And how do these factors interact to determine species distributions and abundances? As a general rule, island faunal composition is determined by the long-term interaction of species colonizations and introductions with species extinctions (MacArthur and Wilson, 1967). These processes, in turn, are influenced by the faunal composition of potential source areas (in this case, most probably the Delmarva Peninsula), and by the over-water dispersal ability, habitat requirements and interspecific competitive ability of the species concerned. Data from a few weeks of observational field work during a single field season cannot possibly untangle these interacting processes. In fact, no short-term study without experimentation could hope to do so. Nevertheless, the results presented here do suggest several lines of speculation to explain faunal differences between the mainland and islands and between islands.

Historically, there has been extensive human activity on and around these islands. There have been long-term year-round settlements, with their associated enterprise, on several of the islands studied, including at least Parramore, Hog and Smith. There has, therefore, been ample opportunity for introductions of mammals and probably even birds. (Ed. note: See Graham, 1975, discussion of Land use history in this Volume). Introductions--particularly the accidental importation of pest species such as the Norway rat and house mouse--have been an important avenue of species shuffling in this island complex. Only Parramore, with the Parramore Beach Coast Guard Station, is still occupied continuously; the other islands receive little traffic and are occupied sporadically, if at all, only during the fall and winter duck hunting season. With the virtual abandonment of the islands for the past 30 to 40 years, the opportunity for accidental introductions must be greatly reduced, if not effectively curtailed. Occasional accidental introductions might still occur with the hauling of livestock feed or waterfowl bait or with the grounding of vessels. There are only two known cases of what might be considered successful intentional introductions of wildlife species, the California jackrabbit on Cobb and the pheasant on Hog and Cobb. Intentional introductions appear not to have been particularly important in determining current species compositions. With the probable exception of chickens on Hog, there appear to be no feral populations of dogs, cats or other domestic species that might have been left behind when an island settlement was disbanded. Graham's (1975) discussion of the history of game stocking on these islands leads to the conclusion that many attempted introductions of game species have been unsuccessful.

At least some of the mammal species on the islands have strong over-water dispersal abilities, allowing their movement between islands. The most obvious such species are the deer and raccoon, the semi-aquatic rice rat and the aquatic muskrat. These species tend to be widely distributed through the island complex. Other species appear to have relatively limited dispersal abilities. The meadow vole and gray squirrel, for example, probably have very limited abilities to move between distantly-separated islands. Neither of these species is known for its long-distance swimming ability. Successful colonizations probably occur very infrequently for these species. Rafting may play an important role in the inter-island movements of some species, particularly during the winter and early spring when seasonally high tides transport enormous quantities of dead matted marsh grass through the backside bays.

The chance that a species will become established on any island that it reaches depends on its rate or frequency of colonization, its habitat preferences relative to habitat availability on the island and the prevailing species composition of the fuana. Deer, for example, are able to reach and utilize, at least temporarily, most or perhaps all of the islands in the complex. They are able to colonize readily and frequently; they can utilize a variety of habitats. This same general argument, perhaps without mention of competition, probably applies also to the rice rat and muskrat. Habitat preference may not be a particularly important issue, since most of the species observed on the islands seem to be able to exploit a variety of habitats. But the rate or frequency of colonization must be very low for most species, so that there are few opportunities to build a breeding population. Interspecific interactions with

the prevailing species also might be important in this respect. There have been cases reported for insular small mammals in which an established species prevented successful colonization by a new species; and, conversely, there have been cases reported in which a colonist species played an important role in the extinction of an established species (Lidicker, 1966).

Extinctions on these barrier islands are likely to result from one or more of four separate types of factors: hunting and trapping; the conventional mortality factors of starvation, predation and disease; the adverse effects of competition on the birth and death processes; and random or stochastic fluctuations of the environment. Reports from life-long residents of the peninsula indicate that there has been hunting for deer and intensive trapping for fur-bearers such as muskrats, mink and otter on at least some of the islands during the past. With several interior lakes and marshes, Parramore seems to have been the center of these activities (Albert Peppler, Quinby, Virginia, pers. comm.). Hunting and trapping are now reduced in intensity, though not abandoned altogether, for all species. With the obvious exception of the "predator control" employed to reduce populations of predators such as red fox and feral house cats, hunting probably was never important for most species (Graham, 1975). The second and third factors listed involve a complex of ecological relationships that can be untangled only through relatively long-term, in-depth studies and experimentation (Grant, 1972). Extinctions of established island populations in the face of competitively superior colonizing species have been reported elsewhere (Lidicker, 1966; Lidicker and Anderson, 1962).

Stochastic fluctuations of the environment may be a very important influence on species distributions, particularly when considered in conjunction with species colonization rates. The major source of such fluctuations in this island complex is the flooding and inundation associated with severe, prolonged coastal storms. Although such flooding occurs infrequently (probably less than once per decade), it may constitute a major influence on the vertebrate faunas of the low-lying islands.

Perhaps the strongest suggestion of storm-related extinction comes from Cobb Island. Why are there rice rats but no other small mammals on this large but low-lying island? A casual observor, aware of the occurrence of the meadow vole on some islands in the complex, would predict its occurrence on this particular island. On the basis of habitat type, this grassland island appears to offer favorable habitat for the meadow vole. It is possible that this species has occupied the island in the past but that the population has gone at least temporarily extinct. And storm-induced inundation seems to be a likely candidate for the agent of extinction. Cobb was severely flooded and probably even inundated, perhaps for 24+ hours, during the Ash Wednesday Storm of March 6-8, 1962 (U.S. Army Corps of Engineers, 1963). It is unlikely that any terrestrial mammal population survived this event;1/ a substantiated date before 1962 for the jackrabbit introduction would restrict the generality of this statement. Crowell (1973) has found that the meadow vole can disperse readily by swimming across water barriers up to about 1 km (.62 mi) in breadth, readily colonizing islands within this range. But the colonization rate decreases

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1/Ed. note. Weske (1976) has produced evidence substantiating an introduction date at least 15 years b.p. He also cites a substantial over-water dispersal ability for the jackrabbit and implies a resistance to temporary island inundation.

rapidly with increasing isolation. According to the present results, the nearest known meadow vole population is at least several kilometers (apparently on Parramore or Revel) from Cobb. Given limited over-water dispersal ability, on the one hand, and the isolation of Cobb, on the other, it is possible that the meadow vole has not successfully recolonized Cobb after being exterminated by this or some previous severe storm. The semi-aquatic rice rat, in contrast, has been able to colonize or recolonize this island and establish what appears to be a dense breeding population. This scenario is sheer speculation at this point, based on circumstantial inferential evidence, but it is consistent with the historical facts available for Cobb and the biological facts available for these species.

Avian species composition also is determined by interaction of species colonizations and introductions with extinctions. With the exception of the pheasant on Hog and Cobb, and possibly the chicken on Hog, there is no direct evidence of species introductions in the island avifaunas. "Domestic" species such as the starling and house sparrow are abundant on the mainland but absent on the islands. For the migratory species, at least, "colonizations" and "extinctions" occur regularly on an annual basis. Colonizations must be easier for birds than for most mammals; none of the islands studied are sufficiently remote to seriously impede avian colonization and frequent inter-island movements. If colonizations are more easily accomplished, then local extinctions must occur less frequently for birds.

The initial hypothesis was that the mainland and island avifaunas would be substantially similar, with each species simply occupying its favored habitat in both places. Habitat selection should place each species into one or a few favored habitats wherever these habitats are found, on the mainland or on an island. Three aspects of the results presented here, however, cast doubt on this initial hypothesis. First, species overlap between mainland and islands, 45% of the total species observed, was not that great. Second, there is at least a suggestion that most species occurred in a single vegetation (habitat) type, while most island species occurred in multiple types. Also, many of the species observed in both places exhibited conspicuous habitat expansion on the islands. Although sparse observations for the mainland species preclude any more detailed comparison, it appears that the mainland and islands avifaunas are much more dissimilar than might be predicted on the basis of island proximity to the mainland.

Several zoogeographic patterns reported previously for isolated, undisturbed vertebrate faunas seem to pertain also to this barrier island complex. In particular, species diversity for both mammals and birds increases with increasing island elevation, vegetation complexity and, perhaps, size. Although these three intrinsic island characteristics are interrelated and difficult to separate in their individual effects on species diversity, this same general pattern is commonly observed for vertebrate faunas (MacArthur and Wilson, 1967). Also, each species as a rule occupies a broader range of habitat (vegetation) types on the islands than on the mainland, and several species occupy island habitats very different from their usual mainland habitats. This pattern of habitat expansion in insular faunas has been reported previously for both mammals (e.g., Grant, 1971) and birds (e.g., Crowell, 1962). Third, species with greater over-water dispersal abilities are found on more islands than are species with poor dispersal capabilities. This pattern has been well-documented previously for small mammals on the undisturbed islands along the coast of Maine (e.g., Crowell, 1973). The central point here is that these rather predictable, and previously observed, patterns seem to persist in this island complex, in spite of a long history of human occupation and

in spite of the relatively close proximity of the islands to the mainland. This conclusion is based on rather limited sampling for each island, and these zoogeographic patterns are described here without benefit of statistical treatment. Nevertheless, the patterns are clear enough to justify the perpetuation and use of this island complex as a natural laboratory for ecological research.

There also are several curious, and perhaps unique, aspects to the results reported from several habitats on Assateague Island to the north (Paradise and Handley, 1965) and from grassland-dunes on Cape Hatteras to the south (H. D. Quarles and R. D. Dueser, unpublished data). Second, there appear to be no small insectivores on the naturally-formed islands. Again, the least shrew, but not the short-tailed shrew, has been reported from Assateague (Paradise and Handley, 1965). Since insectivores as a group are difficult to census, it is possible that they occur on one or more islands but simply were not detected in this limited initial sampling. Third, as mentioned above, the absence of the meadow vole from Cobb is rather conspicuous, as is the very low population density of the rice rat on Smith. Overall, these island faunas appear to be depauperate relative to Assateague. This may reflect their greater isolation and, perhaps, the greater intensity and duration of observations reported for Assateague.

It is hoped that the results, interpretations and conclusions reported here will stimulate or at least ease additional research on the vertebrate zoogeography of the Virginia barrier island complex. This study suggests several future research topics having implications for island management and/or preservation. What impact do large herbivores have on the composition and/or productivity of the island vegetation? Examination of the foraging relationships among the cattle, sheep and deer on Hog Island would be the logical place to begin study on this question. What is the population status of the California jackrabbit on Cobb Island? This appears to be the only successful intentional wild mammal introduction in the island complex. Intensive population analysis should make possible short-term predictions about the future abundance of this population. How isolated are the island small mammal communities through time? Examination of genetic and/or morphological variation among island populations of selected small mammal species would indicate generally the extent to which these populations have been isolated in the recent past. In conjunction with other natural history information, significant dissimilarity between island populations of a particular species might be interpreted as evidence of effective isolation through time for those populations. Are the herpetofaunas of Hog and Smith Islands really much more diverse than those of the other islands? Intensive spring sampling of reptile and amphibian populations on several islands would help clarify one of the most intriguing zoogeographic patterns suggested by the available data, the conspicuously high herpetofauna diversity on certain islands. The timing of the field work during the spring and early summer would be critical to the value of any study of reptiles and amphibians. Finally, what effects does the sharp zonation of island vegetation have on avian species diversity? Preliminary analyses indicate that the edges between adjacent sharply bounded vegetation zones are very important in promoting increased bird diversity and abundance on the islands (McCuskey and Dueser, 1976).

There are several specific management policies that TNC could institute to facilitate this continued research. First, limited collecting of vertebrates should be allowed by properly-permitted researchers. This collecting should be controlled

by species and by island. Permanent records of each individual removed should include species, sex, date, capture location, and permanent location and number of preserved specimens. Requests for collecting permits should include a written statement of purpose and objectives. Second, limited experimental manipulations of resident populations should be allowed, probably not including the introduction of new species. Enclosure and exclosure experiments provide the only efficient way to answer many questions about biotic relationships between plants and animals and about interspecific interactions among species. For example, such experiments will be required in any study of the impact of introduced herbivores such as the California jackrabbit on island vegetation or in any study of the biological mechanisms involved in the coexistence of ecologically similar species on any given island. Third, TNC should endeavor to establish a small fund specifically to support research on short-term, transient events, events for which funding simply is not available through normal channels on a short time-scale. This is the only way that the effects of events such as island flooding will ever be documented. This funding probably would never exceed $2,500.00 per year, and it would be zero in many years. Fourth, copies of the McCaffrey vegetation maps should be made routinely available to island researchers. The quality of these maps assures that they will provide critical support information for all future ecological research on the islands.

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ANALYSIS OF THE PAST AND PRESENT STATUS OF THE BEACH NESTING AND COLONIAL BIRDS OF THE VIRGINIA COAST RESERVE

BY

BILL WILLIAMS

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ANALYSIS OF THE PAST AND PRESENT STATUS OF THE BEACH NESTING AND COLONIAL BIRDS OF THE VIRGINIA COAST RESERVE

INTRODUCTION

The barrier islands of the eastern shore of Virginia have long been recognized as areas of major ornithological importance. A survey of eastern barrier island egg collections in the U.S. National Museum conducted by Roger B. Clapp in August, 1975, reveals that during the 1860's, ornithologists were attracted to the area for collection of specimens. Such names as Robert Ridgway, Elliot B. Coues, and Arthur Cleveland Bent appear on the collector labels to further indicate the recognized importance of this ornithologically productive area.

Along the beaches were to be found readily available eggs and specimens of black skimmers, oystercatchers, willets, gull-billed, roseate, royal, common, least, Forster's, and Caspian terns, laughing gulls, as well as piping and Wilson's plovers. In addition, (from the islands' interiors), eggs were collected from ospreys, fish crows, clapper and Virginia rails, red-winged blackbirds, cliff and barn swallows, prairie warblers, common and boat-tailed grackles, meadowlarks, song and seaside sparrows, cardinals, yellowthroats, eastern kingbirds, crested flycatchers, great blue and green herons, and common nighthawks.

"Egging" as a food source by watermen and residents of the islands combined with a millinery trade demanding the plumes and skins of the egrets and terns for fashion brought on an even greater interest in the bird-rich eastern shore islands. Bailey (1876) relates that the eggers were so persistent in robbing the nests of the local nesting birds that many species were forced to leave for other breeding localities. "For apparently every colony of laughing gulls, skimmers, terns and clapper rails in that region must reckon with repeated visits of egging parties, which for years have been in the bane of the breeding birds of the Virginia coast" (Harper, 1912). "Egging had been indulged in for generations - fathers, grandfathers and great-grandfathers had probably egged on these sandy stretches" (Cleaves, 1911). Cleaves estimated that on July 30, 1911, three men collected 550 tern and skimmer eggs from the southern end of Cobb Island and the following day, 150 more eggs were removed by a group of six men. Egging was legalized during the early weeks of the breeding season (Dutcher, 1903) with July 4 considered to be the cut-off date for such activities (Bent, 1907). However, it is apparent by the report of Cleaves that the law was not adhered to. Enforcement of such a law was virtually impossible, being contrary to a practice steeped in tradition. Egging is still practiced locally by the watermen of the area, though on a very limited scale.

While the effects of egging may be compensated for by renesting, in most cases (Bent, 1907), the slaughter resulting from the demands of the millinery trade had marked effects on these populations which are probably persistent to this day. Chapman (1899) relates having spoken to a bayman about the bird destruction and being told of single-day harvests of 1,400 terns from Cobb Island alone and

upwards of 40,000 are said to have been shot there during a single summer with destruction at other favorable places proportionately great. The least tern probably suffered the most destruction from the killing. "For ten cents apiece, men shot these birds until their shoulders had become too raw to fire a gun" (Howell, 1911). By the early 1900's, the least tern and royal terns were unknown as breeders on Cobb Island having been present there in large numbers in the 1880's (Chapman, 1903). Other species suffering drastically were the oystercatcher, willet, and Caspian tern (Austin, 1932). The latter species has regained its breeding status only very recently, one pair having been found nesting successfully on Metomkin Island in 1974 (Weske) and again this season. Likewise, the roseate tern was completely eliminated as a breeder on the barrier islands, though its status was always considered marginal.

By the late 1800's, a movement was underway to secure protection for these birds by law. Abbot H. Thayer worked diligently to obtain local laws for bird protection and to establish a $1,400 fund from which wardens could be paid to enforce these laws (Dutcher, 1901). At intervals of several miles along the coastal beaches lifesaving stations had been established by the government. The captains of these stations were paid from the Thayer Fund to enforce the laws during the summer months. "It shall be unlawful for any person to shoot, or in any manner kill or destroy the bird known as the gull or striker before the first day of September, or to take its eggs later in the season than the twentieth of July" (Dutcher, 1901). However, the laws were only vague county ordinances differing from one county to another. Nevertheless, through the wardens' efforts and continued education of the public (Dutcher, 1903), especially in Maryland, many of the breeding species were saved even though being dangerously close to local extinction (Bent, 1907).

In addition to relentless plundering by eggers and plume hunters, the beach nesting species had to and still have to withstand the ravages of storms. The barrier islands are in a constant state of flux, changing markedly from season to season. Experience has shown the instability of the beaches as witnessed by the total disappearance of Dawson Shoals in Wachapreague Inlet after the passage of Hurricane Agnes in June, 1972. It subsequently was rebuilt by tidal action and during 1975 supported a sizeable colony of black skimmers and terns. Furthermore, channels which are clearly marked on the topographic maps of Smith Island have it divided into three separate parts as of 1968. No such island division was evident during the nesting season of 1975 as the entire length of Smith Island was walked twice. The areas where channels had been are now open sandy stretches supporting substantial nesting bird colonies. Ship Shoal Island, on the other hand, has had a portion of its northern end separated from the main island by a small channel from the ocean to the marsh, and a similar channel was cut at the southern end of the northern one-third of Metomkin Island with the passage of tropical depression Amy during June 30-July 1.

METHODS

A field survey of the beaches and marshes of the Virginia Barrier Islands was conducted from June 18, 1975 through July 16, 1975 to ascertain the species, numbers of adult pairs, and productivity of the colonial beach nesting birds. Every barrier island from Assawoman Island on the north to Fisherman's Island on the south was surveyed during the course of the study. Except for Fisherman's Island, each island was traversed by foot, and where convenient and necessary, by boat. In addition, the entire area was surveyed from the air by Dr. M.A. Byrd. Additional information for the study was gathered for Wallops and Assateague Island through correspondence.

Except for Cobb, Rogue, Sandy and a portion of Hog, each island was visited twice. The initial visit was made to locate the breeding bird colonies, identify the breeding species present, and estimate the number of adult pairs present. Birds were considered as breeding when any of the following criteria were met: presence of nest scrapes, presence of nests with eggs and/or young, aggresive displays of the adults over suitable nesting sites. The latter was never used solely to establish nesting. Wherever aggressive displays were encountered young or nests were usually located nearby. The second visit was to ascertain the productivity of breeding success of each species at the various breeding locations.

Since the surveys were conducted on foot, it was possible to walk through the colonies as each was located. At each colonial location the area was observed through binoculars at a distance to get a count of the adults sitting on nests, or to count the numbers of young scattered about the nesting area. It was often necessary to avoid actually walking through the colonies due to the presence of the nidifugous young. Upon approach they could be seen running for protective cover, or into the ocean surf. To minimize disruption at nesting sites where young were obvious, the surveyor made his observations from the surf side of the colony. This kept the young up on the beach away from the water and caused them to retreat to the grassy dunes where adults would follow them either in flight or by landing nearby. In addition, every effort was made to spend a minimal amount of time in each colony. Often the ground temperature in the area was very high which posed a threat to the viability of eggs and the survival of young.

In view of the precautions stated above it is clear that the numbers recorded for the breeding locations are estimates based on the best visual counts the observers could make without disrupting the birds to a large degree. The primary concern on every visit to the nesting colonies was to prevent loss of young and/or eggs. Where the numbers seemed great an attempt was made to have at least two observers survey the area simultaneously and then compare their results. In addition, these numbers were compared to the data gathered from aerial surveys of the colonies.

One further consideration must be made concerning the production of young. Being virtually nidifugous at hatching the young of these species are capable of leaving their nests within a day of their emergence. The task of locating all of the young amidst the drift on the beaches or the grasses of the dunes is realistically impossible without spending a great deal of time in the area with more than one person searching. As previously mentioned this is not only quite disruptive, but hazardous to eggs and young.

A brief account of historical ornithological data is given for each island to give some perspective to the 1975 results. These numbers should be treated solely as indicators. In view of the problems of estimating large numbers of colonial birds, the numbers presented in these reports are somewhat suspect. Furthermore, the data almost always fail to indicate exactly where on the islands they were collected and, with the possible exception of Cobb Island, none of the islands has been regularly or accurately monitored over any period of time. One is presented with a mosaic of information that must be dealt with in terms of both past and present data with the former being much less reliable qualitatively.

ISLAND SURVEY

I. ASSATEAGUE ISLAND

According to National Wildlife Refuge personnel, no colonial nesting species were to be found breeding on this island during 1975. Records dating back to the early 1900's (Dutcher, 1902 and 1903) as well as U.S. Fish and Wildlife Service records from the 1940's show that black skimmers, terns (no species identified), laughing gulls, oystercatchers, willets, clapper rails and both Wilson's and piping plovers have bred on the southern "hook" on an irregular basis. Except for possibly the clapper rails no breeding activity has been found there in several years, especially since the National Park Service now allows vehicular access to the area. Breeding information summarizing numbers of breeding pairs, location of colonies, and the status of the bird species occuring on the Virginia Coast Reserve are given in Tables 1 thru 3 on Pages 547-558.

II. WALLOPS ISLAND

Willets, oystercatchers and piping and Wilson's plovers appear to be the only beach nesting species presently using this island for breeding. Mr. Charles Vaughn has communicated that black skimmers used the northern end of the island during 1971, and possibly least terns have also bred there.

Early breeding reports from Wallops Island support this view. During 1902, a report of 2,000 laughing gulls and 3,000 terns was filed by John Whealton of the the Wallops Beach lifesaving station (Dutcher, 1902). Poole (1922) indicated the presence of 40 pairs of least terns there and a smaller colony of common terns in June of 1921, but since then no additional data on these species is available for Wallops Island.

Hog Creek Marsh on the southern end of the island has supported a mixed heron colony in the past. Valentine (1957 and 1958) monitored the breeding activity of the snowy egret, Louisiana heron and green heron pairs which occupied the area during the late 1950's and early 1960's (Scott, 1962). Ospreys have also been breeding on this island for a number of years. Five pairs were found there in 1972 (Audubon Field Notes, 1972) and again this past season.

III. ASSAWOMAN ISLAND

No colonial nesting species were found on Assawoman Island during the July 5, 1975 survey. Piping and Wilson's plovers were recorded as were willets and oystercatchers though no actual evidence for breeding was found. John Weske found no breeding activity on the island in 1974.

However, according to Dr. Mitchell Byrd (personal communication), during the 1970 and 1971 nesting seasons an estimated 200 pair of black skimmers, 100 pair of common terns and 50 pair of gull-billed terns were located on Assawoman Island and during 1972 he reported a colony of 250 gull-billed terns there (Audubon Field Notes, 1972).

Part of the reason for lack of breeding activity may be due to an increase in vehicular traffic along the beach. Suitable areas, especially for least terns, are present yet there is no evidence of breeding attempts in recent years.

IV. METOMKIN ISLAND

Metomkin Island is actually divided into three separate parts. The northern section supports a mixed heron colony and three least tern colonies. The heron colony was composed of 2 pair of cattle egrets, 90 pair of snowy egrets, 2 pair of great egrets, 70 pair of Louisiana herons, 7 pair of black-crowned night herons and 23 pair of glossy ibis and was under constant surveillance during a summer-long heron study sponsored by the U.S. Fish and Wildlife Service. The colony, located in the middle of this section of the island about one quarter of a mile west of the beach, was in a thick growth of Iva frutescens about chest high surrounded by sand flats and Spartina alterniflora.

The least tern colonies were found at either end of this section of Metomkin and one in the center along the beach. Typically, the nesting areas were open shell-strewn sand with no vegetation. The northern-most colony was composed of 25 pair (on June 25) and was constantly subjected to visits by campers and fishermen as it was adjacent to Gargathy Inlet. The middle colony was located on June 19 initially and was found to have 30 pair. The southern colony had only 15 pair on June 25. Also on that date 15 adult clapper rails were seen with a total of 25 young and 5 pair of Wilson's plover and 6 pair of piping plover were recorded.

The second visit to this section of Metomkin Island on July 14 revealed only 5 pair of least terns on the busy northern end at Gargathy Inlet. Five fledged young were observed here, however. The middle colony still had 30 pair, and appeared to be attempting to renest following the beach overwash from tropical depression Amy. The southern colony was not found at all and in all probability had been washed away.

For the colonial nesting bird enthusiast, the middle section of Metomkin Island is a sight to behold. The section is about one mile long, yet on its beach and its interior an amazing spectacle of breeding activity takes place as the following figures will attest. On June 25, two nests of oystercatchers with two eggs each were found. In addition, there were 600 pair of common terns, 600 pair of black skimmers, 250-275 pair of gull-billed terns, 1,600 pair of royal terns, 7 pair of least terns, 3 pair of sandwich terns, 1 pair of Caspian tern and 1 pair of Wilson's plover. Estimates of these huge numbers were made from close observations from the beach side of the colonies. Many young of all species were seen and it was estimated that their numbers were roughly equal to thirty percent of the number of adult pairs. John Weske banded over 1,500 royal tern chicks only a few days subsequent to our visit.

The second survey of the middle section of Metomkin on July 14 revealed a lower number of adult pairs. Only 1,300 royal tern pairs were evident though numerous young about to fledge were observed. Similarly, gull-billed terns were estimated at 200 pair, common terns at 450 pair and a similar figure was set on black skimmer pairs. One Caspian tern chick, the second in as many years, was found and Weske estimated about six sandwich tern young were present. No young least terns were found and the species was not recorded on the second survey.

This area had been washed over during the tropical depression, but the advanced age of many of the chicks enabled them to reach high ground keeping losses low. Numerous chicks of all the species were still present on our second visit, in the same percentage as previously mentioned. This figure is probably conservative since it is literally impossible to count or even locate all the young in such a productive area.

The nesting area chosen by the species present was a sparsely vegetated sandy expanse with flotsam mounds present. The royal terns nested apart from the mixed tern-skimmer aggregation on a high, raised sand and sparse vegetation area towards the southern section of this portion of the island. The least terns were peripheral, choosing the open shell-strewn sandy spaces devoid of vegetation.

The southern section of Metomkin Island is also a prolific breeding location. Pockets of breeding activity were scattered continuously over its entire length (about one to one and a half miles). On June 22, three colonies of 25, 45, and 15 pair of gull-billed terns were recorded from the southern tip to the northern tip. A large colony of 350 pair of black skimmers on the southern tip was noted. From south to north four colonies of 25, 14, 4, and 35 pair of common terns were observed. Least terns were present in two groups. One at the northern end of the section was composed of 25 pair and 15 pair were noted in the middle of the section. Also present in the middle of the section nesting on and behind the dunes in the Spartina patens were 80 pair of laughing gulls, and 60 pair of herring gulls. On this visit, very few young were found in contrast to what was noted for the middle section of Metomkin Island.

On July 14 during our second census of the area, we discovered the isolated groups had blended into one continuous breeding bird colony. The reason was that many young black skimmers and gull-billed terns were evident especially at the southern tip of the section. An estimate of 75 young gull-billed terns and 200 young skimmers was noted. For these species the overwash that was apparent from the recent tropical storm had not been detrimental. However, only seven young herring gulls were seen though 69 pair of adults were present. Few adult common terns or their young were observed and no least tern activity at all was discerned nor was there any laughing gull activity found. A species that had not been in much evidence on the initial survey, oystercatchers, were present in large numbers and 10-15 young were counted.

The breeding sites of the birds on this section of the island were sand-flotsam mound areas which were plentiful over the entire length of the upper beach. Sparse vegetation was available except at the northern tip where the shell-strewn sandy spaces were preferred by the least terns.

In addition to the beach nesting species there was a mixed heron colony located in a waist-high stand of Iva frutescens on the southwest corner of this portion of the island. It was composed of 20 pair of little blue herons, 30 pair of cattle egrets, 250 pair of snowy egrets, 30 pair of great egrets, 200 pair of Louisiana herons, 1 pair of black crowned night herons, 75 pair of glossy ibis and was continuously surveyed as was the colony on the northern portion of Metomkin Island.

In the past the breeding birds of Metomkin Island mentioned in the literature were laughing gulls and terns (Dutcher 1901, 1902, 1903). During 1969 and 1971, herons were mentioned as breeding on the island (Audubon Field Notes) on the same sites they occupied this past season. In a detailed summary of the nesting activity on the Virginia Barrier Islands for 1974 by John Weske, it was noted that Metomkin Island was the most important breeding location for terns and black skimmers in the region. Fifteen hundred royal tern pairs were located on the southern section of the island in 1974 instead of the middle section where they nested in 1975. The southern portion also had 350 pair of black skimmers, identical to this year's figures, 300 pair of common terns, 25 pair of gull-billed terns, 50 pair of least terns (very similar to 1975), 300 pair of laughing gulls and 20 pair of herring gulls.

The middle portion had 350 pair of black skimmers, 150 pair of common terns, 40 pair of gull-billed terns, 1 pair of Caspian terns, and 30-40 pair of least terns. These figures are quite different from this past season's totals for the same section and indicate the transient character of the activities of these nesting colonies.

The northern portion had only 30 pair of common terns on it during 1974.

V. CEDAR ISLAND

Across Metomkin Inlet to the south lies Cedar Island. The northern third of this island is heavily covered by trees. The remaining two-thirds of the island is typical beach-dune-marsh habitat. During 1975, very little colonial nesting activity was found on this island. On the northern end adjacent to Metomkin Inlet a colony of least terns was located. They nested on a raised area of mixed sand and shell fragments typical of their preference on all the islands. Scattered clumps of grasses were located throughout the area.

On June 22, this colony had only 16 pair, though by July 14, 67 were estimated there and four fledged young were observed. Also found in this area was one pair each of piping and Wilson's plovers. The latter pair had three chicks on June 22.

This section of Cedar Island is heavily traversed by vehicular and pedestrian traffic. It is a popular fishing, picnicking and camping area and many people were present there during each of our visits, possibly explaining the paucity of fledged least terns.

The remaining nesting activity on the island was largely that of least terns. Fifty-one pair were present on the first mile of the southern end of the island on June 22, as well as ten pair of common terns and two pair of gull-billed terns. On July 19, along this same stretch of beach, only one pair of gull-billed terns was seen with one fledged young present. One fledged young of the common tern was observed and sixteen to twenty fledged least tern young were counted on July 10.

The passage of tropical depression Amy had washed over the beach here and no signs of renesting by any of the species was found on July 10. The previous nesting sites were dune overwash areas where sand and flotsam had accumulated providing mounds where nests could be built. The least

terns preferred the shell-strewn sandy areas of overwash adjacent to these sand-flotsam habitats where the common and gull-billed terns nested. An increase from 16 to 40 pairs of least terns in the northern colony on Cedar Island could possibly be attributed to some of the southern end pairs re-nesting there after the beach wash out from the tropical depression. However, no proof of this exists.

Also present along the beach in the dune areas of the central portion of the island where the beach itself is narrow and no flotsam areas occur, were pairs of piping and Wilson's plover as well as many oystercatchers. Willets were estimated at 300-400 pair on June 22 and were most concentrated in the inter-dune and marsh habitats. Barn swallows were numerous around the buildings on the island.

Historical information concerning Cedar Island dates back to 1901 (Dutcher). In that year, Captain Savage of the Wachapreague lifesaving station noted the following breeding species: laughing gulls, clapper rails, black skimmers, terns (no species given) and willets. He reported that all species seemed to be more numerous than in previous years, and concluded that the efforts "being made for their protection have resulted in much good".

In 1902 (Dutcher), Mr. Savage reported 3,000 marsh hens (clapper rails), 500 laughing gulls, 600 black skimmers and 200 terns were raised in a three by two mile area of marsh and beach. He emphasized that without local protection, many of the species would probably be extinct.

In his report of 1903 (Dutcher) Captain Savage mentioned that the clapper rails had increased, but that the other species previously mentioned had shown no increases. He accounts for this by explaining that the beach was washing away, leaving no high areas for nesting and forcing the birds to choose other localities. He noted that killing and egging in his areas were virtually nonexistent.

Not until the 1950's do reports from Cedar Island appear in the literature again. A report from 1955 (Terborgh) lists an estimated 150 pair of willets nesting on the island with 35 nests located, half of them having young. Fred Scott (1956) noted black skimmer young and 1 common tern nest on the southern end of Cedar Island in early August of 1956. Paxton (1957) recorded 4 oystercatcher nests and 4 clapper rail nests on Cedar in May of 1957, as well as 10 green heron nests and Stierly et al. (1959) found an oystercatcher nest at the southern end of the island with young in May of 1959. A 1960 Virginia Society of Ornithology field trip in late August found black skimmers on the island with eggs close to hatching (Audubon Field Notes, 1960). Also earlier in that some month, Paul Sykes (Audubon Field Notes, 1960) had reported oystercatcher family groups on the island in addition to one young piping plover.

In 1962 (Scott), 55 pair of gull-billed terns were located on Cedar Island, and black skimmers were also noted as nesting on the island (Wachenfeld, 1962). A roseate tern nest was found and photographed in June of 1963 by Calvert (Audubon Field Notes, 1963) and herring gulls were found nesting there in August of 1966 (Audubon Field Notes) as well as black skimmers and common terns (Prior, 1966).

By August of the following year, only a few black skimmers with young were present on Cedar Island (Audubon Field Notes, 1967) and in 1968, a piping plover nest with 4 eggs was found on June 22 by Byrd (Audubon Field Notes, 1968). Another late August report for 1969 by Scott noted that the black skimmers on the island still had a few young and eggs (Audubon Field Notes, 1969).

Observations on this island in 1974 revealed three small least tern colonies totaling about 30 adults. These were located on the fringes of widely scattered aggregations of nesting common and gull-billed terns and black skimmers, Wilson's and piping plover nests were found and willet breeding activity beyond the dunes was substantial leading to the conclusion that they are one of the most prevalent nesters on this particular island. This impression is echoed in this past season's results also.

VI. DAWSON SHOALS

This narrow strip of sand at the mouth of Wachapreague Inlet between the south end of Cedar Island and the north end of Parramore Island attracted 80 pair of black skimmers, 15 pair of common terns, and 14 pair of gull-billed terns during July 1975.

In the late 1960's, this area of only a few hundred yards of sand supported a sizeable royal tern colony in addition to black skimmers and common terns (Prior, 1966). On July of 1967, the colony contained over 450 royal tern nests and by August 200 non-flying young were still present there (Audubon Field Notes, 1967 and Eike, 1967). The subsequent season, Byrd estimated 600 nests present in May. These were washed out in early June and on June 16, only 200 nests could be located. In 1969, the royal terns did not nest on Dawson Shoals (Byrd, 1970) and it seems they have not returned there to breed.

A report from August of 1970 (Hacker) lists black skimmers breeding there as well as unspecified terns all in a wide variety of nesting stages. In 1972, Hurricane Agnes inundated Dawson Shoals which has since reformed and during 1974 had about a dozen pair of each of common terns and black skimmers according to John Weske.

VII. PARRAMORE ISLAND

During the 1975 breeding season colonial nesting was confined to the southern end of the island where the trees give way to open shell strewn beach and low, sparse vegetation.

Two separate colonial areas exist here removed from each other by a deep tidal gut that sets a beach colony area apart from a long narrow sand spit to the west. On June 18, the beach area was occupied by 45 pair of black skimmers, 25 pair of common terns, 50 pair of least terns, and 8 to 10 pair of gull-billed terns. The area had no vegetation on it and the nests of the birds were located on sand-flotsam mounds, except for the least terns which chose adjacent sand and shell-strewn overwash areas.

The sand spit area to the west (Stingaree Point) across a narrow channel, was covered by sparse vegetation and was occupied by 25 pair of black skimmers and 15 pair of common terns.

A return survey of the area on July 6 revealed that the beach area had been washed over by tropical depression Amy. About 75 pair of black skimmers were present and the presence of many nest scrapes and incomplete clutch nests indicated they were renesting. The least terns present numbered 6-8 pairs with 6 young evident. Only 4 pair of common terns were seen and 2 pair of gull-billed terns were observed, neither species with young. Apparently, the storm had destroyed their breeding efforts.

On the sand-spit, only 1 skimmer nest could be found with no adults in the area. Possibly the additional recruitment of pairs across the channel on the beach had come from here. Ten pair of common terns were also observed. No young of either species were found and it was noted that the area had not been flooded by the recent storm. What happened to the nesting activity of approximately three weeks previous is a mystery. The area had been used as an intensive study area by another research group, and they may very well have caused the apparent complete failure of this colony.

Since Parramore Island is heavily wooded over two-thirds of its length and the beaches are narrow, bird occupation is primarily passerine in nature. Prairie warblers, yellow warblers, yellowthroats, song sparrows, kingbirds and house wrens are quite evident in song over the entire island, as are common and boat-tailed grackles, catbirds and great-crested flycatchers. Barn swallows are numerous about an old house in the middle of the island and willets and oystercatchers are prevalent on the dune-beach margin. Three pair of ospreys nested on the island this year, with two of them successfully rearing young. Scott (1957) reported 3 nests of ospreys there in 1957 and Wachenfeld (1962) noted 6 nests of this species there in July 1962. These constitute the only literature notations of nesting for the island.

Experience on Parramore in July of 1974 revealed nesting concentrations of black skimmers and common, gull-billed, and least terns in numbers similar to those observed on our initial visit of this nesting season. However, during 1974, numerous young of the first four species were seen and banded in the area, very much in contrast to the total absence of young during 1975.

VIII. REVEL ISLAND

No colonial nesting species could be found in the two visits to the island. Likewise, no mention of any such species is revealed through the literature. Revel supports small populations of clapper rails, eastern kingbirds, Carolina and house wrens, seaside sparrows, yellowthroats, prairie warblers, and barn swallows. In addition, one barn owl was found there as well as 5 pair of ospreys. A similar number of pair of ospreys has been noted there since 1971 by Dr. M.A. Byrd.

The importance of Revel Island to colonial nesting species is as a feeding area. The creeks and channels around it are frequented by many least terns.

and laughing gulls. The terns are probably from the colonies on nearby Parramore Island to the east of Revel. In addition, the shallow inland short grass marshes are feeding areas for herons, ibis and egrets, as well as Forster's terns.

IX. CHIMNEY POLE MARSH

Immediately west of the northern end of Hog Island is Chimney Pole Marsh. An aerial survey of the area by Byrd revealed 25 pair of black skimmers and 10 pair of common terns nesting on the northeast corner of this marsh where a sandy spit had been created. Also, 50 pair of laughing gulls were found on the southeast corner. A ground survey of July 6 confirmed these reports noting that breeding activity of the tern-skimmer colonies was complete with only a few adults seen and no young observed. The laughing gull colony was not surveyed.

X. SANDY ISLAND

Located west of the northern end of Hog Island and immediately west of Chimney Pole Marsh, this island of Spartina alterniflora had three colonies of laughing gulls. Preliminary observations had revealed little besides occasional clapper rails, seaside sparrows and passing egrets from Hog Island. However, during a flood tide on July 15, 1975, we were able to penetrate to the interior of Sandy Island by boat and investigate aggregations of laughing gulls seen from a distance. The first colony had 75 pair with many young found about the nesting area approximately one week old. This colony was located in the northwest corner of Sandy Island.

South of this first colony was a second one of approximately 125 pair with about thirty percent of this number of fledged young flying about the area. A third colony to the east could not be reached at all, and a visual estimate based on adults in flight totaled 30-40 pair present there.

No mention of nesting birds for Sandy Island has been discovered in the literature or in conversations with banders familiar with the area. Whether or not these colonies are firsts this year for Sandy cannot be ascertained. In all probability, there have been colonies there in the past, but due to their inaccessibility they have been overlooked. They fit into the scheme of laughing gull colonies on those interior islands that are dominated by Spartina alterniflora which are common from Hog Island south.

XI. HOG ISLAND

Crossing Quinby Inlet from Parramore Island one reaches Hog Island, the northernmost island in Northampton County. The inlet serves to separate that county from Accomack County to the north.

Breeding activity here is largely that of the black skimmer, although an extensive mixed heron and glossy ibis colony is located on the northern third of the island. These birds were nesting in a dense thicket of wax myrtle (Myrica cerifera) which stands at well over 15 feet high in many places. Numerous willets and clapper rails were encountered in the marshes on the western side of the island, and one brood of black ducks was seen. The wooded areas near the heronry supported prairie and yellow warblers, house wrens, cardinals, catbirds, and white-eyed vireos, as well as common

and boat-tailed grackles. Seaside and song sparrows and kingbirds were also frequently encountered. Barn swallows were numerous around the old coast guard station.

On June 19, the heronry was censused. Three hundred adult glossy ibis were counted. The herons that were recorded were: 50 great egrets, 110 snowy egrets, 4 cattle egrets, 10 little blue herons, 68 adult Louisiana herons with many young, 141 black-crowned night herons and 20 yellow-crowned night herons, representing but a fraction of the adult pairs noted earlier.

Also on that date three pair of piping plovers including one young were found in the dunes on the northern end of the island. Many adult oyster-catchers were observed and two nests were found along with two young.

On the very northern end of the island two large black skimmer colonies were encountered. The largest was on the northwest corner of the island. It contained 150 pair of skimmers, 15 pair of common terns and 6 pair of gull-billed terns. East of this colony, nearer the ocean side of Hog Island, was a colony of 75 black skimmers and 20 pair of common terns. This latter colony was under observation by a research team and appeared to be disrupted, as broken eggs and disarranged nests were quite evident. To the south of this area six least terns were seen though only one nest scrape could be found.

The southern end of Hog Island was not surveyed until July 15. At this time nesting activity was found to occur over the entire length of the beach for the first one and a half to two miles of the island. As on the northern end of the island, the nesters were predominantly black skimmers. The nesting areas were typical of those found on the previous islands. Sand-flotsam accumulations had attracted the skimmers as well as many terns. The number of pairs of skimmers recorded was 175. Forty-five common terns in pairs and 35 pair of gull-billed terns were also seen. The species appeared to be attempting to renest since many eggs were seen. A few young of all these species were seen, but apparently the storm earlier in July had taken a heavy toll. In addition, 2 pair of Wilson's plovers were found and 8 pair of piping plovers were also observed as were 16 pair of least terns with 12 fledged young present near the old coast guard station.

To the north of this station about one quarter of a mile another 60 pair of black skimmers were nesting along with 20 pair each of gull-billed terns and one common tern pair.

Disturbance factors were evident on Hog Island during both visits. Not only was the northern end of the island laced with motor vehicle tire tracks, but the entire island is traversed by flocks of sheep and cattle. The vehicle tracks obviously were detrimental to the colonies since they were found to go directly through them. Whether or not the livestock do very much disturbance cannot be answered. There were some areas of the beach where some habitat destruction had occurred, but none of these places were near the breeding bird colonies. Nevertheless, it is evident that their potential for disruption is very real.

Available nesting activity records for Hog Island extend back to the early 1900's. Captain Johnson of the Hog Island Lifesaving Station reported in 1901 that there were many laughing gulls, terns (common and least), willets

and clapper rails breeding on the island (Dutcher, 1901). The following season, he recorded the following estimates of young produced there: common tern, 2,000; gull-billed tern, 200; laughing gull, 2,000; black skimmer, 1,000; willet, 100; Wilson's plover, 50; and, oystercatchers, 100 (Dutcher, 1903). The captain's report of 1903 stated only that many young laughing gulls, terns and willets were raised and that high tides were detrimental to the clapper rail nesting success (Dutcher, 1903).

Further records of breeding for Hog Island are not found until the 1950's. Miller (1953) spent some time on the southern end of the island in early June and reported that black skimmers and common terns were very numerous. Gull-billed terns and least terns were also present and nesting, as were oystercatchers (4 pair) and clapper rails. In addition, one osprey nest with two eggs were found. He reported also that a heronry was on the island, but provided no further information concerning it.

On June 23, 1956, Fred Scott (1956) made the following estimates of numbers of nests in the Hog Island heronry: 10 great egret, 500 snowy egret, 400 Louisiana heron, 60 little blue heron, and 50 black-crowned night heron. He suspected that one pair of glossy ibis may have been nesting, which would be a Virginia first. These suspicions were borne out by Terborgh (1956) who found two ibis nests each with young.

The subsequent two years provided additional data from the heronry. On the first of June, 1957, the following nest estimates were made by Scott (Audubon Field Notes, 1957): 5 great egret, 500 snowy egret, 400 Louisiana heron, 100 little blue heron, 60 black-crowned night heron, and 3 glossy ibis. During June, 1958, Scott estimated that 450 pairs of Louisiana herons and 350 pairs of snowy egrets were present there (Audubon Field Notes, 1958). By 1960, the number of glossy ibis in the heronry had grown to about 50 pair (Audubon Field Notes, 1961) and by 1969, their numbers were estimated to be 325 pairs. A total of 950 pairs of herons were recorded for the heronry that year (Audubon Field Notes, 1969).

The only mention of beach nesting activity during the past twenty years was a record of 15 pair of gull-billed terns on the southern end of the island (Scott, 1954). In all likelihood, the beach nesting species have been active on Hog Island, but their importance was greatly overshadowed by the attraction of the heron colony. Observations of the southern end of the island during the past five years, especially 1974, have shown that black skimmers, common, least, and gull-billed terns as well as ospreys are regular occupants and breeders during the summer months.

XII. ROGUE ISLAND

Located just west of the southern tip of Hog Island, Rogue Island has supported a mixed heron colony (Scott, 1954) and small colonies of terns and skimmers in the past. On June 10, 1953, Miller (1953) noted 6 pair of royal terns, 12 pair of gull-billed terns, 15 black skimmer nests, and 4 oystercatcher nests. Common tern nests were listed as "many". Also present as breeding birds were willets and 1 pair of ospreys.

From this point on there are no further records from Rogue Island. At the present, the island has no colonial nesting species except for a very small number of green herons. Eight of them were seen on July 11, 1975, at least

three of which were fledgling young. One nest was located. Also on that date, a nest with young of the fish crow was found, and young seaside sparrows and boat-tailed grackles were also observed.

As with many of the smaller inland islands, this area seems to serve the colonial nesting species (probably from Hog Island) as a feeding area. Black skimmers, royal, least, gull-billed and Forster's terns, as well as oyster-catchers and most of the herons were recorded there during our survey.

XIII. COBB ISLAND AND LITTLE COBB ISLAND

One of the most well known barrier islands of Virginia is Cobb Island located immediately south of Hog Island. The history and bird life of this area have been widely recognized since the mid-1800's. At the present time the island is almost desolate in terms of bird breeding activity which is entirely confined to its northern end.

The only survey of this island was conducted on July 11. On a section of sand and flotsam which extends out into the ocean on the northern tip of Cobb Island, 100 pair of black skimmers with 30-35 young were seen. Renesting of this species and the others present was obvious as was evidence of a recent wash-out from the tropical storm. Common tern pairs were estimated to be 80 and 30-40 young were found. Also present were 2 pair of gull-billed terns.

On the main northern end of Cobb Island 25 pair of skimmers and 20 pair of gull-billed terns were located. Also found here were 5 common tern pairs and 10 pair of least terns. Small numbers of young of each species were seen. One Wilson's plover pair with one young was observed as were 6 pair of piping plovers. Towards the center of the island away from the beach, 6 pairs of common nighthawks were flushed though no evidence of nesting could be discovered. There was also one pair of ospreys on the northern end nearer the marshes on the western side of the island.

The only nesting activity found on the southern end of the island was one clapper rail nest with seven eggs and another which was empty. Barn swallows were observed around the old coast guard building and two pair of ospreys were seen.

A small channel separates main Cobb Island from Little Cobb once known as Cordwell's Island. Here, 400 pair of black skimmers were estimated from aerial surveys and 150 pair of terns were estimated. The latter figure includes gull-billed terns and common terns though the proportion of each is uncertain.

Additionally, two broods of blue-winged teal were reported on one of the small standing pools in the center of the island, and two apparent pairs of marsh hawks showed great concern over our presence, though no signs of nesting activity could be uncovered after a thorough search of the area was made.

Published material concerning Cobb Island is extensive. Austin (1932) gives an excellent account of the breeding bird activity there prior to 1932, in addition to a local history of the island and its inhabitants. He cites

overhunting and the natural forces of erosion as major contributors to the steady decline of populations of gulls, terns and skimmers which had been prolific breeders on Cobb Island marshes and beaches in the past.

Additional information not covered by Austin's paper include discussions of the Caspian tern (Pearsall, 1881 and Coues, 1879) and Forster's tern (Brewster, 1882). Breeding information may also be found for black skimmers, gulls, and terns in reports on Cobb Island from Baily (1899), Bowdish (1909), Harper (1912), Poole (1922), Worth (1929), and Kuerzi (1929).

Subsequently, data for the island continued to be substantial for the next twenty years, with the impression that breeding activity there was waning. Walsh (1936) noted that the royal terns found on the island in 1936 (3 pair) was an increase over 1935 totals! The following season (1937) 85 nests of black skimmers from two colonies on the southern end of the island were noted, as well as 6 common tern nests and 2 gull-billed tern nests during June (Murray, 1937). Also present were willets, oystercatchers, Wilson's plovers, least terns and laughing gulls. McIlwaine (1939) and Reed (1939) each recorded that black skimmers, willets, Wilson's plovers and clapper rails were breeding on Cobb Island during 1939. Similarly, McIlwaine (1941) found the same species nesting there two years later, including least terns and gull-billed terns additionally.

During 1946, 180 black skimmers, 80 common terns and 30 gull-billed terns were found to colonize the island (Barnes, 1946) and in 1947, 300 black skimmers, 30 common terns, 25 gull-billed terns, 12 Forster's terns and 15 least terns were breeding there (Barnes, 1947). Similar observations were recorded for 1951 (Scott) and 1952 (Murray) noting that a colony of 500 adult black skimmers was present in the latter year (Audubon Field Notes, 1951). Green herons were found breeding there during 1952 (Murray) and 1953 (Scott). An estimated 50 gull-billed terns were present on Cobb on June 13, 1955 (Terborgh).

Further mention of breeding activity doesn't appear until John Weske's report of 1974. He found 170 adult black skimmers in two colonies and 50-100 common terns breeding on the northern tip of the island.

XIV. WRECK ISLAND

South of Little Cobb Island one encounters Wreck Island. Although this is not owned by The Nature Conservancy, it was surveyed during a period when the heronry on the island was censused.

On June 20, 1975, the following figures were obtained for the heron species and glossy ibis which were nesting on Wreck Island: 7 pair of cattle egrets, 6 pair of great egrets, 10 pair of little blue herons, 80 pair of Louisiana herons, 10 pair of green herons, 35 pair of black-crowned night herons, 25 pair of snowy egrets, and 13 pair of glossy ibis. The heronry was located in the middle of the island in a tall (10-15 feet) stand of *Myrica cerifera*.

Also on that date, a colony of 1,300 pair of laughing gulls was found near the southern end of the island. The birds nested in the *Spartina patens* expanses and low *Iva frutescens* clumps west of the dune area. On the southern tip of the island six pair of common terns, 6 pair of gull-billed terns, and 75 pair of black skimmers including 33 young were observed. A

nighthawk's nest containing 2 eggs was discovered on the ground in the center of the island. An estimated 100 pair of willets were seen and 60 pair of oystercatchers were noted with 1 young of each of these latter two species located. These species were distributed over the entire island.

The return survey of Wreck Island found thirty percent fledging success for the laughing gull colony based on the number of adult pairs previously observed (1,300). At the heronry the following estimates for fledging of young based on the number of adult pairs was recorded: great egret 15%, green heron 70%, glossy ibis 10%, black-crowned night heron 20%, Louisiana heron 90%, cattle egret 10%, snowy egret 60%. No young of the little blue heron were seen.

The tern-skimmer colony on the southern end of the island was gone and no renesting was apparent. This area had been washed over by high tides from the passage of tropical depression Amy.

The earliest mention of breeding activity for Wreck Island was noted in 1881 (Pearsall). In that year, a nest of the Caspian tern was found on the island by the author. Arthur Bent (1907) reported a large colony of laughing gulls in the short grass areas on the island at the turn of the century. Also, he noted 8-10 pairs of gull-billed terns there as well as a large colony of black skimmers. Cleaves (1911) recorded a colony of 300-400 black skimmers on the island with no common or gull-billed terns present. He did indicate that Forster's terns bred on Wreck Island. A report in 1948 (Audubon Field Notes) of heavy mortality (after a storm) in laughing gull young is interesting since the only other mention of the island which had been made was in reference to 50 pair of willets there in 1936 (Walsh). Also in 1948 an increase in the gull-billed tern population was noted and Buckalew (1948) indicated that the royal tern population on the island had increased from 50 pairs in 1947 to better than 250 pairs in 1948. Black skimmers in that year were estimated at 600 pairs, and "many" young common terns were seen though no young gull-billed terns could be located. One oystercatcher was banded.

During the summer of 1952 (Murray) 106 black skimmer nests were found on the island, as were 14 common tern nests, 13 least tern nests and 1 gull-billed tern nest. Two summers later, 59 nests and 23 young of the black skimmer were noted (Steirly, 1954) along with 8 common tern nests with 3 young and 5 nests of gull-billed terns with no young. One willet nest with 4 eggs in it was noted for the island in July of 1970 (Audubon Field Notes).

Weske's report of 1974 included three colonies of black skimmers totaling 150 pairs for the island. Also found there was a small colony of common terns, 8 pair of gull-billed terns, and 500 pair of laughing gulls.

As has been consistent with other islands, the nesting activity of the terns and skimmers was confined to sandy areas of the upper beach where scattered flotsam had accumulated. The terns chose to nest on the mounds themselves while the skimmers chose similar sites or just made their scrapes right in the sand. Although no definite references to the heronry on the island can be found, it is believed that it is a remnant of the heron population which once nested on Rogue Island to the north (Scott, 1954).

XV. SHIP SHOAL ISLAND

To the south of Wreck Island lies Ship Shoal Island. The northern end of this island is where the breeding activity of the colonial beach nesting species occurred. This area is characterized by open sandy stretches of beach and sparse vegetation where flotsam has accumulated. Also there is an extended overwash area that is entirely sand and shells. The latter habitat was occupied by 20 pair of least terns on June 26, 1975. The flotsam vegetation areas were occupied by 500 pair of black skimmers, 400 pairs of common terns, and 275 pair of gull-billed terns. Also present on the periphery were 1 pair of piping plovers, 4 pair of Wilson's plovers including 1 young, and 14 pair of oystercatchers with one young seen.

The remainder of the island is covered by scattered thickets of taller shrub vegetation which extends down to the narrow beach. One clapper rail nest containing 8 eggs was located in the marsh on the western side of the island, and a nighthawk's nest with 1 egg was found in the mid-portion of the island on a shell-sand space near the beach.

The southern end of the island had a small mixed heron colony on it. The colony was located in a narrow Iva frutescens outgrowth about forty yards long which was situated on the western edge of the island near the marsh. Twenty-three pair of snowy egrets were present, as well as 25 pair of Louisiana herons, 6 pair of great egrets, 2 pair of black-crowned night herons and 4 pair of green herons.

During the June 26 survey, many young of all the beach nesting species were observed, and on the follow-up survey of July 16, many young and fledged young were apparent over the entire nesting area. The nesting sites appeared to have weathered the passage of the tropical depression earlier in the month. It was estimated that 250-300 pair of black skimmers were present with approximately fifty percent of that number of young seen. Only 20 pair of gull-billed terns were seen and similarly only 20 pair of common terns were located. However, many young of these species were observed. Only 5 pair of least terns were seen with no young recorded.

The heronry on the southern end had 18 black-crowned night herons in it, 7 green herons, 22 adult Louisiana herons with 106 fledglings, 3 young great egrets, and 13 adult snowy egrets accompanied by 29 fledged young.

In previous years, Ship Shoal Island had been the breeding location of an extensive royal tern colony. A colony of 5,000 pair was noted there in 1970 (Audubon Field Notes). The following year it was estimated that 3,000 pair were present (Audubon Field Notes, 1971). Experience from banding terns in 1972 put estimates of 4,500 pair of royals on the island, and also approximately 20 pair of sandwich terns were observed (Audubon Field Notes, 1972). According to Weske, 3,500 pair of royal terns nested on the island in 1973 (Weske, 1974) and none were present on the island in 1974. Remnants of this colony are believed to have gone to Metomkin Island and Fisherman's Island. This is further evidence for the transcience of the colonial birds on the Virginia Barrier Islands.

XVI. GODWIN ISLAND

Godwin Island is located to the west of the southern end of Ship Shoal Island. It is predominantly Spartina alterniflora and is dissected by numerous small channels. No colonial nesting species were found breeding here though many of them were observed on the island feeding. There is no mention of past colonial bird activity for Godwin Island in the literature.

XVII. MINK ISLAND

Just to the west of the northern end of Myrtle Island lies Mink Island. Like Godwin Island, no colonial nesting of birds was found there. One green heron nest with four eggs in it was the only breeding activity discovered. The area was frequented by colonial nesting species that were feeding. No records for colonial bird activity has been noted in the literature for this island.

XVIII. MYRTLE ISLAND

This small three-mile long island south of Ship Shoal Island is not mentioned at all in the literature. Weske (1974) found three small colonies of black skimmers there in 1974 of approximately 100 pair total. Also there were 50 pair of common terns and "a few" gull-billed terns.

The surveys of this past breeding season, however, tell a different story. In the middle of the island on a flotsam-sand overwash area, one nest of an oystercatcher was found. It contained 2 eggs and 1 young. Also present were 15 pair of least terns, which nested where the shell fragment accumulations were greatest, 500 pair of common terns, 75 pair of gull-billed terns and 90 pair of black skimmers. Many young of all these species were seen.

Somewhat south of this area about one quarter of a mile, 25 pair of black skimmers was found, 28 pair of common terns with two fledged young were counted, and 13 pair of gull-billed terns were present. Here also many young were seen.

The southern end of the island was occupied by 100 pair of black skimmers, 75 pair of common terns, and 60 pair of gull-billed terns all with many young.

Over the entire length of the island, 4 pair of Wilson's plovers were seen and 2 pair of piping plovers were discovered.

The survey of July 16 revealed the number of colonies had been increased by one. On the northern end of the island, 100 pair of black skimmers, 110 pair of common terns and 20 pair of gull-billed terns had taken up residence. All of these species had many young.

The mid-island colony on July 16 consisted of 4 adult least terns with one fledged young. Forty pair of common terns were counted, as were 25 pair of black skimmers and 3 pair of gull-billed terns. To the south of this area 25-30 pair of black skimmers were located in addition to 4 pair and 3 pair of gull-billed and common tern respectively.

The southernmost colony consisted of 200 pair of black skimmers, 25 pair of common terns and 20 pair of gull-billed terns. All of these colonial areas were bustling with young of each species. There seemed to be a little destruction anywhere from the tropical storm, and estimates of nesting success were high (fifty percent of the adult pairs). The nesting habitat chosen by the birds present was the typical sand-flotsam mounds on the higher beach where sparse clumps of vegetation were growing.

XIX. SMITH ISLAND

Eight mile long Smith Island lies south of Myrtle Island across Little Inlet. Topographic maps of 1968 show this island divided into three parts. However, the island is presently entirely intact. On the northern third of the island, four colonies of beach nesting species were located on June 26.

The northernmost colony located about one mile south of the inlet consisted of 30 pair of black skimmers, 36 pair of common terns, and 5 pair of gull-billed terns. A few young of each species were seen, but hatching was only beginning. A quarter of a mile south of this colony 25 pair of black skimmers, 20 pair each of common terns, gull-billed terns, and least terns were discovered. Also present was a willet's nest containing 4 eggs. Further south about one quarter of a mile 50 pair of least terns, 6 pair of common terns and 3 pair of gull-billed terns were nesting. The final colony was located a mile beyond this one to the south and consisted of 200 pair of black skimmers, 100 pair of common terns, and 50 pair of gull-billed terns.

The only nesting encountered on the rest of the island was 3 pair of Wilson's plovers at intervals along the beach. On the southern third of Smith Island a colony of 60 pair of common terns was surveyed and a colony of 14 pair of least terns was found at the southern tip. In the wooded section surrounding the light tower 8 pair of yellow-crowned night herons were noted, and 5 pair of ospreys were located nearby.

As has been consistent throughout the survey area the nesting sites of the black skimmers and common and gull-billed terns were those areas of upper beach covered by sand-flotsam mounds with scattered vegetation. Overwash areas where vegetation was absent and shell accumulations were evident were chosen by least terns.

The return survey of Smith Island on July 16 found nesting success in the northernmost colony on the island of forty to fifty percent based on numbers of adult pairs for the black skimmers and common and gull-billed terns. Least terns were few in number, only 12-15 pair seen in the northern colony with 2 young, and 10 adults in the southern colony with only 2 young.

The colonies to the south of this had been virtually wiped out by the tropical depression two weeks prior to this survey. Only 40 pair of black skimmers were found with a few young present, and scattered groups of small numbers of common and gull-billed terns were seen each with no young recorded.

Breeding records for Smith Island date back to the turn of the century. Brown (1894) reported that least terns and gull-billed terns were present there and three years later (Palmer, 1897) an interesting report of tree swallows breeding on the island was published.

From the wardens of the Smith Island lifesaving station the following data was received during 1901 (Dutcher): north end of island -- common tern, 50-100 (the first in 10 years); laughing gulls, 100-150 (as opposed to none the previous year); 3 pair of oystercatchers, 12 pair of royal terns (no evidence of breeding) and a few pairs each of willets and Wilson's plovers. Clapper rails were numerous in the marshes. In 1902 (Dutcher) common terns numbered 1,000 as did the laughing gulls. Twenty oystercatchers were recorded in addition to 6 Wilson's plovers. Clapper rails were estimated at 5,000. One hundred royal terns were noted and twice that count of black skimmers were found. Also present were 75 willets. In 1946, 50 ospreys were found nesting on the island (Barnes, 1946). Further records from this island are not found until 1964 (Audubon Field Notes). During that year, a royal tern colony on the island was visited and young banded (no numbers given). In 1965, 946 young royal terns were banded there (VanVelzen, 1968) and in 1969 (Audubon Field Notes) a colony of over 200 gull-billed terns was found on the island.

John Weske's report for 1974 states only that a sizeable colony of black skimmers was located on the north end of Smith Island, and that another one was observed about halfway down the island. In view of this season's results, it is very likely that other species, especially terns, were present, and have been in the years past. However, with no firm data in this regard, this becomes mere speculation.

XX. FISHERMAN ISLAND

Aerial and ground surveys by Mitchell Byrd and John Weske provide the information for this island. On the northwest corner of Fisherman Island, along Fisherman's Inlet, 25 pair of black skimmers and 15 pair of common terns were observed. The southern beach bordering Chesapeake Bay was used for nesting by 800 pair of royal terns which had moved here during May from a small tump north of Skidmore Island according to Byrd. Four hundred black skimmer pairs and half that number of common tern pairs were also recorded there. The eastern portion of the island known as "The Issacs" had 75 pair of black skimmers and 70 pair of common terns nesting there as well as 600 pair of herring gulls. In addition, John Weske confirmed the nesting of at least one pair of great black-backed gulls. Adams Island on the northeast corner of Fisherman Island had a colony of 200 pair of laughing gulls.

The nesting habitats of the terns and black skimmers were consistent with those of the other barrier islands. The royal terns preferred higher ground with more scattered vegetation than did the common terns and black skimmers. The herring gulls nested on the dunes in the Spartina patens growths which cover them as they were found to do on Metomkin Island. The laughing gulls nested in the marsh.

Other nesting birds on this island were found on the western side. Six pair of ospreys were there only two of which were successful this year. This species nests on the tall towers around the old coast guard station. The wooded area in the middle of this side of the island contained a mixed heron colony consisting of 302 pair of black-crowned night herons, 5 pair of yellow-crowned night herons, 21 pair of Louisiana herons, 152 pair of snowy egrets, 57 pair of great egrets, 200 pair of cattle egrets, 44 pair of little blue herons and 25 pair of glossy ibis.

The earliest mention of breeding bird activity for Fisherman Island indicates that during 1901 "thousands" of common terns bred on Isaacs Island (Dutcher, 1901). Also during that season, two to three thousand black skimmers bred and a few laughing gulls were breeding. Cleaves (1911) noted that seven to eight hundred black skimmers nested in the same area during 1911, as well as two hundred common terns.

Not until 1964 is any further information for this island recorded. During that year royal terns were found nesting there (Audubon Field Notes, 1964). The following year the ospreys suffered their second straight year without raising young. Also 28 herring gull nests were found and a colony of 2,200 royal terns was surveyed. A black skimmer colony was washed out during an early June storm (Audubon Field Notes, 1965).

During 1966 (Audubon Field Notes) a gull-billed tern colony on Fisherman Island contained some 40 nests and 500 royal tern chicks were observed. Buckley and Buckley (Audubon Field Notes, 1967) estimated that the royal tern colony contained 300 nests during May, 1967, and that a herring gull colony on the island had 52 active nests. By July of that same year, the royal tern colony had 4,500 pairs present and one pair of sandwich terns. This latter species was making its first breeding appearance in 55 years according to the Buckleys who were conducting research on the royal tern colonies along the east coast.

In 1968 (Audubon Field Notes) herring gulls were present as breeders on the island, and the royal tern colony was washed out in June. Two years later, 4 young great black-backed gulls were produced on the island (Audubon Field Notes, 1970). This established the first nesting record for this species in Virginia.

Most of the attention given to the breeding birds of the island centered around royal terns. In all probability, other terns (common and gull-billed) were also nesting as were black skimmers and laughing gulls. In fact, Weske's report of 1974 confirms this in view of the data for this year. He found 850-900 pair of royal terns, 300-400 pair of common terns, "a few" pair of gull-billed terns, 10 pair of sandwich terns, 250-300 pair of black skimmers, 300 pair of herring gulls, 2 pair (nesting possible) of great black-backed gulls, and a small colony of Forster's terns. In addition, he noted the presence of the heronry on the western side of the island which he said had been there for some years. Ospreys have been present on the island for many years as well as a few pairs of barn owls which use the water towers for nesting sites.

ADDITIONAL IMPORTANCE OF THE VIRGINIA BARRIER ISLANDS

In addition to the important role the Virginia Barrier Islands play as breeding locations for the colonial nesting species of birds, they are also extremely important to the migratory shorebirds and waterfowl. The tidal flats of all the islands from Assateague to Fisherman attract thousands of shorebirds during their spring and fall flights and the numerous creeks and channels in between these islands serve as refuges for myriad ducks and geese.

Beginning in March and continuing into late May, such species as whimbrel, dunlin, short-billed dowitcher, redknot, semipalmated plover, western and semipalmated sandpiper are numerous on the western side of all the islands especially at low tide. Black-bellied plovers and sanderlings are prominent both here and on the beaches. During this time, large concentrations of horned grebes, buffleheads and common goldeneyes are evident in the waterways. These attract the peregrine falcon, an endangered species, which are frequently encountered during February and March hunting the tidal channels around Mockhorn and Smith Islands. On the islands themselves, one often finds short-eared owls and marsh hawks which have wintered there as data from annual Christmas bird counts can attest.

During the first of July, the shorebirds begin to reappear on their southward journey and by the middle of the month and continuing on into late October, concentrations of the species previously mentioned can be found throughout the area. Other less common species such as marbled godwits and white-rumped sandpipers are also present, as are an occasional rare species such as Baird's and curlew sandpipers. The fresh water ponds attract the greater and lesser yellowlegs in large numbers. Mid-July totals of 600 red knots, 500 dowitchers, and 150-200 whimbrel for Metomkin Island alone during one day is an indication of the importance these islands have to migrating shorebirds.

Fall landing data on the peregrine falcon from Assateague Island in the early 1970's (Ward & Berry, 1972) and a recent communication with Ward indicates that "the east coast of the U.S. is a major flyway, perhaps the major flyway, in North America for migrating tundra falcon". The peregrines seem to follow the east coast as a "leading line, therefore all barrier islands are important". The birds tend to concentrate at favorable locations such as Assateague Island until cold fronts stimulate them to continue south.

The Chesapeake Bay region is world famous for its waterfowl. Brant by the hundreds are encountered all along the Virginia Barrier Islands and Canada and snow geese concentrate on Assateague and Parramore Islands during the winter. In addition, both here and on virtually all the other islands one can easily find concentrations of pintails, mallards, black ducks, gadwall, American widgeon, shovelers, and green-winged teal, as well as coots, ruddy ducks and hooded mergansers. Whistling swans are prominent in the winter around the refuge areas. The ocean areas off the islands harbor scaup ducks and all three species of scoters and red-breasted mergansers in large numbers. Christmas bird count data over the last ten years from the Chincoteague and Cape Charles regions substantiate this quite well and are firm evidence of the vast bird life that exists along the eastern shore during the non-breeding seasons.

Although not listed among the "endangered" species, the threatened osprey finds the eastern shore of Virginia a prime breeding area. According to Dr. Mitchell Byrd, the osprey population from Maryland south along the eastern shore has gradually been increasing. However, the populations on the barrier islands themselves have declined. These birds are apparently relocating themselves along the interior islands and channel markers west of the barrier islands near the mainland. Productivity among the ospreys also seem to be showing a gradual increase, though further research over the ensuing years is necessary before any firm conclusions can be drawn.

PARALLEL RESEARCH

With continued interest in the prospects of offshore oil exploitation, and the ever-increasing demands of a public that wants to get away from it all to quiet beaches, much emphasis is being placed on faunal studies of the coastal islands. Throughout the northeast and central Atlantic states to Virginia, the National Audubon Society and the Cooperative Wildlife Research unit of the University of Massachusetts are conducting a sea bird survey. The information on breeding colonies from Maine to Virginia is being gathered by Dr. Michael Erwin and compared to data from previous nesting seasons. Arrangements are being made to continue to gather this data in future years. Similar research is being conducted in North Carolina by Dr. James Parnell of the University of North Carolina at Wilmington.

In addition, the United States Fish and Wildlife Service under the direction of Dr. Thomas Custer of Patuxent Wildlife Research Center in Laurel, Maryland, is conducting an intensive study of the heronries along the entire east coast and the Gulf of Mexico. An attempt is being made to ascertain the importance of the heron and ibis species as environmental indicators.

MANAGEMENT RECOMMENDATIONS

The single most drastic danger threatening any breeding colony of birds of the Virginia Barrier Islands is the weather. Its effects have been noted previously. Prevention of such natural calamities is impossible.

However, one unnatural hazard can be controlled. The unthinking, often wanton, destruction and disruption of breeding bird colonies by human beings often produce detrimental results. It is recommended that the major breeding sites be located early in the breeding season on all the Virginia Barrier Islands and that they be designated as off limits during the breeding season. Effective signs have been produced by the Florida and Massachusetts Audubon Societies which picture the various nesting species present and explain the restriction of the area to facilitate undisturbed nesting by the colonies. Such signs should be spaced at intervals around the entire breeding site and be removed when the colony completes its activities. The areas should be under these restrictions from May through mid-August in many cases.

Further, these signs combined with detailed factual information should be made public through newspaper exposure. They could also be given public awareness by locating them at boat ramps, marinas and sporting goods stores, as well as being publicized educationally at local schools. The ensuing generations of Eastern Shore inhabitants should begin to develop an appreciation of the uniqueness of their local avifauna in terms of aesthetics instead of exploitation.

Locating the colonies for marking them as protected areas will serve also to accumulate the additional data that will be needed to fully understand the dynamics of these greatly fluctuating populations. Much work is needed on the reasons for colony site selection from year to year, and the relative stability of these populations during the nesting seasons. Species requirements for the various nesting

sites should also be elucidated to explain why they are found only on one or two islands and not on others. These and other related studies must be done for all the islands and their respective colonies. No one colony can be truly representative since the dynamics of each are as individual as the islands on which they are located. Data must be accumulated regularly over a number of years before conclusions can be drawn and a firm understanding of the ecology of those colonial nesting species can be fully appreciated.

SUMMARY

A survey of fifty-four colonial and beach nesting bird species colonies was conducted on twenty-one Virginia Barrier Islands from June 18 - July 19, 1975. Sixteen of the islands were surveyed by foot, all of them were surveyed by air. Except for Assawoman Island, Sandy Island, a portion (southern) of Hog, Rogue and Cobb Islands, each island was visited twice. These latter islands were surveyed only once. Fisherman Island, Wallops Island and Assateague Island were not personally surveyed, though reliable information on them was obtained.

Seven of the islands, Assateague, Wallops, Assawoman, Revel, Rogue, Mink and Godwin had no colonial nesting species breeding on them, though all of them except Revel, Mink and Godwin had had colonial species breeding in the past. Sandy Island supported only laughing gull colonies.

The data from the remaining thirteen islands (Table 1) indicates that the black skimmer was the most numerous breeding species recorded during the survey followed by common terns, royal terns, and laughing gulls. Other species recorded are listed in order of their abundance: gull-billed terns, willet, herring gull, snowy egret, black-crowned night heron, Louisiana heron, glossy ibis, least tern, oystercatcher, cattle egret, great egret, little blue heron, piping plover, osprey, Wilson's plover, yellow-crowned night heron, green heron, sandwich tern and Caspian tern.

Fledging success was high for royal terns, laughing gulls, Caspian terns and sandwich terns based on numbers of adult pairs. The heron species, glossy ibis, black skimmer, common and gull-billed tern fledging success was estimated at 30%-40% of the number of adult pairs.

Least terns and ospreys showed a low success of fledging conservatively estimated at 20%.

Of the remaining species (willet, oystercatcher, piping and Wilson's plovers and herring gulls) no estimates could be made though they were assumed to be relatively high due to observations of young individuals in the area subsequent to the breeding season.

Lack of success was attributed primarily to a tropical depression which inundated beaches and inlets over the entire study area during early July when nesting activity was at its peak. Human disturbance was a factor on only a few islands, and animal disturbance was noted as minimal for Hog Island only.

Historical information for the entire survey area indicates the mobility and fluctuations of individual colonies in the past, but data for former years is

TABLE 1

NUMBER OF BREEDING PAIRS OF COLONIAL AND BEACH NESTING BIRDS OF THE VIRGINIA BARRIER ISLANDS: June - July 1975

	Assateague*	Wallops*	Assawoman*	Metomkin	Cedar	Dawson Shoals*	Parramore	Revel	Chimney Pole Marsh*	Sandy	Hog	Rogue	Cobb	Little Cobb	Wreck	Ship Shoal	Godwin	Mink	Myrtle	Smith	Fisherman	TOTAL
GREEN HERON	-	-	-	-	-	-	-	-	-	-	-	3	-	-	10	4	-	-	-	-	-	17
LITTLE BLUE HERON	-	-	-	20	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	44	74
CATTLE EGRET	-	-	-	32	-	-	-	-	-	-	2	-	-	-	7	-	-	-	-	-	200	241
GREAT EGRET	-	-	-	32	-	-	-	-	-	-	25	-	-	-	6	6	-	-	-	-	57	126
SNOWY EGRET	-	-	-	340	-	-	-	-	-	-	55	-	-	-	25	23	-	-	-	-	153	596
LOUISIANA HERON	-	-	-	270	-	-	-	-	-	-	34	-	-	-	80	25	-	-	-	-	21	430
BLACK-CROWNED NIGHT HERON	-	-	-	8	-	-	-	-	-	-	71	-	-	-	35	2	-	-	-	-	453	569
YELLOW-CROWNED NIGHT HERON	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	8	5	23
GLOSSY IBIS	-	-	-	198	-	-	-	-	-	-	150	-	-	-	13	-	-	-	-	-	25	386
OSPREY	2	5	-	-	1	-	3	5	-	-	-	-	3	-	-	-	-	-	-	5	6	30
OYSTERCATCHER	-	a few	10	30	30	-	4	-	-	-	28	-	23	-	60	14	-	-	15	50	-	264+
PIPING PLOVER	-	a few	3	7	4	-	4	-	-	-	11	-	6	-	-	2	-	-	2	-	-	39+
WILSON'S PLOVER	-	a few	3	6	3	-	-	-	-	-	2	-	2	-	-	4	-	-	4	5	-	29+
WILLET	-	a few	18	30	350	-	30	-	-	-	100	-	34	-	100	25	-	-	25	-	40	752+
HERRING GULL	-	-	-	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	600	660
LAUGHING GULL	-	-	-	80	-	-	-	-	50	235	-	-	-	-	1300	-	-	-	-	-	200	1865
GULL-BILLED TERN	-	-	-	360	2	4	8	-	-	-	61	-	22	150	6	275	-	-	148	78	?	1114
COMMON TERN	-	-	-	680	10	15	40	-	10	-	93	-	85	150	6	410	-	-	603	222	285	2609

TABLE 1 CONTINUED

	Assateague*	Wallops*	Assawoman*	Metomkin	Cedar	Dawson Shoals*	Parramore	Revel	Chimney Pole*	Sandy	Hog	Rogue	Cobb	Little Cobb	Wreck	Ship Shoal	Godwin	Mink	Myrtle	Smith	Fisherman	TOTAL
LEAST TERN	-	-	-	115	67	-	50	-	-	-	22	-	10	-	-	20	-	-	15	84	-	383
ROYAL TERN	-	-	-	1600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	800	2400
SANDWICH TERN	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5-6	8-9
CASPIAN TERN	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
BLACK SKIMMER	-	-	-	950	-	80	75	-	25	-	560	-	125	400	75	500	-	-	215	255	500	3760

*Islands not owned by The Nature Conservancy.

lacking or incomplete in most cases. Site selections for the various species colonies are consistent for each in terms of habitat preference and utilization.

Failure to mention the Forster's tern in the breeding data is significant. This species prefers the Spartina alterniflora "tumps" and islands located on the western side of the barrier islands. They nest on accumulations of plant debris which flood tides concentrate on those raised areas which lie along the creeks and channels. Recorded as local residents on the surveys, these terns utilize the barrier islands for feeding areas only.

CONCLUSION

The Virginia Barrier Islands provide a vital habitat to the birds of the entire Atlantic seaboard. Not only do they provide a nesting sanctuary for literally thousands of colonial nesting birds of many species, they also provide a vast area for migratory shorebirds and waterfowl to feed and rest. Many of these species, especially waterfowl, use the area as wintering grounds providing sport for the bird enthusiast and hunter.

It is apparent both through historical information and recently observed events that the Virginia Barrier Islands are in a constant state of flux. Because of this the individual breeding colonies of each island also fluctuate not only from site to site and season to season, but often during the same season generally directed by climatic disturbances. The overall populations of each species appears to remain relatively constant not necessarily on individual islands, but over the entire eastern shore area. This needs to be further investigated in detail since past data is sparse if not unreliable. Every effort should be made to assess the breeding populations at least twice annually. Efforts should be made to educate the public to the presence of the colonial birds and their dependence on the Virginia Barrier Islands.

Each colonial species is consistent in its choice of habitats for its breeding. sites along the entire island chain. Amount of vegetation and access to feeding areas often seem to be important in this selection, though further information is needed.

Though human disturbances are minimal in considering the total survey area, those locations where human activity is heavy showed a drastic decrease in the nesting success of the species present.

TABLE 2

COLONIAL BIRD COLONIES OF THE VIRGINIA BARRIER ISLANDS 1975*

Island	USGS Quadrangle	Species Composition[a]	Habitat[b]
North Metomkin	Bloxom	L.T.	B
North Metomkin	Bloxom	M.H.	t
Middle Metomkin	Bloxom	L.T., C.T.	B
Middle Metomkin	Metomkin Inlet	L.T.	B
Middle Metomkin	Metomkin Inlet	B.S., C.T., G.B.T., CA.T., L.T.	B
Middle Metomkin	Metomkin Inlet	R.T., S.T.	B
South Metomkin	Metomkin Inlet	L.T.	B
South Metomkin	Metomkin Inlet	G.B.T., L.G., H.G., C.T., L.T.	B,Ag
South Metomkin	Metomkin Inlet	B.S., C.T.	B
South Metomkin	Metomkin Inlet	M.H.	t
Cedar	Metomkin Inlet	L.T.	B
Cedar	Wachapreague	L.T., G.B.T., C.T.	B
Cedar	Wachapreague	L.T.	B
Dawson Shoals	Wachapreague	B.S., G.B.T., C.T.	B
Parramore	Quinby Inlet	L.T., C.T., G.B.T., B.S.	B
Parramore	Quinby Inlet	B.S., C.T.	B
Chimney Pole Marsh	Quinby Inlet	B.S., C.T.	B
Sandy	Quinby Inlet	L.G.	M
Sandy	Quinby Inlet	L.G.	M
Sandy	Quinby Inlet	L.G.	M
Hog	Quinby Inlet	C.T., B.S., G.B.T.	B
Chimney Pole Marsh	Quinby Inlet	L.G.	M

TABLE 2 CONTINUED

Island	Quadrangle	Species Composition[a]	Habitat[b]
Hog	Quinby Inlet	B.S., C.T.	B
Hog	Quinby Inlet	L.T.	B
Hog	Quinby Inlet	M.H.	T
Hog	Quinby Inlet	B.S., C.T., G.B.T., L.T.	B
Hog	Quinby Inlet	B.S., C.T., G.B.T., L.T.	B
Rogue	Quinby Inlet	G.H.	t
Cobb	Great Machipongo Inlet	B.S., C.T., G.B.T.	B
Cobb	Great Machipongo Inlet	B.S., C.T., G.B.T., L.T.	B
Little Cobb	Cobb Island	B.S., C.T., G.B.T.	B
Wreck	Cobb Island	M.H.	t
Wreck	Cobb Island	L.G.	G
Wreck	Cobb Island	B.S., C.T., G.B.T.	B
Ship Shoal	Ship Shoal Inlet	C.T.	B
Ship Shoal	Ship Shoal Inlet	B.S., C.T., L.T., G.B.T.	B
Ship Shoal	Ship Shoal Inlet	M.H.	t
Myrtle	Ship Shoal Inlet	B.S., C.T., G.B.T.	B
Myrtle	Ship Shoal Inlet	B.S., C.T., G.B.T., L.T.	B
Myrtle	Ship Shoal Inlet	B.S., C.T., G.B.T.	B
Smith	Ship Shoal Inlet	B.S., C.T., G.B.T.	B
Smith	Ship Shoal Inlet	B.S., C.T., G.B.T., L.T.	B
Smith	Ship Shoal Inlet	G.B.T., C.T., L.T.	B
Smith	Ship Shoal Inlet	B.S., C.T., G.B.T.	B
Smith	Townsend	C.T.	B
Smith	Fisherman Island	C.T.	B

TABLE 2 CONTINUED

Island	Quadrangle	Species Composition[a]	Habitat[b]
Smith	Fisherman Island	L.T.	B
Fisherman	Fisherman Island	B.S., C.T.	B
Fisherman	Fisherman Island	M.H.	T
Adams (Fisherman)	Fisherman Island	L.G.	G
Isaacs (Fisherman)	Fisherman Island	H.G.	Ag
Isaacs (Fisherman)	Fisherman Island	B.S., C.T.	B
Fisherman	Fisherman Island	B.S., C.T.	B
Fisherman	Fisherman Island	R.T., S.T.	B

a SPECIES ABBREVIATIONS

G.H. - Green Heron
M.H. - Mixed Heronry
H.G. - Herring Gull
L.G. - Laughing Gull
G.B.T. - Gull-billed Tern
C.T. - Common Tern
L.T. - Least Tern
R.T. - Royal Tern
S.T. - Sandwich Tern
CA.T. - Caspian Tern
B.S. - Black Skimmer

b SEE ATTACHED LEGEND FOR HABITAT DESCRIPTION ACCORDING TO McCAFFREY (1975)

* SEE ATTACHED MAPS

LEGEND FOR VEGETATION

B	Ocean beach and spits. Upper beach sparcely vegetated; *Cakile harperi*, *Salsola kali*. 10% cover.
M	Low salt marsh. *Spartina alterniflora* 2-5.5 feet tall. 30-100% cover.
Ag	Sparcely vegetated dunes surrounded by dense grassland. *Ammophila*, *Andropogon scoparius* dunes. 20% cover. *Spartina patens* grassland 80-100% cover.
T	Tall shrub thicket. *Myrica cerifera*. 8 feet tall dense cover. 100% cover.
t	Low shrub thicket. *Myrica cerifera* or *Iva frutescens* 8 feet tall. 50% shrub cover. 100% vegetation cover. May have 50-100% ground cover of *Spartina patens*.
G	Dense grassland. 80-100% cover. *Spartina patens*.

TABLE 3

STATUS OF ALL BIRD SPECIES ENCOUNTERED DURING

THE SURVEY PERIOD JUNE 18-JULY 19, 1975

	Metomkin	Cedar	Dawson Shoals*	Parramore	Revel	Sandy	Hog	Rogue	Cobb	Wreck*	Ship Shoal	Godwin	Mink	Myrtle	Smith	Fisherman*	Assawoman*
GREATER SHEARWATER							D		D						D		D
D.C. CORMORANT	S																
GREAT BLUE HERON	LP			LP				LP					LP	LP		LP	
GREEN HERON	R			R		LP		RB	R	RB	RB	LP	RB	LP	R	RB	
LITTLE BLUE HERON		LP		LP	LP	LP	RB			RB					LP	RB	
CATTLE EGRET						LP	RB			RB						RB	
GREAT EGRET	RB			LP	LP	LP	RB	LP	LP	RB	RB	LP		LP		RB	
SNOWY EGRET	RB				LP	LP	RB	LP	LP	RB	RB	LP		LP		RB	
LOUISIANA HERON	RB	LP		LP	LP	LP	RB	LP	LP	RB	RB	LP		LP	LP	RB	
BLACK-CROWNED NIGHT				R	LP		RB	LP	LP	RB	RB			LP		RB	
YELLOW-CROWNED NIGHT							RB								RB	RB	
GLOSSY IBIS		LP		LP	LP		RB		LP	RB	LP				LP	RB	
BRANT										M							
BLACK DUCK				RB			RB		RB		LP					R	
GADWALL				R			R										
BLUE-WINGED TEAL									RB								
SURF SCOTER															S		
COMMON SCOTER	S						S								S		
RED-BREASTED MERG.	S						S										

TABLE 3 CONTINUED

	Metomkin	Cedar	Dawson Shoals*	Parramore	Revel	Sandy	Hog	Rogue	Cobb	Wreck*	Ship Shoal	Godwin	Mink	Myrtle	Smith	Fisherman*	Assawoman*
RED-TAILED HAWK					R												
MARSH HAWK	M						R		R								
OSPREY				RB	RB				RB					LP	RB	RB	
BOBWHITE				R													
CLAPPER RAIL	RB	RB		RB	RB	RB	RB	RB	RB	RB	RB	RB	RB	RB	RB	RB	RB
OYSTER CATCHER	RB	RN		R			RB	LP	RB	RB	RB			RB	RB	RB	R
SEMIPALM. PLOVER	M	M		M			M		M	M					M	M	
PIPING PLOVER	RB	RB		RB			RB		RB	RB	RB			RB	RB	RB	RB
WILSON'S PLOVER	RB	RB		RB			RB		RB	RB	RB			RB	RB	RB	RB
KILLDEER	M								M								
BLACK-BELLIED PLOVER	M	M		M			M		M	M	M			M	M	M	M
RUDDY TURNSTONE	M	M		M			M		M	M	M			M	M	M	M
WHIMBREL	M	M			M		M		M	M	M				M	M	
SPOTTED SAND.	M	M		M	M	M	M	M	M	M	M			M	M	M	M
WILLET	RB	RB		RB	R	R	RB	R	RB	RB	RB	R	R	RB	RB	RB	R
GREAT. YELLOWLEGS							M								M	M	
LESS. YELLOWLEGS	M						M								M	M	
KNOT	M	M	M	M			M		M	M	M			M	M	M	M
WHITE-RUMP. SAND	M															M	
LEAST SAND.	M	M		M	M		M		M	M					M	M	
DUNLIN	M	M		M	M		M	M	M	M	M	M	M	M	M	M	M
SH.-BILLED DOWITCHER	M	M		M	M		M	M	M	M	M	M	M	M	M	M	M
SEMI-PALM. SAND.	M	M		M			M	M	M	M	M			M	M	M	M

TABLE 3 CONTINUED

	Metomkin	Cedar	Dawson Shoals*	Parramore	Revel	Sandy	Hog	Rogue	Cobb	Wreck*	Ship Shoal	Godwin	Mink	Myrtle	Smith	Fisherman*	Assawoman*
WESTERN SAND.	M						M		M	M					M	M	
MARBLED GODWIT									M	M					M		
SANDERLING	M	M		M			M		M	M	M			M	M	M	M
SKUA																	M
ICELAND GULL															S,M		
GREAT BLACK-BACK GULL	LP	LP		LP			LP	LP	LP	LP	LP			LP	LP	R	LP
HERRING GULL	RB	LP		LP		LP	LP	LP	LP		LP	LP		LP	LP	RB	LP
LAUGHING GULL	RB	LP		LP	LP	RB	LP	LP	LP	RB	LP	LP		LP	LP	LP	LP
GULL-BILLED TERN	RB	RB	RB	RB			RB	LP	RB	RB	RB	LP		RB	RB	RB	LP
FORSTER'S TERN	LP				LP	LP		LP							LP	LP	
COMMON TERN	RB	RB	RB	RB			RB		RB	RB	RB			RB	RB	RB	LP
LEAST TERN																	
ROYAL TERN	RB	LP		LP			LP	LP		LP				LP	LP	RB	LP
SANDWICH TERN	RB														LP	RB	
CASPIAN TERN	RB																
BLACK SKIMMER	RB	LP	RB	RB			RB	LP	RB	RB	RB	LP		RB	RB	RB	
MOURNING DOVE																LP	
BARN OWL					R											RB	
COMMON NIGHTHAWK									R	RB	RB			R	R		
FLICKER				R	R												
GR. CRESTED FLYCATCHER				R													
KINGBIRD				R													
HORNED LARK			R					R									

TABLE 3 CONTINUED

	Metomkin	Cedar	Dawson Shoals*	Parramore	Revel	Sandy	Hog	Rogue	Cobb	Wreck*	Ship Shoal	Godwin	Mink	Myrtle	Smith	Fisherman*	Assawoman*
BARN SWALLOW	LP	RB		RB	RB		RB		RB	LP	LP			LP	RB	RB	
FISH CROW		R					R	RB			R		LP		R	R	
HOUSE WREN				R	R		R									R	
CAROLINA WREN				R	R											R	
CATBIRD		R		R			R			R						R	
BROWN THRASHER													R			R	
STARLING							R									R	
WHITE-EYED VIREO							R										
YELLOW WARBLER				R			R										
PRAIRIE WARBLER		R		R	R		R								R		
YELLOWTHROAT				R	R		R	R	R	R	R				R	R	
MEADOWLARK		R		R	R		R	R	R	R	R			R	R	R	
REDWING	R	R		R	R			R	R	R	R		R	R	R	R	
BOAT-TAIL GRACKLE	RB	R		R	R	R	RB	RB	R	RB	R	R	R	R		RB	
COMMON GRACKLE		R		R				R									
CARDINAL				R											R	R	
TOWHEE				R		R									R		
SHARP-TAIL SPARR.	R						R	R				R			R	R	R
SEASIDE SPARR.	R	R		R	R	R	RB	R	R			R	RB	R	R	R	R
SONG SPARR.	R	R		R	R	R		R	R	R	R	R	R	R	R	R	R

TABLE 3

STATUS OF ALL BIRD SPECIES ENCOUNTERED DURING

THE SURVEY PERIOD JUNE 18-JULY 19, 1975

LEGEND:

RB - RESIDENT BREEDER

R - RESIDENT-BREEDING NOT CONFIRMED

LP - LOCAL RESIDENT-PASSER-BY

M - MIGRANT

S - SUMMERING

D - FOUND DEAD ON BEACH ONLY

* Not owned by The Nature Conservancy.

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TERRESTRIAL ARTHROPODS

Generally speaking, there are large numbers of terrestrial arthropods that are inadequately known. Some may have never been scientifically described. Specifically, little is known at all about them on barrrier islands. The status of these species, whether they are rare, endangered, or threatened, is uncertain. However, the large number of species of these animals in salt marsh and sand dune areas indicates their importance to the region's total species diversity. Hinckes, et al. (1951-1954) recorded over 2,000 species of these invertebrates on the sand dune and salt marsh complex at Sprunhead in Great Britain. These accounted for 20-25% of the British fauna. No such thorough analysis of the Virginia Coast Reserve's terrestrial arthropod fauna was undertaken as part of this study due to fiscal and temporal limitations.

Ecosystems management for the preservation of critical arthropod fauna is almost a non-existent occurrence. Some techniques have been explored, specifically intended to preserve habitat for certain lepidopteran species (Pyle, 1974). The type of protection offered by preservation of the barrier islands will forestall depletion of their arthropod fauna by keeping intact the natural habitats these species require.

Limited investigations of Parramore Island's arthropod fauna were conducted on three separate occasions. These included collecting sand dune arthropods, those attracted to a cyanide light trap, and ticks from freshly killed white-tailed deer carcasses. Findings from these brief outings were limited. They generally served to reinforce the ecological value of the island based on "....its undisturbed nature, the inherent individuality of all islands, and the fact that the ecosystem to which it belongs is geographically limited " (Opler, 1976).

The tick species have not been identified as of this printing. It is suspected that they may contain some exotic or naturalized species established on the island through the historical introduction of domestic livestock and game animals (Settle, 1975). The unusual abundance of ticks and chiggers on the island may be linked to the presence of an extensive historical and present day population of large host species. These have included horses, cattle, and goats and presently include many deer and raccoons.

Some unusual island lepidoptrean records have been established on the basis of two nights of trapping, July 2 and 3, 1975 (Shaffer, 1976). Though these are isolated instances, they point out the diverse, unexplored nature of this component of the islands' ecosystem.

> Coenochroa bipunctella (Barnes & McDunnough). This is the only species of this genus occurring in the southeastern United States. It is a coastal plain species and nearly all known specimens come from Florida, with one from Mississippi, four from North Carolina, and one from New Jersey. This find constitutes a new record for Virginia.
>
> Eccritothria trimaculella (Chambers, Family Tineidae). This is a tiny moth thought to live in association with ants. The larva builds a small, flat, figure eight shaped case.

Leucania extincta. This uncommon noctuid moth is largely restricted to coastal salt marshes.

_____ _____ (Pyralidae, subfamily Schoenobiinae). Several specimens of a dark-winged species likely represent a new northern record for the species. (They are unnamed due to the poor state of the subfamily's taxonomy).

Acentropus sp. (Pyralidae, subfamily Nymphulinae). This surprising find is ordinarily associated with large bodies of fresh water. The larva of the moth usually live in aquatic plants.

_____ _____ a large unidentified phycitine moth of the family Pyralidae was found. It is a cactus-feeder associated with prickley-pear.

Another component of the islands' arthropod fauna which deserves mention is the forest insect Dendroctanue frontralis, the southern pine bark beetle. Infestations of this species occur in the islands' loblolly pine forest following stress induced by lightning strikes, wind damage, flood damage, and wild-fire. Bark beetle activity is cyclic and is dependent on relationships between weather, soil, tree vigor, and predator conditions. Many pine forest areas on the mainland were totally wiped out in the late 1960's and early 1970's. For unknown reasons, the beetles have not been very destructive to the island forests (Folk, 1975). Their cyclicity on Parramore differs from the adjacent mainland.

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THE VIRGINIA COAST RESERVE FISHERIES

The barrier islands are surrounded by the Atlantic Ocean, and a system of inlets, salt marshes and shallow lagoons. The bays behind the islands are highly saline and well mixed with mud, sand, clay, or shell substrates. Channels transecting marsh surround the embayments. Beaches have a sand and sand-mud substrate grading into soft mud in deeper water. The salinity and temperature of the waters indicate strong verticle mixing. Water temperatures range from 4.0 to 31.5 degrees C with a peak in temperature during August and early September (Richards and Castagna, 1970). The islands of the Virginia Coast Reserve are an integral component of this marine system. They form the barrier permitting the development of marshes, channels, and lagoons. This productive system provides habitat for a variety of marine fish and shellfish. It is primarily the fish species, though not components of the upland barrier island system, that influence human activity on the islands and adjacent waters. They are therefore considered significant components of the Virginia Coast Reserve System. The rest of the offshore and inshore communities are excluded from consideration in this report.

Ninety-six species of marine fish have been recorded for the waters surrounding the islands. (Table 4). Of these, twelve are often commercially or recreationally sought. Seven of these are caught from the islands' beaches by surf casting. Their presence influences the stewardship of the islands. These species include striped bass, bluefish, weakfish, Atlantic croaker, blackdrum, reddrum, and summer flounder. Periods of peak catch rates occur annually from April through October. The schedule of availability for each species varies during this period (Table 4). Fish are caught using traditional surf-casting methods along the ocean and inlet sides of the beach.

The human activity accompanying surf-casting causes concern. Beach vehicle use, discarded fishing lines, and disruption to ecologically sensitive areas often accompany surf-casting. The sport itself is a form of outdoor recreation which the islands can support well, provided steps are taken to eliminate disturbances. A plan accommodating the sport fisherman and precluding ecological insult is outlined in Volume IV of this study.

TABLE 4

MARINE FISH OF THE VIRGINIA COAST RESERVE'S INLET AND MARSH WATERS

		Scientific Name	Common Name
1.		Carcharias taurus Rafinesque	sand shark
2.		Alopias vulpinus (Bonnaterre)	thresher shark
3.		Carcharhinus milberti (Muller and Henle)	sandbar shark
4.		Galeocerdo cuvieri (Peron and LeSueur)	tiger shark
5.		Mustelus canis (Mitchell)	smooth dogfish
6.		Negaprion brevirostris (Poey)	lemon shark
7.		Sphyrna zygaena (Linnaeus)	smooth hammerhead
8.		Squalus acanthias Linnaeus	spiny dogfish
9.		Squatina dumerili LeSueur	Atlantic angel shark
10.		Raja eglanteria Bosc	clearnose skate
11.		Dasyatis americana Hildebrand & Schroeder	southern stingray
12.		Dasyatis centroura (Mitchell)	roughtail stingray
13.		Dasyatis sayi (LeSueuer)	bluntnose stingray
14.		Gymnura altavela (Linnaeus)	spiny butterfly ray
15.		Gymnura micrura (Bloch and Schneider)	smooth butterfly ray
16.		Rhinoptera bonasus (Mitchell)	cownose ray
17.		Manta birostris (Walbaum)	Atlantic manta
18.		Elops saurus Linnaeus	ladyfish
19.		Megalops atlantica Valenciennes	tarpoon
20.		Alosa aestivalis (Mitchell)	blueback herring
21.		Alosa mediocris (Mitchell)	hickory shad
22.		Alosa pseudoharengus (Wilson)	alewife
23.		Alosa sapidissima (Wilson)	American shad
24.		Brevoortia tyrannus (Latrobe)	Atlantic menhaden
25.		Clupea harengus Linnaeus	Atlantic herring
26.		Anchoa hepsetus (Linnaeus)	striped anchovy
27.	R	Anchoa mitchilli (Valenciennes)	bay anchovy
28.		Synodus foetens (Linnaeus)	inshore lizardfish
29.		Anguilla rostrata (LeSueur)	American eel
30.		Conger oceanicus (Mitchell)	conger eel
31.		Strongylura marina (Walbaum)	Atlantic needlefish
32.		Hyporhamphus sp.	halfbeak
33.	R	Cryprinodon variegatus Laoepede	sheepshead minnow
34.	R	Fundulus heteroclitus (Linnaeus)	mummichog
35.		Fundulus luciae (Baird)	spotfin killifish
36.		Fundulus majalis (Walbaum)	striped killifish
37.	R	Lucania parva (Baird and Girard)	rainwater killifish
38.		Pollachius virens (Linnaeus)	pollock
39.		Urophycis chuss (Walbaum)	squirrel hake
40.		Urophycis regius (Walbaum)	spotted hake
41.		Apeltes quadracus (Mitchell)	fourspine stickleback
42.		Gasterosteus aculeatus Linnaeus	three-spine stickleback
43.		Hippocampus erectus Perry	spotted seahorse
44.	R	Syngnathus fucus Storer	northern pipefish
45.		Holocentrus ascensionis (Osbeck)	squirrel fish
46.	C	Centropristes striatus (Linnaeus)	black seabass
47.		Mycteroperca microlepis (Goode and Bean)	gag
48.		Morone americana (Gmelin)	white perch
49.	C	Monrone saxtilis (Walbaum)	striped bass

TABLE 4 CONTINUED

		Scientific Name	Common Name
50.		Pristigenys alta (Gill)	short bigeye
51.	C	Pomatomus saltatrix (Linnaeus)	bluefish
52.	C	Rachycentron canadum (Linnaeus)	cobia
53.		Caranx hippos (Linnaeus)	crevalle jack
54.		Trachinotus falcatus (Linnaeus)	permit
55.		Orthopristis chrysopterus (Linnaeus)	pigfish
56.		Bairdiella chrysura (Lacepede)	silver perch
57.	C	Cynoscion regalis (Bloch & Schneider)	weakfish
58.	C	Leiostomus xanthurus Lacepede	spot
59.	C	Menticirrhus americanus (Linnaeus)	southern kingfish
60.	C	Menticirrhus saxatilis (Bloch and Schneider)	northern kingfish
61.	C	Micropogon undulatus (Linnaeus)	Atlantic croaker
62.	C	Pogonias cromis (Linnaeus)	black drum
63.	C	Sciaenops ocellata (Linnaeus)	red drum
64.		Mullus auratus Jordan and Gilbert	red goatfish
65.	C	Stenotomus chrysops (Linnaeus)	scup
66.		Tautoga onitis (Linnaeus)	tautog
67.		Tautogolaribrus adspersus (Walbaum)	cunner
68.	R	Gobisoma bosci (Lacepede)	naked goby
69.		Gobiosoma ginsburgi Hildebrand & Schroeder	seaboard goby
70.		Microgobius thalassinus (Jordan and Gilbert)	green goby
71.		Prionotus carolinus (Linnaeus)	northern searobin
72.		Prionotus evolans (Linnaeus)	striped searobin
73.		Myoxocephalus octodecemspinosus (Mitchell)	longhorn sculpin
74.		Astroscopus guttatus Abbott	northern stargazer
75.		Rissola marginata (DeKay)	striped cusk-eel
76.		Peprilus triancanthus (Peck)	butterfish
77.		Sphyraena borealis DeKay	northern sennet
78.		Mugil oephalus Linnaeus	striped mullet
79.		Mugil curema Valenciennes	white mullet
80.		Membras martinica (Valenciennes)	rough silverside
81.		Menidia beryllina (Cope)	tidewater silverside
82.	R	Menidia menidia (Linnaeus)	Atlantic silverside
83.		Etropus crossotus Jordan and Gilbert	fringed flounder
84.	R	Etropus microstomus (Gill)	smallmouth flounder
85.	C	Paralichthys dentatus (Linnaeus)	summer flounder
86.		Scophthalmus aquosus (Mitchell)	windowpane
87.		Pseudopleuronectes americanus (Walbaum)	winter flounder
88.		Trinectes maculatus (Bloch and Schneider)	hogchoker
89.		Symphurus plagiusa (Linnaeus)	black-cheek tonguefish
90.		Echeneis naucrates Linnaeus	sharksucker
91.		Stephanolepis hispidus (Linnaeus)	planehead filefish
92.		Lagocephalus laevigatus (Linnaeus)	smooth puffer
93.		Sphocroides maculatus (Bloch and Schneider)	northern puffer
94.		Chilomycterus schoepfi (Walbaum)	striped burrfish
95.	R	Opsanus tau (Linnaeus)	oyster toadfish
96.		Lophius americanus Valenciennes	goosefish

R: Resident Species. C: Commercially or recreationally sought species.

Source: Richards, C.E., 1965. Availability Patterns of Marine Fishes Caught by Charter Boats Operating Off Virginia's Eastern Shore, 1955-62. Chesapeake Science Vol. 6, No. 2, pp. 96-108.
Richards C.E., and M. Castagna, 1970. Marine Fishes of Virginia's Eastern Shore (Inlet & Marsh, Seaside Waters). Chesapeake Science Vol. II, No. 4, pp. 235-24

TABLE 5

PERIODS OF PEAK CATCH RATE FOR THE GAME FISH OF THE WATERS

ADJACENT TO THE VIRGINIA COAST RESERVE

Species	Period	Peak
striped bass	September - December	----
bluefish	June - August	June
weakfish	June - October	September - October
Atlantic croaker	May - October	August
black drum	April - July, September	May
red drum	April - June, September - October	April, June, September
summer flounder	April - October	July

Source: Richards, C.E., 1965, Availability Patterns of Marine Fishes Caught by Charter Boats Operating Off Virginia's Eastern Shore, 1955-62. Chesapeake Science Vol. 6, No. 2, pp. 96-108.

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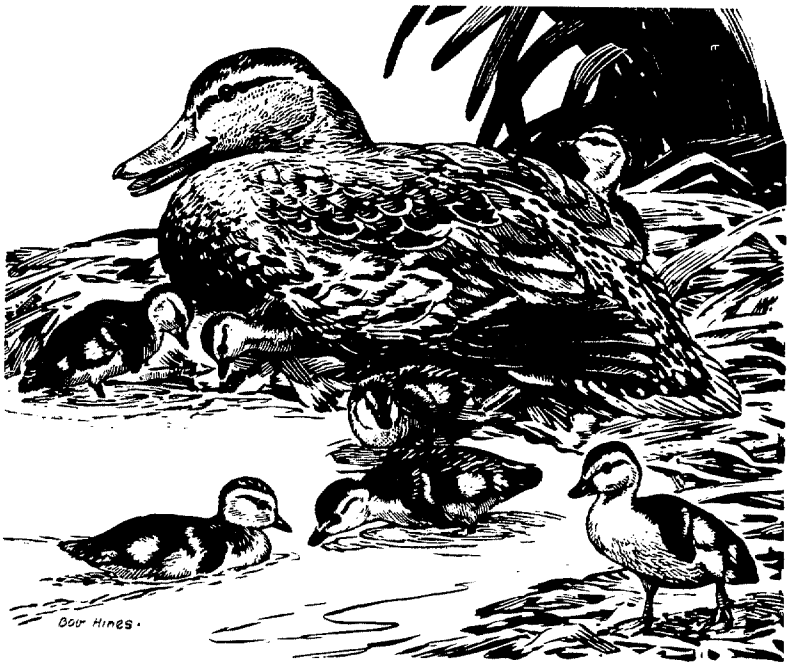
Appendix



APPENDIX A

ACKNOWLEDGEMENTS

Miles Barnes: Eastern Shore Public Library. Mr. Barnes' familiarity with the library and its resources proved to be invaluable.

J.C. Appel: Mr. Appel, of Chincoteague National Wildlife Refuge, is a good source of information on the history of hunting, especially market hunting.

John Crumb: Oyster. Mr. Crumb is a local game warden and is thus familiar with hunting in the area of the barrier islands. He has in his possession several duck trapping photographs.

Kellam Doughty: Deputy Sheriff of Northampton County. Mr. Doughty has in his possession a Hog Island Lighthouse log of the late 1800's, Broadwater Club furniture, and several old market guns.

Mr. and Mrs. John Edmunds: Accomack. The Edmunds have kept a file of clippings on the islands.

Archie Bradford: Exmore. Mr. Bradford has an interest in the Indian shell mounds on Hog Island.

L.W. Johnson: Painter. Mr. Johnson is an Eastern Shore historian who may have some information on the barrier islands and their history.

Captain and Mrs. George Peppler: Wachapreague. The Pepplers have photographs of the Accomack Club and have given several to The Nature Conservancy. They are also interested in other hunting clubs of the area.

Bowdie Lusk: Cheriton. Mr. Lusk is interested in the hunting history of the Eastern Shore and has suggested many old-timers who might be interviewed on the subject.

Cheryl McCaffrey: Ms. McCaffrey was the researcher in charge of the vegetational studies of the Virginia Coast Reserve Study and was helpful in making suggestions and supplying information.

L. Floyd Nock: Accomack. Mr. Nock is an architectural historian who offered several suggestions for tracking down potential sources.

George Reiger: Locustville. Mr. Reiger is responsible for many helpful suggestions on subject matter. He is particularly familiar with fishing in the vicinity of Virginia's Eastern Shore.

John Reiger (Dr.): Miami, Florida. Dr. Reiger is an environmental historian and has suggested literature which might be of help to future researchers in this area.

John W. Robertson (Dr.): Onancock. Dr. Robertson has published several photographic volumes on the Eastern Shore.

Becky Rogers: Eastern Shore Public Library. Mrs. Rogers has in her possession the mastadon teeth found on Cedar Island.

Fannie Rhetta Smith: Wachapreague. Mrs. Smith's father was a caretaker of the Accomack Club, thus she has many photographs of the club in its heyday.

Col. James Turner: Alexandria, Virginia. Col. Turner supplied information on the barrier islands which he discovered in his search of county court records.

Mrs. Wade Walker: Morleys Wharf. Mrs. Walker is familiar with many of the islands, especially Revel Island.

Ann Pardee: Wardtown. Mrs. Pardee brought to my attention many people who have helped me with my work or who may be future sources of information for such a study.

Ted Ward: Exmore. Mr. Ward is a photographer who has a collection of Hog Island photographs, some of which are included in this report.

Faye Wilson: Eastville. Mrs. Wilson has collected much Hog Island information in hopes of writing a book. She has a good knowledge of the island and its people.

William Wroten (Dr.): Salisbury, Maryland. Dr. Wroten is the author of a book on the history of Assateague and is presently studying the history of the barrier island Coast Guard Stations.

Robert H. Burgess: Mariners Museum, Newport News, Virginia. The museum has some sources of historical literature pertaining to the islands of Virginia's Eastern Shore as well as a collection of photographs.

Mr. & Mrs. J.D. Fosque: Onancock. The Fosques are leaders in the local historical society; they and the society have contributed greatly to this research. The Eastern Shore Historical Society has taken on the task of transcribing the taped interviews which have been invaluable in compiling historical information on the barrier islands.

Dick Moore: The Daily and Sunday Times. Salisbury, Maryland. Mr. Moore supplied information concerning the storms of this coast.

Curtis Badger: The Eastern Shore News, Accomack. Mr. Badger offered the use of the back issues of this local newspaper dating from approximately 1903.

Dr. Kimball: Melfa. Dr. Kimball has answered my many questions about barrier island bird life.

Mike Castagna: Virginia Institute of Marine Sciences, Wachapreague. Mr. Castagna was helpful in supplying material and offering suggestions for this research.

Charles Handley (Dr.): Smithsonian Museum of Natural History. Dr. Handey has a knowledge of the faunal history of this region and was thus helpful in this field.

Bill Belote: Mr. Belote is a local expert on Indians who may be valuable in future assessment of the extent of Indian activity on the barrier islands.

Gerard J. Hennessey: Director of the Virginia Coast Reserve Study, Wachapreague. Mr. Hennessey offered suggestions and encouragement throughout the course of this research.

James MacFarland: The Nature Conservancy, Wachapreague. Mr. MacFarland supplied many of the photographs accompanying this report and also offered many helpful suggestions.

APPENDIX B

TAPED INTERVIEWS

(Tapes and Transcript of tapes can be found at the Eastern Shore Historical Society)

R.W. Phillips: Accomack Co. Parole Officer. Mr. Phillips' father was with the Coast Guard on Parramore and Cedar Islands for 33 years. Information primarily about Parramore Island. age: unknown. Tape #1 August 13, 1975.

Herbert Powell: Wachapreague. Mr. Powell discussed Parramore, Cedar, and Revel Island history. Mrs. Powell's father built the Wachapreague and Cedar Island Hotels. age: 78. Tape #1 & 2 August 14, 1975.

Nora Miller Turman: Parksley. Local historian and author of the book The Eastern Shore of Virginia 1603-1964. age: unknown. Tape #2 & 3 August 15, 1975.

Earl Bonniwell: Wachapreague. Mr. Bonniwell was employed by Parramore Island hunt clubs and thus is most familiar with this island. age: 83. Tape #2 & 3 August 19, 1975.

Mr. & Mrs. Ralph Bowen: Bells Neck. Mr. and Mrs. Bowen grew up on Hog Island and Mr. Bowen is believed to be the oldest living Hog Islander today. Discussion centered primarily on Broadwater community life. The Bowens' home in Bells Neck was built on Hog Island and moved to the mainland. Mr. Bowen age: 83 and Mrs. Bowen age: 73. Tape #3 August 21, 1975.

Buzzy Terry: Willis Wharf oyster business. Information primarily about Hog Island. age: 57. Tape #4 August 22, 1975.

Amine Kellam: Lochwood Farm. Mrs. Kellam is the great great grand-daughter of Nathan Cobb, Sr. Discussion centered on Cobb Island. The Cobb Island Hotel guest register is in Mrs. Kellam's possession as well as other sources of family history. age: unknown. Tape #5 September 2, 1975.

Berlie Bell: Oyster. Mr. Bell was born on Hog Island in 1912. Most information concerns Hog Island. Tape #5 September 4, 1975.

G. Martin: Townsend. Information focused on Smith Island. age: 73. Tape #6 September 3, 1975.

Greer Matthews: Wachapreague. Mr. Matthews was a Coast Guardsman on many of the barrier islands for approximately 30 years. He has in his possession many photographs of Coast Guard Station life, also several good photographs of the Smith Island light shortly before and after it fell into the sea. age: 85. Tape #6 & 7 September 8, 1975.

Willie Webb: Webb's Island. Some information about Hog and Wreck Islands. age: 75. Tape #7 September 12, 1975.

Mrs. Parker and Mr. and Mrs. Clyde Richardson: Wachapreague. Mrs. Parker was employed by Parramore Island hunt clubs. age: 84. Tape #8 September 17, 1975.

Harvey Bowen: Willis Wharf oyster business. Born on Hog Island in 1901. Mr. Bowen has been an invaluable source of information on Hog Island history. Tape #8 September 17, 1975.

John Wesley Bowen: Exmore. Born on Hog Island in 1913. Again, information primarily on Hog Island, some information on Cobb Island. Tape #9 September 18, 1975.

Edgar Bunting (Capt. Bunky): Wachapreague. Fisherman and party boat captain familiar with the Parramore Island area. age: 72. Tape #10 September 23, 1975.

Roy Bull: Magotha. Decoy Collector. Discussion of decoy and hunting history. Additional information on Cobb and Smith Islands. age: unknown. Tape #10 & 11. September 24, 1975.

Mr. and Mrs. Thomas Parsons: Oyster. Mr. Parsons is the present day lamplighter on Smith Island. Mrs. Parsons was born on Hog Island. Mr. Parsons age: 63. Tape #11 October 1, 1975.

Victor Simpson: Willis Wharf. Born on Hog Island in 1905. Presently a boat builder. Information primarily on Hog Island. Tape #11 September 30, 1975.

John Simpson: Oyster. Hog Island fisherman. age: 70. Tape #12 October 1, 1975.

Captain and Mrs. Moe Birch: Wachapreague. The Birches were caretakers on several barrier islands, most recently on Mockhorn Island. They have several photographs of Mockhorn Island life. Mr. Birch age: 78. Tape #12 & 13 October 9, 1975.

Granville Hogg: Cheriton. Mr. Hogg's father was a caretaker of the Bungalow Club on Smith Island and thus Mr. Hogg spent his boyhood on the island. Mr. Hogg may have some photographs of that period. age: 61. Tape #13 & 14. October 16, 1975.

Dick Webb: Webb's Island. General hunting and fishing information. age: 67. Tape #14 October 16, 1975.

The following people were interviewed without the aid of a tape recorder:

Frank Steelman: Capeville. Familiar with the Smith Island area. age: 69. Interview conducted on September 17, 1975.

Dr. Carl Schmidlapp: Oyster Bay, N.Y. Interview on Parramore Island about the Schmidlapp family ownership of that island. October 2, 1975.

Sara Nock: The Hermitage. Family frequently visited the Metomkin Island Hotel. age: 85(?) October 9, 1975.

APPENDIX C
POTENTIAL SOURCES OF INFORMATION

Due to the limited time available for this research, all sources of potential information were not pursued. If future work is to be done in this area, the following is a list of local people who may have information pertinent to the Virginia Barrier Islands:

John Adams - Keller
Norman (Buddy) Bell - Oyster
George Bell - Quinby
Gene Bowen - Willis Wharf
Grafton Bowen - Willis Wharf
Wendell Bowen - Willis Wharf
Hilda Carpenter - Marionville
Tommy Colonna - Wachapreague
Mrs. W. L. Cosby - Painter
Archie Doughty - Quinby
J. W. Downing - Machipongo
Charlie Farlow - Quinby
Winston 'Red' Godsey - Accomack
Horace E. Kelly - New Church
Andy Killmon - Wachapreague
George Killmon - Wachapreague
Hoyle Laton - Townsend
Bruce T. Martin - Virginia Beach
Albert Peppler - Quinby
Dickie Parks - Cape Charles
Lee Payne - Norfolk
Tom Reed - Chincoteague
Ralph Selby - Chincoteague
H. Allen Smith - Oyster
Nat Steelman - Chincoteague
John Sterling - Parksley
Dr. Bill Sturgis - Franktown
Alice Trower - Cape Charles
Dr. Harry Walsh - Easton, Maryland
Jean Watkinson - Wachapreague
Edward Skidmore White - Magotha

APPENDIX D

ADDITIONAL REFERENCES

All references used in this work are cited in footnotes above. Literature which may be productive but which was used is listed below.

The Virginia Historical Society at Richmond - literature includes old newspapers of the Eastern Shore.

Early newspapers often lasted only a few years. Some which might be checked are

- The Accomac News - 1896 (became the Eastern Shore News)
- National Recorder - Accomack 1860
- Eastern Shore Herald - Eastville 1881
- The Pioneer - Cape Charles 1885
- The Farmer and Fisherman - Wachapreague 1890, Belle Haven 1891
- The Eastern Virginian - Onancock 1870's
- Peninsula Enterprise - Accomack 1881 (note - the Peninsula Enterprise continued until approximately 1964, during the time of this research it was being microfilmed and thus unavailable. The microfilming should be complete in 1976.)
- Northampton Times - Cape Charles 1903

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APPENDIX E

PARTIAL LIST OF PLANT SPECIES OF THE VIRGINIA COAST RESERVE
By Cheryl Ann McCaffrey

SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL GODWIN	MYRTLE	MINK	SMITH
ALGAE													
Aghardiella tenera 719 no manual									uw 4				
Enteromorpha lensa 619 no manual					uw 2								
Fucus vesiculosis Kelp 620 no manual					(m, uw)3		(m, uw)3	(m, uw)3	(m, uw)3				
Gracilaria verricosa 717 no manual									uw 3				
Polysiphonia denudata 718 no manual					w 3				uw 4	uw 4			
Ulva lactuca Sea Lettuce 619A no manual	mf 1		m 4		uw 2		m 2	(m, wf)2	m 2	(m, uw)4			uw 4
MOSSES													
Funaria hygrometrica 542 no manual					(AG)5								
FERNS (PTERIDOPITYTES)													
ASPIDIACEAE Thelypteris palustris Schott Marsh Fern 692													(PH,T)5
ASPLENIACEAE Asplenium platyneuron Ebony Spleenwort (L.) Oakes 449			PH 6										
BLECHNACEAE Woodwardia areolata Netted Chain-fern (L.) Moore 693													(t,T)5

PARTIAL LIST OF PLANT SPECIES OF THE VIRGINIA COAST RESERVE
By Cheryl Ann McCaffrey

SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL GODWIN	MYRTLE	MINK	SMITH
OSMUNDACEAE Osmunda regalis var. spectabilis (Willd.) Gray Royal Fern 476							t 6						T 5
PTERIDACEAE Pteridium aquilinum (L.) Kuhn Bracken Fern 423, 461, 687													(G,H,A)5, (PH,T)3
GYMNOSPERMS													
CUPRESSACEAE Juniperus virginiana L. Red Cedar 544		A3,G4,AG5 (t,J)1, T2	At2, P4, (H,PH,t,J)1	(A,M)5, (t,J)1, G4,PH2	(T,AT,t)5 G4	G5			(G,T)5	M5		G5	(A,G,t)5, (PH,T)6 Noticeably Uncommon
PINACEAE Pinus taeda L. Loblolly Pine 547, 416		(T,t)5	At4, t5, T4,(P,PH)1	G5, PH1	(T,AT,t)5		G6(planted)						(T,H)5, PH2
ANGIOSPERMS													
ACERACEAE Acer rubrum L. Red Maple 439, 708, 749			H6										PH6
AIZOACEAE Mollugo verticillata L. Carpetweed 672	g5						G5						
Sesuvium maritimum (Walter) BSP. Sea Purslane 623				Chimney Pole - Mm5									
ANACARDIACEAE Rhus copallina L. Dwarf Sumac; Winged Sumac 509		T6	P6		T6								(A,G,T,H)5
Rhus radicans L. Poison Ivy 555		T1, (Ag,G, t)2 (A,B)3 g4, AG5	(P,H,PH)2	PH4	(T,AT,t)4	(G,t)3	t5					G3	(H,PH,T)2, G3, t4

PARTIAL LIST OF PLANT SPECIES OF THE VIRGINIA COAST RESERVE
By Cheryl Ann McCaffrey

SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL GODWIN	MYRTLE	MINK	SMITH
APIACEAE (UMBELLIFERAE)													
Hydrocotyle verticillata Pennywort Thurb. (?) 441, 518, 506		T3	F3		(T,AT,t)3								T5
Ptilimnium capillaceum (Michx.)Raf. Mock Bishop's Weed 739			(F,M)5										
APOCYNACEAE													
Apocynum cannabinum L. Indian Hemp 475, 606		(A,G,g, Ag)5	F5				(G,t)2		(A,G,T)5				(A,G)5, F4
Trachelospermum difforme (Walter) Gray 729													T6
AQUIFOLIACEAE													
Ilex opaca (L.) Aiton American Holly 552,661		T5	At5, (P, PH)4	PH4									(PH,T,GB
Ilex vomitoria Aiton Yaupon 451				PH6									(PH,H)2, (G,T)4, t5
ARALIACEAE													
Aralia spinosa L. Hercules Club 679													T5
ASTERACEAE (COMPOSITAE)													
Achillea millefolium L. Milfoil, Yarrow 662, 495		Ag5	H5		(A,T,AT, t)2, (G, AG)5		G5		A3	(A,G)4	A5	G4	(A,G,H)4
Ambrosia artemisiifolia Ragweed 699	t3	G5							G5				(G,T)5
Aster tenuifolius L. 725			Mm4		84								

PARTIAL LIST OF PLANT SPECIES OF THE VIRGINIA COAST RESERVE
By Cheryl Ann McCaffrey

SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL GODWIN	MYRTLE	MINK	SMITH
Baccharis halmifolia L. Groundsel-tree, Silverling, Sea-myrtle, Consumption-weed 532	(G,Ag)5	G4,AG5, T2,t	(H,F)3,G5, t2	(G,M)5,t4	(g,M)3, (G,AG)5, (T,AT,t)2	(G,M)4,t1	(G,AG)4, g3, t2		G4,T2,t1	(G,Mm,s, dr)4	(A,G)5, Mm3,t4	G3	(H,PH,M, dr)3, G4, t2
Borrichia frutescens (L.) DC. Sea Ox-eye 569, 658	(G,M,t)2		(t,Mm)3	(M,Mm,t)4	Mm4	dr2, (M, Mm,t)3	Mm3,G5,s2		Mm2, G3	(m,s)3, (M,Mm,dr) 2	Mm3, dr5	(G,Mm)3	(G,g,T,M, Mm, mf)3, t4, wf5, dr2
Carduus spinosissimus Walter Yellow Thistle 617, 535, 536		G4, (AG, T)5, t2	At2, G4, (t,P)3, PH5	A4	(G,AG,AT, t)2		AG4		G4, A5	(A,G)4			(A,G)4
Elephantopus Sp.													PH3
Erigeron annuus (L.) Persoon Daisy-Fleabane, White Top 616	Ag5	G3, (AG, t)5							A5				
Erigeron canadensis var. canadensis L. Fleabane 594	Ag5	(A,G)5, AG4,Ag2			A5				A4		G5	A5	A4, Ag2, G3
Eupatorium capillifolium var. capillifolium (Lam.) Small Dog-Fennel Yankee Weed 665, 575			G4, (t, At, P)3						A5		A5		H3, (A,G)5
Eupatorium hyssopifolium L. Thoroughwort 636, 652							G3		A5				(G,g)5
Eupatorium pilosum Walter Thoroughwort 477							(AG,G)4						

PARTIAL LIST OF PLANT SPECIES OF THE VIRGINIA COAST RESERVE
By Cheryl Ann McCaffrey

SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL GODWIN	MYRTLE	MINK	SMITH
Eupatorium rotundifolium L. Thoroughwort 631							G3						PH5
Gnaphalium chilense Sprengel Rabbit Tobacco 651, 716									G4				g3
Gnaphalium obtusifolium L. Rabbit Tobacco, Catfoot 493		(G,T,t)5			(G,AG,AT)5		(AG,G,g)4		A4	G4	A4, G5		G5, A4
Gnaphalium purpureum var. purpureum L. Rabbit Tobacco, Purple Catfoot 455, 590, 496		(AG,G) 5			AG5,AT3,A4		G5,(AG,g)4		A5, M3	A4			(A,Ag,G)5
Hieracium gronovii L. Hawkweed 479			(t,T)3		(t,AT)5		(AG,G)5						
Iva frutescens L. Marsh Elder 553, 657	M2,Ag3, (G,t)1	(G,Mm)5, (M,T)3,t1	G5, (M, Mm,t)3	t1,M2,s5	(G,M,Mm,T, t)3	G4, (M, Mm)3, t1	(M,Mm,s)3 G5		Mm3, t1, (G,g)4	A5, (G, dr)2, (Mm,s)3	dr2	G3	(H,M,mf)3, (t,Mm,dr)1
Krigia virginica (L.) Willd. Dwarf Dandelion 464					(G,T,t,AT) 5								G5
Mikania scandens (L.) Willd. Climbing Hempweed 576, 678			(G,t,M)3, F2		G3								
Pluchea purpurascens (Swartz) DC. Camphorweed, Marsh Fleabane 740, 503, 548, 558		(G,AG,M)5	F2, (t,T, M)3		M2,F1,M4, AG5,(t,T,C, s,w)3		G3						

PARTIAL LIST OF PLANT SPECIES OF THE VIRGINIA COAST RESERVE
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SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL GODWIN	MYRTLE	MINK	SMITH
Solidago microcephala (Greene) Bush Small Headed Goldenrod 653, 408, 521, 526, 756					(G,AG,AT)5		G5		A4				G5, H3
Solidago sempervirens L. Seaside Goldenrod 589	M1,(Ag,s)2 g3, (t,B, G)4, A5	(g,Ag,AG) 1, (A,G, t)2, s4, (M,s,dr)5	(A,G)5	(A,t,G)4, M3	G2	G4;M2;t3	g1, (A,G, AG)2	g4	A2,(g,dr)4 (B,wf)5	G2,m3,(A, B)4	(B,g)2, Mm3,(A, G)4	(G,Mm,dr) 2	g1, (Ag, A)2, (G, B,dr)4, (s,Mm)5
Sonchus asper (L.) Hill. Spiny-leaved Sow-thistle 597		AG5			(AG,G)5		G5		G5				A5
Verbesina occidentalis (L.) Walter Crown-Beard 567			P6										
Xanthium strumarium L. Cocklebur 683	B6	B5								G5	A5	dr2, G5	B1, g2, A3, Ag4, dr5
BIGNONIACEAE													
Campsis radicans (L.) Seemann Trumpet Vine, Cow-itch Vine 563, 685			(P,H,PH)5										(P,H,PH)4, (A,G)5
Paulownia tomentosa (Thunberg) Steudel Princess Tree													PH6
BORAGINACEAE													
Myosotis verna Nuttall Forget-Me-Not 507A					AT3								
BRASSICACEAE (CRUCIFERAE)													
Cakile edentula (Bigelow) Hooker Sea Rocket, Sea Kale 696, 405, 423	(A,g,B)1, (Ag,wf)5	B1,(A,G,g) 5	A 3	s3	(B,g)5	M3	(g,B)1	g 1	B1,g2,wf5	(A,B,s,dr) 4	(A,dr)4, (B,g)1	dr2, G5	(Ag, g, B, dr)2, A3, (s,wf,mf)5
Lepidium virginicum L. Poor Man's Pepper 584, 625, 537			At4		AG5	M3	G3, g4		A2	G5	(A,G)5	G5	(G,A)4, g5

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CACTACEAE Opuntia compressa (Salisbury) Macbride Prickly Pear Cactus 450		(A,G,Ag, T,J)5	(T,t)3, (P,PH)4	(G,PH,t)3	(T,t)3	G5	G5		G5	(A,G)4	A6	G5	(A,G)5
CAMPANULACEAE Specularia perfoliata (L.) A.DC. Venus' Looking-Glass 626							G4		(A,G,T)5				
CAPRIFOLIACEAE Lonicera sempervirens L. Coral Honeysuckle, Trumpet Honeysuckle													T6
Sambucus canadensis L. Common Elder 668			At6										
CARYOPHYLLACEAE Cerastium glomeratum Thuillier Chickweed 487		AG5			(AG,T,AT, t)3, s5	G5	G5		G5		A5		A5
Sagina decumbens (Ell.) T.&G. Pearlwort 436		A3, (M, dr)5	(s,G,Mm)3		(G,AG,AT)3, g5		G4				G5		
Spergularia marina (L.) Griesb. Sand Spurrey 492, 507, 659, 499	s4	Mm2			s2,(g,B)3	M2				m3, s4			
CELASTRACEAE Euonymus japonica L. 599					G6 (planted one tree)								
CHENOPODIACEAE Atriplex arenaria Nuttall Seabeach Orach 624, 753	A2, (Ag, g,B,t,s)4 wf5						g4		(A,G)5, (g,wf)4		(g,Mm)5		(g,Mm,s, dr,wf,mf) 5, A4, B3

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SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL GODWIN	MYRTLE	MINK	SMITH
Atriplex patula L. Orach 486, 707	(Mm,t)5	s5			(M,Mm)3	(M,Mm,t)3	Mm5		g5	(Mm,s)4	(t,Mm,s, dr)5	G5	(M,Mm,s, dr,wf)5
Bassia hirsuta (L.) Aschers 615, 737; Fernald		(Mm,s)5	Mm 5				g5		Mm5,(g,wf) 3				
Chenopodium album L. Pigweed Lamb's Quarters 673	g6												
Chenopodium ambrosioides L. Mexican Tea 721, 491		(T,J)5				(G)4	(G,g)5		A5	G4, A5	A3	G5	(A,G,Ag)5
Salicornia bigelovii Torrey Glasswort 404, 595	(Mm,wf)5, s4	Mm5, s2	s1, (Mm, t)3		(Mm,s)4, wf5		Mm4		s5		(s,Mm)5	s5	(m,s,dr, wf,mf)5
Salicornia evropaea L. Glasswort 425, 609, 453	Mm2, wf5	(Mm,s)2	(s,Mm)4, (t,M)3				Mm4		mf2	Mm5		Mm4	mf4, (Mm,m)5
Salicornia virginica L. Glasswort 550, 424	Mm2,s1,(t, G,Ag)3	(Mm,s)2	(M,m,t)3, (Mm,s)1	Mm1	Mm1, s2	Mm1	m4,(Mm,s)2		Mm2	m4, Mm1	(Mm,s)2	Mm3,s2	Mm1, (m, s,wf)5
Salsola kali L. Russian Thistle 429	(g,B)2, (A,Ag)5	(A,G)5	G5,A2,B4		A5		g4	g2	B5, g4		(B,g)2	(Mm,dr)4 G5	(G,A,g)4, B2
Suaeda linearis (Ell.) Moq. Sea-blite 731, 614	Ag3, (s, Mm)4, t5	(Mm,s)5							wf2, (Mm, G)4, g5	(wf,Mm)4	Mm5		(dr,s)4, (g,Mm,wf) 5
CISTACEAE Helianthemum canadense (L.) Michaux Frostweed, Rockrose 466													G6

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SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL CODWIN	MYRTLE	MINK	SMITH
CONVOVULACEAE Calystegia sepium (L.) R. Brown Hedge Bindweed 700, 489, 494, 675, 583	(M,t)3, (G,Ag)4	(G,AG,T, t)5	t5		G5	(G,M)2	(G,g,t,M) 2, AG4		(A,T)2	(A,dr)4, G2	(G,dr)2, A4	G2	(G,T)5, (A,g)4
CYPERACEAE Bulbostylis capillaris (L.) C.B. Clarke 738			At 5										
Carex festucacea Schkuhr 504, 642		t4	T2, (M, F)3		(AG,G)3		G2		(A,G)2				PH3, (A, G)4
Carex pensylvanica Lam. 434			PH 6										
Carex vulpinoidea Michx. 663			T2										
Cyperus esculentus L. Nut Grass 743			B5										
Cyperus grayi Torrey Sedge 437			t6										
Cyperus odoratus L. Sedge 741			t5										
Cyperus Sp. Sedge 664			P5										
Eleocharis acicularis (L.) R. & S. Spike-rush 641			F3				Mm3						M5
Eleocharis erythropoda Steudel. Spikerush 634							G2						

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Eleocharis palustris (L.) R. & S. Spikerush 571			(M,F)2, (T,PH)3										
Eleocharis parvula (R. & S.) Link. Spikerush 528, 529					(G,g,M, s)3								
Eleocharis Spp.		(AG,M)5, t3			AG3								
Eleocharis tenuis (Willdenow) Schultes Spikerush 691													M5
Fimbristylis spadicea (L.) Vahl. 546, 579, 540, 426	M5, G4	(G,M)5, AG4	M3	(M,t)5	(G,AG,g)2 (T,AT,t, M,Mm,s)3		G5		G5, g4, Mm3	A5, G4	G4	G4	(A,T,Mm)3, (G,g,t,M)5
Scirpus americanus Persoon Three-square Sedge 630, 457, 508	(Mm,G,Ag) 3, M1	(Mm,A,AG) 3, t2, (G,M)4, (g,Ag)5	(G,M,F)3, A5		M3, (F,G, AG)4,(t, s)5	G5	(A,g)5, (G,t)4		G5	G4	(A,G)4	G5	(A,G,T,t, M,dr)5,M3, (G,g)4, F2
Scirpus cyperinus (L.) Kunth. Bulrush, Woolgrass 639			(T,F)3				G6						
Scirpus robustus Pursh. Big Three Square Sedge 648, 612		M5	M5	M5					Mm5				(G,M,F,t)5
EBENACEAE Diospyros virginiana L. Persimmon 413, 712													(H,T)6
ERICACEAE Vaccinum atrococcum (Gray) Porter Black Highbush Blueberry 460													(T,H,PH)5

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Vaccinium corymbosum X *atrococcum* (?) Highbush Blueberry 705													PH5
EUPHORBIACEAE *Euphorbia polygonifolia* L. Seaside Spurge 628, 702	(Ag,g)5, A4	(A,g)5	At4				g5, G3		g5		A5		(A,Ag)5, G3, B4
FABACEAE (LEGUMINOSAE) *Cassia fasciculata* Michaux Partridge Pea 645							G6						
Centrosema virginianum (L.) Benth. Butterfly Pea 699													(PH,t)5, (G,H)4
Robinia pseudo-acacia L. Black Locust 414, 682													PH2, H1, (t,T,G)5
Strophostyles helvola (L.) Ell. Wild Bean 587	(Ag,G)4, A2	(A,AG)4, (G,Ag,t)5				G5	(G,g)2, AG5		(G,g)2, (g,dr)4, B5	G2	(A,G)2	G4	(A,g,Ag)2, (B,G)4, (A,G)5
Strophostyles umbellata (Muhl. ex Willd.) (?) Britton Wild Bean 654, 403							B5, G4						
FAGACEAE *Quercus falcata* Michx. Southern Red Oak, Spanish Oak 417, 714													(PH,H,T,t)5
Quercus laurifolia Michaux Laurel Oak, Darlington Oak 758													PH6
Quercus nigra L. Water Oak, Possum Oak 713, 462													(PH,H,t)5

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Quercus stellata Wang. Post Oak 715													(PH,H)5
Quercus virginiana Miller Southern Live Oak 469													T6
GENTIANACEAE Sabatia stellaris Pursh. Marsh Pink 747				G5	G4								A5
Centaurium pulchellum (Sw.) Druce Centaury 734; Fernald			PH 6										
GERANIACEAE Geranium carolinianum L. Cranesbill 520					(T,AT,t)4								
HAMAMELIDACEAE Liquidambar styraciflua L. Sweet Gum 418, 688, 750			P6										PH4, (H, T)5
HYPERICACEAE (GUTTIFERAE) Hypericum gentianoides (L.) BSP. Pineweed 505			At3		(A,G,AT, t)5		(G,AG)5						
Hypericum hypericoides (L.) Crantz St. Andrew's Cross 440			T6				t6						
IRIDACEAE Sisyrinchium angustifolium Blue-eyed Grass 644, 746			(H,P)3				(G,t)5						

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SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL GODWIN	MYRTLE	MINK	SMITH
JUNCACEAE													
Juncus acuminatus Michaux Rush 671			F5										
Juncus biflorus Elliott Rush 711													PH5
Juncus bufonius L. Toad Rush 575, 539		G5	M3		Mm3								
Juncus coriaceus MacKenzie Rush 432			H6										
Juncus debilis Gray 638							G5						
Juncus dichotomus Ell. Rush 412, 422, 650, 448, 459, 482		G5, M4	(T,At)5		(G,AG,t)2, AT4, M5		AG4, G2		G5				H4,G5
Juncus gerardi Loisel. Black Grass 613 ; Fernald		Mm3	M3										
Juncus roemerianus Scheele Black Rush, Needle Rush 568, 690		M5	(F,M,T, t)3	(M,Mm)3		M5						G5	(M,Mm)4,A6
Juncus scirpoides Lam. Rush 402, 483			(A,At,T, F)3		(AG,AT,G, t)3		(G,t)4		(T,G)5				
Juncus tenuis Willd. Path Rush 736	t5	M3,G5,t2	M4, PH5		G5				G3				

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SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL GODWIN	MYRTLE	MINK	SMITH
LAMIACEAE (LABIATAE) Monarda punctata L. Horsemint 585, 500						(G,dr)5	G5		A5, G3	G5			(A,G)4, H3
Teucrium canadense L. American Germander, Wood Sage 485, 549, 454		G5, T2	A4		G4	G2	M3, G5		A5	G4	(T,t,dr)4, A5	Mm3, (G, dr)4	(A,G,T,dr) 5
LAURACEAE Persea palustris (Raf.) Sarg. Red Bay 430; Fernald			At4, (P, PH,H,t)1										PH2, H1, (T,t)5
Sassafras albidum (Nuttall) Nees Sassafras 510		T6	(PH,H)5, P4		T6								(PH,H)4, (A,G,T)5
LILIACEAE Allium canadense L. Wild Onion 647			t 5						A5				g5
Smilax bona-nox L. Greenbriar 554			H1, t4, (P,PH)4	PH4	(T,AT,t)5	G5							PH3,t4,A5, H1,(T,G)2
Smilax glauca Walter Greenbriar 472, 442, 703, 686			T5										T5, PH4
Smilax rotundifolia L. Greenbriar, Catbriar 733, 471, 556		T3	PH2										(T,H,PH)4
Yucca filamentosa L. (non sensu modern authors). Y. flacida in part Bear Grass 415, 706, 757													(T,A)6

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LINACEAE Linum virginianum var. floridanum Planchon Flax 677					G5								G5
MALVACEAE Hibiscus moscheutos ssp moscheutos L. Rose Mallow 722, 632		(G,t)3							(G,T)5				(G,t)5, (M,T)3
Kosteletskya virginica (L.) Presl. Seashore Mallow 607, 742		M4, AG5	(M,F)4		G5								(PH,T)3, (M,F)4, (G,M,t,dr) 5
MORACEAE Ficus carica L. Fig					G6								
Maclura pomifera (Raf.) Schneider Osage Orange, Hedge Apple 605		A6											
MYRICACEAE Myrica cerifera L. Wax Myrtle 618, 497	(G,Ag)5	(A,G,AG)5, (T,J)2,t1	A3, At2, G5, (T, t,P,H,PH) 1	t2, G5	G4, (AT, T,t)1, (G,AG,M)5	G2, t1	(A,G)5, t1		T1, G5	G4, (t,M)5	G5		(A,G)4,g5, (H,PH)2, (T,t)1
Myrica pensylvanica Loisel. Bayberry 498, 610	(Ag,G)5	(T,t)2, (A,G,g)5	At3	G5	t5	G5	G5		T1	G5	G6		(H,G,A)5
NYSSACEAE Nyssa sylvatica Marshall Black Gum, Tupelo 730, 680													(H,PH)5

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ONAGRACEAE Oenothera biennis L. Sundrops 656	Ag3												
Oenothera fruticosa L. Sundrops 643							G5						
Oenothera laciniata Hill Evening Primrose 490, 593					G5				(A,g)5		A5		
Oenothera laciniata Hill (?) (O. humifusa Nuttall?) Evening Primrose		(A,G,g, Ag)5,AG4	(A,t)5,G4		(AG,G,AT) 5		(g,G)5, AG4		G3	A5	G5		(A,G)5
ORCHIDACEAE Spiranthes vernalis Engelm. & Gray Spring Ladies Tresses 678					G5								G5
PHYTOLACCACEAE Phytolacca americana L. Pokeweed, Pigeonberry 596					G5							G5	
PLUMBAGINACEAE Limonium nashii var. nashii Small Sea Lavendar 649, 452	(Ag,G,t)3, M2	(Mm,s)2	(M,s)5, t3, Mm5	Mm2	Mm5	Mm2	Mm4		Mm2	G3, (M, Mm,m)4	Mm4	Mm4	(m,M,Mm, s)5, G3
POACEAE (GRAMINEAE) Aira elegans Willd. ex Gaudin Hair Grass 622					G5		G5						

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Ammophila breviligulata Fernald American Beachgrass 574	(A,Ag)1, g2, (G, B)4, t5	(A,G,AG, g,Ag)1, B4, t5	(A,At)1, (t,P)3, B4	A1, G3	(AG,AT,B)1, G4, g2	G2, t4	G3, g5	g4	(A,g)1,G2, dr4, B5	A1, (G, B)4	A1, G2, (g,B)4	G4	(A,C,g, Ag)1, G4, B2
Andropogon scoparius Michx. Little Bluestem 474, 427			(t,P,PH)5		(AG)4,AT2	G4	AG1, g3, G4						(A,G,g)3 g3, H4
Andropogon virginicus L. Broomsedge 411, 480, 431		(G,AG,t)5	(A,G,P,H, PH)3, t4	t4	(G,AG,AT)2, (T,AT,t)4	G2	(G,AG)3		G5				(t,H)4, (A,G,T)5
Andropogon virginicus var. abbreviatus (L.) Fern. & Grisc. Broomsedge 419, 481		AG4, G5	(A,P,H)3, (G,t)4	t5	(G,AG,t)2, (T,AT,t)3	G2	G3		G4, A5	G4	(A,G)4	G4	(A,G,t)4, (G,E)5, A2
Aristida Sp. Three-Awn Grass 754													H3, A5
Aristida tuberculosa Nuttall Three-Awn Grass 433, 446			A4, At2, (t,P,PH)3	(A,G)4	(AG,AT)3								
Cenchrus tribuloides L. Sandspur 445, 677, 701	(A,Ag)5	A4	A4, At2		AT5				g5	A4			(A,g,B)5, Ag2, (A,G)2
Cynodon dactylon (L.) Persoon Bermuda Grass 728			T4		(AG,T,AT)4				g4				
Danthonia compressa Austin Oat Grass 566			P5										
Distichlis spicata (L.) Greene Salt Grass 578	(Ag,Mm, s)4, (G, wf)5, t1	AG5, (T, Mm,s)4,M1	(s,F)3,t3 (M,Mm)2	(t,M)2, Mm3	(M,Mm,s)2, (G,g,T,t)3	M1, (Mm, t)2	(Mm,s)2, G3, g5		(Mm,g)3	Mm2, G3	Mm4	Mm3, s5	M1, (G,t)3, dr4, (g,m, s,wf)5, (G,Mm)3
Elymus virginicus L. Wild Rye Grass 710			H4									G5	(A,G,H)4, T5
Eragrostis Sp. Love Grass													A2

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SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL GODWIN	MYRTLE	MINK	SMITH
Eragrostis cilianensis (Allioni) Lutati Stink Grass 674	g6												
Festuca rubra L. Red Fescue 559, 602, 600, 458, 601	t4	(G,AG,T, t)2	(t,H)3		G2, (AT, AG)4, t3		G2		G2, A4	G4	(A,G)2	G2	(A,G)2,H3 (T,t)5
Festuca sciurea Nuttall 604, 504		G4, AG5			(AG,G)3								G5
Muhlenbergia capillaris (Lam.) Trin. Hair Grass, Muhly													A6
Panicum amarulum Hitchcock & Chase Panic-Grass 456			A5, G4						(g,dr)4	A5	(A,G)4		(G,A,Ag)4
Panicum amarum Ell. Bitter Panic-Grass 435, 428, 598, 637	(A,g,Ag, B)4	(B,AG)4, A1, Ag2, (G,g,t)5	A1, G4	A4, t3	AG4	G5	G3, g5	g4	B5, (Ag, dr)4	G4, A2	A4, (B,g) 5	G5	(Ag,g)2, (A,G,B)4
Panicum dichotomiflorum Michaux 752			F1										
Panicum lanuginosum Elliott Panic Grass 456			(G,T,t)3	t3			(AG,G)3						
Panicum scoparium Lam. Panic Grass 709, 409													(G,F,T)5
Panicum Sp. Panic-Grass 501					(G,AG,t, AT)3					G4			
Panicum sphaerocarpon Elliott Panic-Grass 635							G2						
Panicum virgatum L. Switchgrass 410, 420, 541	Ag5		G4, PT5		(G,AG)5		G5						(A,G,Ag, T,t,H)5

PARTIAL LIST OF PLANT SPECIES OF THE VIRGINIA COAST RESERVE
By Cheryl Ann McCaffrey

SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL GODWIN	MYRTLE	MINK	SMITH
Paspalum dilatatum Poiret Dallis Grass 745			T3										
Paspalum floridanum Michx. 744			PT3										
Phragmites communis Trinius Common Reed 676, 456, 484, 570	(M,Ag)4	(AG,g,Ag)5, (t,M)4	(G,t,F,M)3				G4		G4	G5	G5		(F,G)5
Poa annua L. Annual Bluegrass 512		G5			(T,t)4								PH5
Polypogon monspeliensis (L.) Desf. Rabbit-foot Grass 621			(T,M)3		G3								PH5
Puccinellia fasciculata (Torr.) Bicknell 660; Fernald	s6												
Setaria geniculata (Lam.) Beauvois Little Fox-Tail 581, 662			(G,t)4, M5,PH3	M5, t4, G2	(G,AG)2, (T,AT)3	G4	G2		G5	(A,G)4	G4, A3	G4	(T,t,g)5, (A,G,Ag)4, M3
Setaria magna Griesb. Giant Foxtail 748			(F,t,At)3										
Spartina alterniflora Loisel Salt-water Cordgrass, Low Marsh Cordgrass 577	(m,Mm,s, wf)1, M4, mf2, (Ag, t,G)3	(m,Mm)1, s2	(m,Mm)1, M3, s5	m1, Mm2	(m,Mm)1, s4, g5	(Mm,m)1	(m,Mm,s)1	(m,wf)1	(m,Mm)1, (wf,dr)4, (g,s)5	(m,Mm)1	(m,Mm,s, wf,dr)1	(m,Mm)1, s2	(m,Mm,s, wf,mf)1, dr4, M5
Spartina patens (Aiton) Muhl. Salt-Meadow Grass, High-Water Grass 527, 580, 667	(G,g,Ag, M,t)1, wf5, (A, B)4	(G,g,AG, Ag,M,t,T, J)1, A2, B4, (Mm, s)5	(A,G,F,M)1, t2, (At,T,P, PH,Mm)3, B4	(t,G,M)1, (A,s)2	(G,AG,B, T,t,AT,M, F,s)1,(A, g)2, Mm3	(G,M,t)1	(G,M)1, (A,AG,t)2 Mm3, g5		(G,t)1, g2, Mm3, dr4	(G,Mm,s, dr)1,m3, A4	G1, (A, Mm)2, (B, g)5	G1	(A,G,g,Ag, M,F)1, (G,E)2, (t,Mm,mf)3 dr4, (s, wf)5

APPENDIX E

PARTIAL LIST OF PLANT SPECIES OF THE VIRGINIA COAST RESERVE.

By Cheryl Ann McCaffrey

SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL GODWIN	MYRTLE	MINK	SMITH
Sphenopholis obtusata (Michx.) Scribner Wedge Grass 640							G3		G5				
Triplasis purpurea (Walter) Chapman Sand Grass 588	Ag5	A5	At2		AG4		g5		A5				Ag2, (A, G,B)4
Uniola laxa (L.) BSP. Spikegrass, Spanglegrass 421, 564			(P,t,T, PH)3		T4								PH2, (H, T)4
Uniola paniculata L. Sea Oats 755													A6
POLYGONACEAE													
Polygonum glaucum Nuttall Seabeach Knotweed 530					(G,g)5		G4, g5						
Polygonum hydropiperoides Michaux Mild Water-Pepper 523			F3		T3								
Rumex acetosella L. Sheep-Sorrel, Sour Grass 572, 478		(A,G,T)5	t4	A4	(AG,G,AT, t)2	G5	(G,AG,g)2						H5, G4
Rumex crispus L. Dock 646							G5		G5			G5	
PRIMULACEAE													
Samolus parviflorus Raf. Water Pimpernell 538, 524, 582	G5	(M,T)4	T3, F5		(AG,G,T, t)3, F5		G3						M5
RHAMNACEAE													
Berchemia scandens (Hill) K. Koch. Rattan-Vine, Supple-Jack 670			(H,PH)2										H5

PARTIAL LIST OF PLANT SPECIES OF THE VIRGINIA COAST RESERVE

By Cheryl Ann McCaffrey

SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL GODWIN	MYRTLE	MINK	SMITH
ROSACEAE													
Amelanchier obovalis (Michx.) Ashe Shadbush, Serviceberry, Junebush 467													(H,PH,t)5
Crataegus viridis L. Hawthorn 704													H6
Prunus maritima Marshall Beach Plum 591; Fernald					G6	G5							
Prunus serotina Ehrhart Black Cherry 400, 561, 443		G5, T4	(At,P,H, PH)4		(T,t,AT)5	G6			T5				(H,PH)1, T2, (t,G)5
Rubus argutus Link. Blackberry 513, 534		T5	T3, t5		(T,AT,t)4, G3		G3						
Rubus Spp. Blackberry					G6								T5, G3
Sorbus arbutifolia (L.) Heynhold Red Chokeberry 681													(PH,H,t)5
RUBIACEAE													
Diodea virginiana L. Buttonweed 724			PH5		AG5								
Galium hispidulum Michaux Bedstraw 698					AG4								G5
Galium pilosum Aiton Bedstraw 514					AT5								

PARTIAL LIST OF PLANT SPECIES OF THE VIRGINIA COAST RESERVE

By Cheryl Ann McCaffrey

SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL CODWIN	MYRTLE	MINK	SMITH
Galium tinctorium L. Bedstraw 517, 629			T3		(F,T,M)4		G5						
Mitchella repens L. Partridge Berry 565			P5										(PH,T)5
RUPPIACEAE *Ruppia maritima* L. Ditchgrass, Widgeon-Grass 557		w5	W2	W2	W2								w5
RUTACEAE *Zanthoxylum clava-hercules* L. Hercules Club, Prickley Ash 407, 684			At4, (P, PH)5		G2, AG5, AT4								t3, (A,G, T)5
SALICACEAE *Populus alba* L. Silver Poplar, White Poplar 727			PH6									G6	
Salix nigra Marshall Black Willow 444, 533, 543, 608		A3, t6	(F,H)3		(T,AT,t)5		t6, (G, t)5						(H,T,F)5
SCROPHULARIACEAE *Agalinis maritima* (Raf.) Raf. Gerardia 723					s4								
Agalinis purpurea (L.) Pennell Gerardia 525					G5								
Bacopa monnieri (L.) Pennell Water Hyssop 676					(S,M)5								

PARTIAL LIST OF PLANT SPECIES OF THE VIRGINIA COAST RESERVE

By Cheryl Ann McCaffrey

SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL CODWIN	MYRTLE	MINK	SMITH
Linaria canadensis (L.) Dumont Toadflax 465, 627		(A,G,AG, T)5	(P,H)3		(A,G,AG, AT)4	G5	G5		A5				G4, (PH, A)5
Verbascum thapsus L. Woolly Mullein 531			PH3		(G,AG)5								G3
Veronica serpyllifolia L. Thyme-leaved Speedwell 581			H3										
SOLANACEAE *Physalis viscosa* ssp. *maritima* (M.A. Curtis) Waterfall Ground Cherry 488, 595						G6					A3	G4	(G,A)5
Solanum carolinense L. Horse-Nettle, Ball-Nettle 515					(AT,AG)5								G5
TYPHACEAE *Typha angustifolia* L. Narrow-leaved Cat-tail 611, 551		M3	F1, M3		F4		G3						F5
Typha latifolia L. Common Cat-tail 735			F3										
URTICACEAE *Boehmeria cylindrica* (L.) Swartz False Nettle 545, 401, 522			F2, (T,H, PH)3		(M,T)5								PH5
ULMACEAE *Ulmus americana* L. American Elm, White Elm 732													H6

PARTIAL LIST OF PLANT SPECIES OF THE VIRGINIA COAST RESERVE

By Cheryl Ann McCaffrey

SPECIES	METOMKIN	CEDAR	PARRAMORE	REVEL	HOG	ROGUE	COBB	LITTLE COBB	WRECK	SHIPSHOAL GODWIN	MYRTLE	MINK	SMITH
VALERIANACEAE													
Valerianella			PH6										
VERBENACEAE													
Callicarpa americana L. French Mulberry, Beauty-Berry 697													(G,A,T,t, PH)5
Lippia lanceolata Michaux Fog-Fruit 726, 573, 519			F2		M3, F4								
VITACEAE													
Parthenocissus quinquefolia (L.) Planchon Virginia Creeper 438, 689, 560	Ag5	A3, (G,Ag, T)2, t5	A3, (H, PH)2		(T,t,AT)2								(T,t,H)4, G3
Vitis aestivalis Michx. Summer Grape 516, 562, 669		A2	(t,T,P, PH)2		(t,T,AT)4								PH2, G3, H4
Vitis rotundifolia Michx. Muscadine Grape 468, 694													PH2, (A, T)3, H4, (G,t)5
ZOSTERACEAE													
Zostera marina L. Eelgrass													dr4

APPENDIX F

PLANT SPECIES LIST

Introduction.

The following is a list of plant taxa observed on the Virginia barrier islands during this study. This included 222 taxa (genera, species, subspecies, and varieties) representing 60 families (excluding the algae). It is, by no means, a complet list of the plants from these islands. Nomenclature follows that of Radford, Ahles, and Bell, 1968, Manual of the Vascular Flora of the Carolinas, unless otherwise noted when that of Fernald, 1974, Gray's Manual (8th ed.) is followed. The latter is noted by an "F" following the collection number.

The tabular form notes, for each plant, the island, mapping unit, and abundance observed during the islands' visits. The authors collection number(s) are noted below the common name. The voucher specimens have been verified by Harry E. Ahles (University of Massachusetts, Amherst), Wilbur H. Duncan (University of Georgia), or by comparisons with specimens at the University of Georgia herbarium. The voucher specimens have been deposited with The Nature Conservancy, Wachapreague, Virginia, with duplicates of most specimens deposited at the herbarium of the University of Massachusetts, Amherst, Massachusetts. All algal identifications are by Dr. Russell Rhodes, Kent State University, Ohio.

The estimations of abundance given are as observed during the author's field time on the particular island. They may be somewhat misleading due to variation in the season each island was visited. The main field work was done from March 23-July 30, thus many significant plants were not yet obvious on many islands. Omissions, then do not necessarily indicate that a plant is absent from an island.

Table 2.(dates of field work) is included to help clarify interpretations of presence and abundances on particular islands.

Explanation.

The community codes are the same as the mapping units of the accompanying vegetation map and are explained in the legend (p.394 in the text).

The abundances are estimated as explained on pages 395-425 of the text (mapping unit descriptions). In this list they are coded by numbers as follows:

1 - Dominant

2 - Abundant

3 - Locally found

4 - Frequent

5 - Occasional

6 - Rare (less than 25 individuals)

All abundances are considered generally ubiquitous in the mapping units except "3" in which plants were found only in some localities of the community, usually abundant or frequent where found.

Mapping units having the same abundance are listed together in parentheses, e.g. (G,A,Ag)3.

Some communities may be listed in groups twice with different abundances, e.g. (T,t,G)2; (A,g,G)5. This indicates that the species will be abundant in interior grasslands, possibly associated with thickets, but occasional in grasslands nearer the beach or with dunes or overwash areas.

The only species on Godwin Island is Spartina alterniflora, thus Ship Shoal/Godwin species are all on Ship Shoal with this exception.

Critical Status.

No threatened or endangered species were seen. (As listed in: USDI, Fish and Wildlife Service, July 1, 1975. Threatened or endangered fauna or flora: review of status of vascular plants and determination of "critical habitat". Federal Register, 40; 127; V; 27824-27924.)

Naturalized Species.

The following species are noted in Fernald, Gray's Manual (8th ed.) as naturalized, that is, they are not native, but have become established:

Achillea millefolium - Asteraceae
Aira elegans - Poaceae
Bassia hirsuta - Chenopodiaceae
Centaurium pulchellum - Gentianaceae
Cerastium glomeratum - Caryophyllacea
Cynodon dactylon - Poaceae
Chenopodium album - Chenopodiaceae
Chenopodium ambrosioides - Chenopodiaceae
Paspalum dilatatum - Poaceae
Poa annua - Poaceae
Polypogon monspeliensis - Poaceae
Populus alba - Salicaceae
Rumex acetosella - Polygonaceae
Rumex crispus - Polygonaceae
Sonchus asper - Asteraceae
Verbascum thapsus - Scrophulariaceae
Veronica serpyllifolia - Scrophulariaceae

Planted Species.

The following species were planted on the islands:

Euonymus japonica - Celastraceae
Ficus carica - Moraceae
Maclura pomifera - Moraceae
Prunus maritima - Rosaceae

Populus alba (Salicaceae) was probably planted and escaped on Parramore Island. The colony of this species on Mink Island, however, is probably an escape.

The two locations of Prunus maritima are known to have been planted. It is, however, native along the coast south to Delaware according to Fernald.

One individual of Paulownia tomentosa was found on a northern ridge of Smith Island. It is probably a stray.

Observations.

Two species which were expected but not found were:

Hudsonia tomentosa (Cistaceae) and Iva imbricata (Asteraceae).

Aristida tuberculosa (Poaceae) shows a break in its northern and southern range here. It is known in the sand hills of the south, and along the coast in the north. (Note from Harry E. Ahles, Curator of the University of Massachusetts herbaria, and co-author of The Manual of The Vascular Flora of the Carolinas).

Cyperus grayi (Cyperaceae) is noted as a rare plant by Radford, Ahles, and Bell 1968.

An unusual tussock type of growth habit was noted for Spartina patens (Poaceae) occasionally in the brackish marshes of Parramore Island.

Range Limits or Unusual Range.

The following species are possibly at or near the ends of their ranges or are not generally expected near the coast. Those with an asterisk (*) probably do reach their limit on the islands studied in this report or are especially unusual. The ranges are based on those given in Fernald, Gray's Manual (8th edition), or on Radford, Ahles, and Bell. 1968. The terms indicating range status follow that of the Center for Natural Areas Ecology Program Smithsonian Institution, 1974. They are:

Northern limit - Northernmost extent of typically southern plants

Northern Outlier - Isolated populations of plants considerably north of the main concentration

Southern Limit - Southernmost extent of typically northern plants

Southern Outlier - Isolated populations of plants considerably south of the main concentration

Coastal Plain Outlier - Mountain or piedmont species occasionally found in small numbers

The following species are significant for their range extent:

*Bassia hirsuta (Chenopodiaceae)----- Southern outlier
Borrichia frutescens (Asteraceae) sea-ox-eye - At or near northern limit
*Centaurium pulchellum (Gentianaceae) druce - At or near southern limit
Crataegus viridis (Rosaceae) hawthorne - At or near northern limit
*Danthonia compressa (Poaceae) oat grass - Coastal plain outlier
Eleocharis erythropoda (Cyperaceae) spike rush - Southern coastal outlier
*Eragrostis cilianensis (Poaceae) stink grass - Coastal plain outlier
*Gnaphalium chilense (Asteraceae) ----- Northern outlier
*Hypericum hyperiocoides (Hypericaceae) St. Andrew's cross - Northern outlier
*Ilex vomitoria (aquifoliaceae) yaupon - Northern outlier
*Linum virginianum var. floridanum (Linaceae) ----- Northern outlier
Paspalum dilatatum (Poaceae) dalis grass - At or near northern limit
Paspalum floridanum (Poaceae) ----- At or near northern limit
*Physalis viscosa ssp. maritima (Solanaceae) ground cherry - Northern outlier
Pluchea purpurascens (Asteraceae) ----- At or near northern limit
*Puccinellia fasciculata (Poaceae) ----- Southern outlier
*Quercus virginiana (Fagaceae) live oak - Northern outlier

*Uniola paniculata (Poaceae) sea oats - Northern outlier
*Veronica serpyllifolia (Scrophulariaceae) thyme-leaved speedwell - Coastal plain outlie
Zanthoxylum clava-hercules (Rutaceae) Hercules club - Northern outlier

TABLE 2 APPENDIX F

DATES OF FIELD WORK (43 days)

LOCATION (Island)	Jan. 28 & 29	March 23 – 29	March 30 – 5	April 6 – 12	April 13 – 19	April 20 – 26	April 27 – 3	May 4 – 10	May 11 – 17	May 18 – 24	May 25 – 31	June 1 – 7	June 8 – 14	June 15 – 21	June 22 – 28	June 29 – 5	July 6 – 12	July 13 – 19	July 20 – 26	July 27 – 2	Oct. 2
Metomkin(North End)																					
Metomkin(So. & Cent.)																					
Cedar																					
Parramore																					
Revel																					
Cresent & Chimney Pole																					
Hog																					
Rogue																					
Cobb																					
Little Cobb																					
Wreck																					
Ship Shoal/ Godwin																					
Myrtle																					
Mink																					
Smith																					

APPENDIX G

COMMONWEALTH of VIRGINIA

R. H. WOODLING, DISTRICT FORESTER

Department of Conservation and Economic Development
DIVISION OF FORESTRY

BOX 3300, PORTSMOUTH, VA. 23703
TELEPHONE 488-1921 (804)

October 27, 1975

FOREST MANAGEMENT
Timberland Examinations
The Nature Conservancy
Parramore Island

Mr. Gerard Hennessey
The Nature Conservancy
Wachapreague, Virginia 23480

Dear "Rod":

On behalf of the Virginia Division of Forestry, allow me to express my gratitude for the opportunity to visit Parramore this month and assist your organization with its studies of the island. A special thanks to Cheryl McCafferty for being a most worthy guide and injecting many valuable comments throughout the examination.

Our reconnaissance from the north end of the island to the approximate center of Italian Ridge seems to indicate zones of plant communities. The dunes on the north end contain cedar (Juniperus virginiana), hercules club (Zanthoxylum clava-herculis), cherry (Prunus serotina) and loblolly pine (Pinus taeda) as the major tree species. All of these species seem to be under constant stress here. Increment boreings from loblolly show rapid growth up to age 35 years. At this point diameter growth shows a marked decrease probably indicating root contact with adverse soil and water conditions. This rapid growth phenomenon may be somewhat misleading since "open-grown" stems do react this way. Other natural factors such as salt spray, storm damage, sand burial and deer browsing are evident and do add to the stunting, the off color apperance and mortality.

A change to lower elevations in this area reveals the presence of waxmyrtle, (Myrica cerifera), redbay (Persea borbonia), greenbriar (Smilax rotundifolia) and a variety of other woody plants that I recognize only by sight. Two separate communities of red maple (Acer rubrum) were seen at the transition of the dune and lowland zones. This might indicate that soil moisture is too limited for hardwoods on the elevated dunes and competition too severe for them in the lowlands. Loblolly pine, mostly old-growth, was found in the transition between the lowland and the inland ridges.

Loblolly pine in an almost pure but not totally even-aged form is present on the entire length of Italian Ridge. Increment boreings indicate very slow development from juvenile growth to the present. Stand density throughout this rotation

as well as site conditions are probably responsible. With the exception of one community of sweet gum (Liquidambar styraciflua), no other deciduous tree species were observed. This is somewhat puzzling in that species of maple, oak, holly, gum, sassfrass and dogwood are usually prevelent as the understory to loblolly. The only explaination I can give are heavy browsing by deer and mortality from wildfire. On a critical site, these two influences would quickly prevent and have a lasting affect on the development of any understory composing hardwoods.

Pine mortality by the southern pine bark beetle (Dendroctanus frontalis) and ips engraver (Ips spp.) has been evident on Parramore for many years. Infestations begin with lightning strikes, wind damage, flood damage and wildfire. Bark beetle activity is cyclic in nature and is dependant on a complex relationship between weather conditions, soil conditions, tree vigor and predator populations. I am somewhat surprised that bark beetles have not been more destructive in recent years than what has occurred. There are many areas on the mainland that were totally wiped out in the late 1960's and early 1970's. Perhaps that wood-sand diet doesn't agree with them.

From the observations I made, the question of succession on Parramore has not been answered. I believe pine to be present on the ridges because the site is acceptable and protected and the species is not forced to compete with any other vegetative cover. As long as the site is not changed, the entire stand is not terminated and ingrowth continues, loblolly pine will indefinitely occupy the sandy ridges. If wildfire and deer browsing are, in part, responsible for maintaining this community, some artificial management may be necessary.

The thought that Parramore might finally result in a thicket of waxmyrtle, redbay, smilax and cedar may have some merit. According to Higgens, Rappleye and Brown from their studies on Assateague, "Any physiographic change on the strand brings about a change in the plant community and it has been shown that the new communities may be of 'lower' successional status as often as one of successional 'advance'.

The Division of Forestry's relationship with Parramore is long standing and has been through technical assistance, fire control and excellent cooperation with the private owners. We extend this same spirit of cooperation to the Nature Conservancy and offer our assistance to its fullest extent.

Very truly yours,

Richard L. Folk

Richard L. Folk
County Forester
Virginia Division of Forestry

RLF/rlf
cc: R. H. Woodling

COMMONWEALTH OF VIRGINIA

MARVIN M. SUTHERLAND
Director
A. S. RACHAEL, JR.
Executive Assistant
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DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF FORESTRY
Box 198, Waverly, Virginia, 23890
Telephone Waverly Temple 4-2300
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ARCHIE L. WENRICH, Hopewell

November 21, 1975

FOREST BOTANY
General

Mr. Richard L. Folk
Box 113
Accomac, Virginia 23301

Dear Doc:

Burchinal and I enjoyed the trip out to Parramore Island with you and Dick. It isn't very often that I get a chance at a pure ecological problem--one where we could, for a change, forget about basal area, board feet per acre, increment etc. I am sure this was a real treat for a land-locked person like Birch. It has been fifteen years since I was last on that island and on Cedar Island.

I think we pretty well agreed about the probable succession in the wooded portion of the island. It is not a hardwood site and probably never will be. On the following day the three of us visited Assateague and I noted that the old dune back by the lighthouse had some southern red oaks. The full and proper climax would call for red and white oaks, hickory and beech. Actually I always use a prevalence of southern red oak as an indicator of a dry, upland site and white oak, yellow poplar etc. as one of a moist upland site.

Obviously the deer are the cause of the lack of pine reproduction in the suitable openings. One look at those "stumps" of the Smilax indicates what happens to the tender pine seedlings. That pine woods does tend toward an all-age forest, at least in small groups. I must admit that I am woefully ignorant of the silvics of red bay although I don't think it will be an important component in any future climax. The wild cherry rather astonished me. I also learned a new term from the lady botanist--"evergreen broadleaf swamp" when referring to the red bay swamp we crossed.

I see no point in scarifying for pine reproduction because the deer will just devour it. I fully believe that fencing would give the young pines a start but why not let it go to Nature if no effort is made to control the deer population.

In short I feel that the edaphic climax there will be loblolly pine--W. W. Ash's "permanent reproducing pine types" as cited in his bulletin "Loblolly or North Carolina Pine", 1915.

Anyway it was an enjoyable and refreshing outing.

Yours very truly,

Charlie

C. C. Steirly
District Forester
Virginia Division of Forestry

CCS/cwt

cc - Woodling
Burchinal

APPENDIX H

SCIENTIFIC AND COMMON NAMES FOR THE MAMMAL SPECIES REPORTED FOR THE MAINLAND AND ISLAND STUDY AREAS (* - INTRODUCED SPECIES).

ORDER	SCIENTIFIC NAME	COMMON NAME
Artiodactyla	Bos taurus	Domestic cow*
	Odocoileus virginianus	White-tailed deer
	Ovis sp.	Domestic sheep*
Carnivora	Mustela vison	Mink
	Procyon lotor	Raccoon
Insectivora	Blarina brevicauda	Short-tailed shrew
Lagomorpha	Lepus californicus	California jackrabbit*
	Sylvilagus floridanus	Eastern cottontail
Rodentia	Microtus pennsylvanicus	Meadow vole
	Mus musculus	House mouse*
	Ondatra zibethica	Muskrat
	Oryzomys palustris	Rice rat
	Peromyscus leucopus	White-footed mouse
	Rattus norvegicus	Norway rat*
	Reithrodontomys humulis	Eastern harvest mouse
	Sciurus carolinensis	Eastern gray squirrel

APPENDIX I

TOTAL OBSERVATIONS FOR THE SMALL MAMMAL SPECIES OF THE ISLAND STUDY AREAS, FOR EACH OF THE McCAFFREY VEGETATION TYPES.

SPECIES	McCAFFREY VEGETATION TYPES						
	Parramore Island						
	Grassland-Dunes		Woodland-Thicket				
	At	B	H	J	PH	T	t
Microtus pennsylvanicus	2	1			42		22
Mus musculus	4						
Oryzomys palustris		1			8		4
Rattus norvegicus			2	1	10	1	4
	Nontidal Marsh		Tidal Marsh				
	F	M	m	Mm			
Microtus pennsylvanicus	50	32	3	5			
Oryzomys palustris	7		15	33			
Rattus norvegicus	1						
	Revel Island						
	Tidal Marsh		Woodland-Thicket				
	m	Mm	J	P	t		
Microtus pennsylvanicus		3	4		1		
Oryzomys palustris	6	48	2				
Rattus norvegicus		1		1			

APPENDIX I

SPECIES	McCAFFREY VEGETATION TYPES					
	Hog Island					
	Grassland-Dunes			Woodland-Thicket		
	A	AG	G	AT	T	t
Mus musculus	5	20	1	9		
Oryzomys palustris		6	64	2	4	4
	Nontidal Marsh			Tidal Marsh		
		M		m		S
Mus musculus						2
Oryzomys palustris		13		9		4
	Cobb Island					
	Grassland-Dunes			Woodland-Thicket		
	Ag	B	G	g		t
Oryzomys palustris	11	2	29	6		8
				Tidal Marsh		
						m
Oryzomys palustris						19
	Smith Island					
	Grassland-Dunes			Woodland-Thicket		
	A	G	g	T		t
Mus musculus	31	19	7	1		1
Oryzomys palustris				1		

APPENDIX I

SMITH ISLAND (CONT.)

SPECIES	McCAFFREY VEGETATION TYPES	
	Nontidal Marsh	Tidal Marsh
	M	m
Mus musculus	5	
Oryzomys palustris	2	2
	Skidmore Island	
	Nontidal Marsh	Woodland-Thicket
	M	t
Oryzomys palustris	2	4
	Raccoon Island	
	Nontidal Marsh	
	M	
Blarina brevicauda	1	

APPENDIX J
SCIENTIFIC AND COMMON NAMES FOR THE LAND BIRD SPECIES REPORTED FOR THE MAINLAND AND ISLAND STUDY AREAS.

ORDER	SCIENTIFIC NAME	COMMON NAME
Falconiformes	Buteo jamaicensis	Red-tailed hawk
	Pandion haliaetus	Osprey
Galliformes	Colinus virginianus	Bobwhite
	Phasianus colchicus	Ring-necked pheasant
Columbiformes	Zenaidura macroura	Mourning dove
Cuculiformes	Coccyzus americanus	Yellow-billed cuckoo
Strigiformes	Bubo virginianus	Great horned owl
	Tyto alba	Barn owl
Caprimulgiformes	Caprimulgus carolinensis	Chuck-will's-widow
	Caprimulgus vociferus	Whip-poor-will
	Chordeiles minor	Common nighthawk
Apodiformes	Chaetura pelagica	Chimney swift
	Archilochus colubris	Ruby-throated hummingbird
Piciformes	Dendrocopos pubescens	Downy woodpecker
	Colaptes auratus	Yellow-shafted flicker
Passeriformes		
Family Tyrannidae	Tyrannus tyrannus	Eastern kingbird
	Myiarchus crinitus	Great crested flycatcher
	Contopus virens	Eastern wood pewee
Family Alaudidae	Eremophila alpestris	Horned lark
Family Hirundinidae	Iridoprocne bicolor	Tree swallow
	Hirundo rustica	Barn swallow
	Progne subis	Purple martin
Family Corvidae	Cyanocitta cristata	Blue jay
	Corvus brachyrhynchos	Common crow
	Corvus ossifragus	Fish crow
Family Paridae	Parus carolinensis	Carolina chickadee
	Parus bicolor	Tufted titmouse
Family Troglodytidae	Troglodytes aedon	House wren
	Thryothorus lucovicianus	Carolina wren

APPENDIX J

ORDER	SCIENTIFIC NAME	COMMON NAME
Passeriformes (cont.)		
Family Mimidae	Mimus polyglottos	Mockingbird
	Dumetella carolinensis	Catbird
	Toxostoma rufum	Brown Thrasher
Family Turdidae	Turdus migratorius	Robin
	Hylocichla mustelina	Wood thrush
	Sialia sialis	Eastern bluebird
Family Sylviidae	Polioptila caerulea	Blue-grey gnatcatcher
Family Sturnidae	Sturnus vulgaris	Starling
Family Vireonidae	Vireo griseus	White-eyed vireo
	Vireo gilvus	Warbling vireo
Family Parulidae	Dendroica dominica	Yellow-throated warbler
	Dendroica pinus	Pine warbler
	Dendroica discolor	Prairie warbler
	Seiurus aurocapillus	Ovenbird
	Geothlypis trichas	Yellowthroat
	Icteria virens	Yellow-breasted chat
Family Ploceidae	Passer domesticus	House sparrow
Family Icteridae	Sturnella magna	Eastern meadowlark
	Agelaius phoeniceus	Redwing blackbird
	Icterus spurius	Orchard oriole
	Cassidix mexicanus	Boat-tailed grackle
	Quiscalus quiscula	Common grackle
	Molothrus ater	Brown-headed cowbird
Family Thraupidae	Piranga rubra	Summer tanager
Family Fringillidae	Richmondena cardinalis	Cardinal
	Passerina cyanea	Indigo bunting
	Spinus tristis	American goldfinch
	Pipilo erythrophthalmus	Rufous-sided towhee
	Ammospiza caudacuta	Sharp-tailed sparrow
	Ammospiza maritima	Seaside sparrow
	Spizella passerina	Chipping sparrow
	Melospiza georgiana	Swamp sparrow
	Melospiza melodia	Song sparrow

APPENDIX K

TOTAL OBSERVATIONS FOR THE LAND BIRD SPECIES OF THE ISLAND STUDY AREAS, FOR EACH OF THE McCAFFREY VEGETATION TYPES.

SPECIES	McCAFFREY VEGETATION TYPES						
	Grassland-Dunes						
	A	AG	Ag	At	B	G	g
Order Falconiformes							
Pandion haliaetus	3		1		2	6	
Order Strigiformes							
Tyto alba						3	3
Order Caprimulgiformes							
Chordeiles minor	1						
Order Passeriformes							
Family Tyrannidae							
Tyrannus tyrannus			4	4			
Family Hirundidae							
Iridoprocne bicolor		2				10	
Hirundo rustica	3	1		10	2	31	
Family Corvidae							
Cyanocitta cristata				1			
Corvus brachyrhynchos	1						
Corvus ossifragus	2					4	
Family Troglodytidae							
Troglodytidae aedon					1	2	
Thryothorus ludovicianus						1	

APPENDIX K

SPECIES	McCAFFREY VEGETATION TYPES						
	Grassland-Dunes (cont.)						
	A	AG	Ag	At	B	G	g
Order Passeriformes (cont.)							
Family Mimidae							
Dumetella carolinensis				2	1	1	
Toxostoma rufum				1			
Family Parulidae							
Dendroica discolor				3	1	2	
Geothlypis trichas	1	1		2		19	4
Family Icteridae							
Sturnella magna		4			1	5	3
Agelaius phoeniceus	18			1	10	45	11
Cassidix mexicanus	1				2	19	8
Family Fringillidae							
Richmondena cardinalis						1	
Pipilo erythrophthalmus				1		1	
Ammospiza caudacuta	2						
Ammospiza maritima	8	3			1	30	6
Melospiza melodia	8		8	2	5	27	4

APPENDIX K

SPECIES	McCAFFREY VEGETATION TYPES						
	Woodland-Thicket						
	AT	H	J	P	PH	T	t
Order Falconiformes							
Buteo jamaicensis			1		2		
Pandion haliaetus			7				14
Order Galliformes							
Phasianus colchicus	2						
Order Columbiformes							
Zenaidura macroura	6		2			1	
Order Cuculiformes							
Coccyzus americanus					1		
Order Strigiformes							
Bubo virginianus					1		
Tyto alba							1
Order Caprimulgiformes							
Caprimulgus carolinensis			1				
Caprimulgus vociferus				1			
Order Piciformes							
Dendrocopos pubescens					2		
Colaptes auratus				1	8		

APPENDIX K

SPECIES	McCAFFREY VEGETATION TYPES						
	Woodland-Thicket (cont.)						
	AT	H	J	P	PH	T	t
Order Passeriformes							
Family Tyrannidae							
Tyrannus tyrannus			2			1	16
Myiarchus crinitus				3	1		
Contopus virens			1	4	6		
Family Hirundidae							
Iridoprocne bicolor			1				7
Hirundo rustica							7
Family Corvidae							
Cyanocitta cristata							1
Corvus brachyrhynchos	2						
Corvus ossifragus	1				1	1	
Family Paridae							
Parus bicolor		1		2	9		
Family Troglodytidae							
Troglodytidae aedon	11	5	13	11	54	13	
Thryothorus ludovicianus	1	8	6	5	33	9	3
Family Mimidae							
Dumetella carolinensis	8	12	8	9	70	7	12
Toxostoma rufum		1			1		

APPENDIX K

SPECIES	McCAFFREY VEGETATION TYPES						
	Woodland-Thicket (cont.)						
	AT	H	J	P	PH	T	t
Order Passeriformes (cont.)							
Family Turdidae							
Turdus migratorius				1	4		
Hylocichla mustelina				2	2		
Family Sylviidae							
Polioptila caerulea		2	2	2	7		
Family Vireonidae							
Vireo griseus		6	1		6		1
Family Parulidae							
Dendroica dominica		1					
Dendroica pinus		2	2		7		
Dendroica discolor		8	4	2	22	3	10
Seirus aurocapillus				3	6		1
Geothlypis trichas	4	4	4	3	25	17	21
Family Icteridae							
Sturnella magna	1					1	1
Agelaius phoeniceus	10	4	20	5	34	20	46
Cassidix mexicanus	14		18			3	11

APPENDIX K

SPECIES	McCAFFREY VEGETATION TYPES						
	Woodland-Thicket (cont.)						
	AT	H	J	P	PH	T	t
Order Passeriformes (cont.)							
Family Fringillidae							
Richmondena cardinalis		2	1	1	5		
Pipilo erythrophthalmus	1		1	1	3		
Ammospiza caudacuta							1
Ammospiza maritima			1			2	5
Melospiza melodia	4	2	10		6	1	36

	Marshes					
	Nontidal		Tidal			
	F	M	m	Mm	S	W
Order Falconiformes						
Buteo jamaicensis	1					
Pandion haliaetus		6	8	3		
Order Columbiformes						
Zenaidura macroura		1				
Order Passeriformes						
Family Tyrannidae						
Tyrannus tyrannus		3	2	2		
Contopus virens				1		
Family Alaudidae						
Eremophila alpestris			1			

APPENDIX K

SPECIES	McCAFFREY VEGETATION TYPES					
	Marshes (cont.)					
	Nontidal		Tidal			
	F	M	m	Mm	S	W
Order Passeriformes (cont.)						
Family Hirundidae						
Iridoprocne bicolor		1	2		5	
Hirundo rustica	2	11	2	1	2	5
Family Corvidae						
Corvus ossifragus		6				
Family Paridae						
Parus bicolor	1					
Family Troglodytidae						
Troglodytidae aedon	2	1				
Thryothorus ludovicianus	3					
Family Mimidae						
Dumetella carolinensis		1				
Family Parulidae						
Geothlypis trichas		2				
Family Icteridae						
Agelaius phoeniceus	28	48	6	6		
Cassidix mexicanus			3	3		
Quiscalus quiscula			2			

APPENDIX K

SPECIES	McCAFFREY VEGETATION TYPES					
	Marshes (cont.)					
	Nontidal		Tidal			
	F	M	m	Mm	S	W
Order Passeriformes (cont.)						
Family Fringillidae						
Richmondena cardinalis	2					
Pipilo erythrophthalmus	2					
Ammospiza maritima		8	6	2	1	
Melospiza georgiana		1				
Melospiza melodia	3	10	1			

APPENDIX L

SCIENTIFIC AND COMMON NAMES FOR THE REPTILES AND AMPHIBIANS OF THE VIRGINIA BARRIER ISLANDS, INCLUDING SEVERAL ISLANDS NOT EXAMINED IN THE PRESENT STUDY. BASED ON A SPECIES LIST PREPARED BY DR. ROGER CONANT FROM PERSONAL COLLECTIONS AND LITERATURE REFERENCES, JUNE 25, 1975.

ORDER	SCIENTIFIC NAME	COMMON NAME
Testudines	Chelydra s. serpentina	Common snapping turtle
	Kinosternon s. subrubrum	Eastern mud turtle
	Clemmys guttata	Spotted turtle
	Terrapene c. carolina	Eastern box turtle
	Malaclemys t. terrapin	Northern diamondback terrapin
	Chrysemys rubriventris	Red-bellied turtle
	Chrysemys p. picta	Eastern painted turtle
	Caretta c. caretta	Atlantic loggerhead
	Chelonia m. mydas	Atlantic green turtle
	Demochelys c. coriacea	Atlantic leatherback
Squamata		
Suborder Lacertilia	Sceloporus u. hyancinthinus	Northern fence lizard
	Leiolopisma laterale	Ground skink
Suborder Serpentes	Natrix s. sipedon	Northern water snake
	Storeria d. dekayi	Northern brown snake
	Virginia v. valeriae	Eastern earth snake
	Diadophis punctatus ssp	Ringneck snake
	Heterodon platyrhinos	Eastern hognose snake
	Coluber c. constrictor	Northern black racer
	Opheodrys aestivus	Rough green snake
	Elaphe o. obsoleta	Black rat snake
	Lampropeltis g. getulus	Eastern kingsnake
Caudata	Plethodon cinereus	Red-backed salamander
Anura	Bufo woodhousei fowleri	Fowler's toad
	Hyla cinerea	Green treefrog
	Rana utricularia	Southern leopard frog

APPENDIX M

BIOGRAPHY OF RESEARCHERS

William C. Brown, Sue A. McCuskey and Gregory S. Hogue were research assistants of Dr. Raymond D. Dueser and postgraduate students in the Department of Environmental Sciences at the University of Virginia. They performed most of the field work associated with the terrestrial vertebrate analysis.

Raymond D. Dueser was the principle investigator responsible for the analysis of the Virginia Coast Reserve's terrestrial vertebrate fauna. His education includes B.A. and M.A. degrees in Anthropology and Zoology from the University of Texas. He received his Ph.D. in Ecology from the University of Michigan in 1975. Dueser's professional experience includes former affiliations with the Universities of Texas and Michigan, and Oak Ridge National Laboratory. He is presently an assistant professor in the Department of Environmental Sciences at the University of Virginia. One of his principal research interests includes wildlife population ecology and management strategies.

Maria Ann Graham conducted the research dealing with the land use history of the Virginia Barrier Islands. She received a B.S. degree in Wildlife Biology from Rutgers University in 1973. Her postgraduate education included emphasis on the history of hunting and resource use of North America at the Yale School of Forestry and Environmental Studies. She was formerly employed by the U. S. Fish and Wildlife Service at Brigantine National Wildlife Refuge. Graham worked on the historical portion of the Virginia Coast Reserve Study for four months During this period she interviewed many Eastern Shore residents and researched additional local sources.

Gerard J. Hennessey directed the Virginia Coast Reserve Study. He received his B.S. in Wildlife Biology from Rutgers University in 1972 and an M.S. degree in Wildlife Ecology in 1974 from Yale University. His previous refuge management experience includes apprenticeship with the New Jersey Division of Fish, Game and Shellfisheries, Harvard University's Black Rock Forest, and the United States Fish and Wildlife Service's National Wildlife Refuge System. Hennessey joined The Nature Conservancy as Director of the Virginia Coast Reserve Study in September 1974. His primary responsibilities have included conducting the Virginia Coast Reserve Study and acting as the Virginia Coast Reserve's land steward from the Conservancy's office on the Eastern Shore of Virginia.

Cheryl McCaffrey received a B.S. in Botany in 1971 from the University of Massachusetts. From the spring of 1972 through the fall of 1973 she was employed as a research assistant of the National Park Service Cooperative Research Unit at the University of Massachusetts. In the fall of 1973 McCaffrey assisted the Management Ecologist of Cape

Hatteras National Seashore in preparation of a library of technical reports dealing with the North Carolina barrier islands. She also compiled a list of all plants reported to be on the North Carolina barrier islands as mentioned in the literature and in Park herbaria. McCaffrey also worked as a seasonal naturalist at Cape Hatteras from April to November of 1974 before participating in the Virginia Coast Reserve Study.

Dr. Alan Niedoroda is the Director of the Coastal Research Center at the University of Massachusetts and an author of the Geology Section of this Report. He has been engaged in research concerning coastal processes for ten years and has published numerous articles on this subject. At present he is responsible for four major funded research projects on a variety of coastal studies. He is also directing graduate research projects. Dr. Niedoroda acquired his Ph.D. from the Florida State University in 1972. Prior to this he was engaged in various coastal and oceanographic studies in the oceans of the world and on Barbados, the Gulf and Atlantic coasts. Since 1972 he has also been an Assistant Professor of Geology at the University of Massachusetts. He teaches graduate and undergraduate courses in coastal processes, physical oceanogeography, geomorphology, coastal management, and mathematical geology.

Anthony P. Pratt is a 1976 graduate of Hampshire College, Amherst, Massachusetts, and he was employed as geological research assistant to Dr. Alan Niedoroda and Dr. Thomas E. Rice. His area of concentration at Hampshire College was ecology, with application to the coastal environment. Pratt's Senior Project (thesis) at Hampshire College was study of the Maryland-Virginia Coastline from north of Ocean City, Maryland, to Chincoteague Inlet in Virginia. The study included a geomorphic description of the barrier islands, bay, and marsh of his study area. Pratt's paper contains a thorough historical account of man's impact on the area, and of the changes that have occurred along Assateague Island since it has come under the control of the State of Maryland and the U. S. National Park Service. As part of his study, he made a correlation of weather patterns, including storm activity, with changes in the morphology of the beach and island areas. This correlative part of the study included a comparative study of the effect of the storms on the "controlled" beach at Ocean City, with the "natural" beach along Assateague Island. The study also included much work on the comparative ecology of the controlled and natural barrier island areas.

Thomas E. Rice's initial professional training and employment was in electrical engineering and electronics. His bachelor of science degree is from the University of Massachusetts at Amherst, with a double major in mathematics and physics. He has done graduate work in geology at the University of Massachusetts, Indiana University, and the University of Colorado at Fort Collins. His graduate work was directed toward

a broad knowledge of geology to support a strong interest in teaching. He has been a member of the faculty of the Department of Geology and Geography at the University of Massachusetts since September 1955, receiving tenure in 1957. Mr. Rice's consulting and research interests since 1964 have been directed to surficial geology and environmental concerns. His consulting work has dealt with problems in groundwater geology, surficial and Pleistocene geology, mass-wasting problems, bedrock mapping, structural geology and public health problems. He teaches an undergraduate research participation course that deals with problems in the physical hydrology of drainage basins, environmental degradation of surface and groundwater supplies, and land use and planning. He also directs graduate and undergraduate Special Problem Studies in these areas.

Bill Williams is the author of the Analysis of the Past and Present Status of the Beach Nesting and Colonial Birds section of the Virginia Coast Reserve Study. He is a 1969 graduate in biology of Emory and Henry College. He holds a Master's Degree in Biology from the College of William and Mary and is presently employed as a biology instructor in the Williamsburg-James City Public Schools, Virginia.