

NEW JERSEY SHORE PROTECTION MASTER PLAN



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STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF COASTAL RESOURCES

OCTOBER 1981

VOLUME I - THE PLAN

NEW JERSEY SHORE PROTECTION MASTER PLAN

VOLUME 1

THE PLAN

OCTOBER 1981

State of New Jersey

Brendan Byrne
Governor

U. S. DEPARTMENT OF COMMERCE NOAA
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STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF THE COMMISSIONER
P. O. BOX 1390
TRENTON, N. J. 08625
609-292-2885

October 1981

Dear Governor Byrne, Members of the Legislature, and Citizens of
New Jersey:

The Jersey Shore is many things to many people: a place to live, a place to work and a place to visit. Sandy beaches, dunes, wetlands, jetties, fishing and amusement piers, inlets, bays, rivers, vacation houses, year-round residences, hotels, motels, and shops all make up the built and natural environment of the shore.

To protect these vital resources, the Department of Environmental Protection takes pride in presenting the first New Jersey Shore Protection Master Plan. This Plan, now adopted after more than two years of studies, workshops, and hearings, will guide five types of decisions and actions of the Department of Environmental Protection, and in particular the Division of Coastal Resources, to protect the shoreline.

First, the Plan will guide DEP's decisions on financial assistance for the construction, repair and maintenance of beaches, groins, jetties, sea-walls, bulkheads, and dunes, investing prudently and rationally the funds available from the Beaches and Harbors Bond Fund of 1977, future bond issues, and other sources, including local government matching funds and federal reimbursement. Second, the Plan provides the framework for DEP's technical assistance on shore protection matters to local officials, citizens, and developers. Third, the Plan recognizes the important role of existing land use regulation by DEP and local governments in protecting sensitive beaches and dunes from inappropriate development. Fourth, the Plan will help DEP raise public awareness of the fragility of our barrier islands and the risks of coastal development. Fifth, the Plan defines DEP policy and provides the basis for the advocacy of proper management of shoreline processes.

The New Jersey Shore Protection Master Plan is presented in three volumes to facilitate its use. Volume I is the Plan itself. Volume II is the basis and background for the Plan, and contains useful reference materials and discussions of all the alternatives considered in developing the Plan. Volume III presents the public comments on the Draft Plan and the DEP responses to those helpful comments.

Life by the sea is exciting. Over the past 200 years, the people of New Jersey have extensively built up our shoreline. Some of these actions have led to disappearing beaches and property destruction during coastal storms. The Shore Protection Master Plan charts many steps that should be taken in coming years to protect the shoreline by working in closer harmony with the natural forces of the sea.

Sincerely,


JERRY FITZGERALD ENGLISH
Commissioner

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CHAPTER I

INTRODUCTION AND BACKGROUND

A. NEW JERSEY SHORE PROTECTION PROGRAM

New Jersey, like all coastal states, has for decades been involved in providing financial and technical assistance to help shorefront communities cope with shoreline erosion. In the early 1940's, legislation (N.J.S.A. 12:6A-1) authorized the Department of Environmental Protection's predecessor (the Department of Conservation and Economic Development) to repair, reconstruct or construct bulkheads, seawalls, breakwaters, groins, jetties, beaches, dunes and any or all appropriate structures for shore protection purposes. The annual appropriation for this work has averaged approximately one million dollars, and \$49 million in State, Federal, municipal, and county funds were spent between 1959 and 1974.

In recent years, the need for shoreline protection planning has been heightened by the cumulative effect of minor and major storms (particularly the March 1962 storm) and the tremendous boom in oceanfront development. The New Jersey Commission on Capital Budgeting and Planning recognized that the annual one million dollar appropriation for State Aid to municipalities for shore protection purposes was inadequate and in 1977 the voters of the State approved a \$30 million Beaches and Harbors Bond Issue, which provided \$20 million for State Aid for shore protection purposes and \$10 million for harbor cleanup.

Local governments in New Jersey have taken different approaches towards shore protection, with some allowing dunes to be overtaken by development, while others worked to acquire oceanfront lots and rebuild dunes. The Federal government has also been actively involved in shorefront protection through the Army Corps of Engineers, and in shorefront development through the National Flood Insurance Program. The net result of these State, Federal and Local activities has been an amalgam and somewhat reactive approach to shore protection. This Shore Protection Master Plan is intended to represent a more cohesive and comprehensive approach to the problem of shore protection for use by the State, and hopefully other levels of government as well.

The five related components that make up the State's Shore Protection Program are: Financial Assistance, Technical Assistance, Land Use Regulation, Public Awareness, and Program Advocacy.

Financial assistance involves the funding of various approaches and solutions to shoreline protection problems by the Department of Environmental Protection (DEP) and local governments. State aid is distributed on a cost sharing basis with municipalities and county governments and, depending upon the area selected for protection, Federal reimbursement may be available. Financial assistance by the Army Corps of Engineers would be based on cost sharing between Federal and non-Federal interests. Reimbursement of Federal costs for approved advance construction by the State is part of the existing cooperative agreement and would occur when project construction is initiated. The current funding source for the State's financial assistance is the Beaches and Harbors Bond Fund and the ratio of the State-local share is determined by the Legislature.

DEP's Division of Coastal Resources provides technical assistance on shore protection matters to municipalities, citizens, developers, and others. Assistance

ranges from technical consultation by the Department's coastal engineers, scientists, and planners, to testimony before local governments in order to assist municipal enforcement of ordinances restricting development in sensitive and hazardous areas.

The Division of Coastal Resources engages in direct land use regulation in the administration of three state regulatory programs in the coastal zone: the Coastal Area Facility Review Act (CAFRA), the Wetlands Act, and the Waterfront Development Law. Those laws, however, do not regulate the construction of most individual homes. In fact, up to 25 homes can be built along the shore without DEP approval. This situation, which has been the subject of several proposed pieces of legislation in the last two years, cannot be changed without action by the New Jersey Legislature.

Since many people have not experienced first hand the fury of the sea when a storm hits a barrier island, it has been necessary to raise public awareness of the hazards and risks associated with such development. The Division has worked with citizens, interest groups and various levels of government to increase the general public understanding of the dynamics of barrier islands.

Advocacy of coastal interests and proper management of shoreline processes is another activity in which the Division is involved. It has made grants to municipalities to develop dune protection programs and work with groups and individuals to identify shore protection problems and to advocate possible solutions for consideration by the public. It also comments on Federal actions affecting barrier islands.

The Shore Protection Program embraces these five components and represents the State's effort to properly manage its shorelines, and in particular its barrier islands. The future must see active work to cope with current erosion problems to increase the preparedness for natural disasters and establish, before the next major coastal storm, the actions that will be taken to enable the natural beach and dune system to recover thereafter.

B. THE NEW JERSEY APPROACH TO SHORE PROTECTION PLANNING

1. Purpose and Scope of the Shore Protection Master Plan

The State of New Jersey has been engaged in shore protection activities for decades, as authorized by law (N.J.S.A. 12:6A-1 et seq.). In 1978, the Legislature passed a Beaches and Harbors Bond Act (P.L., 1978, c.157) and called on DEP to prepare a comprehensive Shore Protection Master Plan. In so doing, the Legislature saw the need to reduce the negative impacts of and conflicts between shoreline erosion management and coastal development, reduce hazard losses, and satisfy shore user demands in an equitable way.

The Shore Protection Master Plan was prepared by Dames & Moore under the direction of New Jersey Department of Environmental Protection, Division of Coastal Resources, under contract with the Department of Treasury, Division of Building and Construction. Its purpose is to:

- o Review earlier shore protection plans and studies;
- o Assess the nature of and extent of the erosion problem;
- o Assess the nature of the coastal processes;
- o Review past, present, and evolving State and Federal policies related to shore protection and coastal resources;

- o Provide a comparative evaluation of suitable alternative approaches (engineering and land management) to the mitigation of shore erosion, including consideration of the costs, benefits, environmental implication, and implementation feasibility;
- o Develop a list of priorities among the engineering plans; and
- o Provide a comprehensive shore protection plan which is consistent with State coastal management policies and objectives.

The shore areas affected by the Shore Protection Master Plan include the municipalities listed in Table I.B-1 and the parks and other State and federally-controlled shorelands which are listed in Table I.B-2. The basic shore types in each of the affected areas is also provided in these tables. This study addresses the shore areas which are exposed to significant erosional forces and have had a history of erosion problems. In particular these areas include the Raritan Bay shore from Perth Amboy to Sandy Hook; the Atlantic Ocean shore from Sandy Hook to Cape May Point; the Delaware Bay shore from Cape May Point to Stow Creek; and the Delaware River from Stow Creek to Crosswicks Creek.

2. The Reach Concept

Where appropriate, development of the engineering plans for New Jersey is based on a regional (reach) approach, rather than the stop-gap piecemeal solutions of the past. Along ocean shores, piecemeal solutions often tend to aggravate the problem in adjacent shore areas.

The "reach concept" or approach is the method whereby consistent shore protection engineering plans are developed within areas affected by similar coastal processes. The reach concept in the engineering design process endeavors to reduce the potential for any one shore erosion control program to produce adverse effects in adjacent shore areas (e.g., down-drift effects). Shore protection is thereby provided for an entire coastal compartment, irrespective of political subdivision boundaries, rather than for only local erosion problem areas as has been the traditional practice in New Jersey.

As discussed in Section I.C-3, coastal processes interrelationships do exist between major coastal geomorphic zones. However, the major geomorphic zones can be divided into smaller portions (reaches), which reflect a sufficient degree of similarity of processes, to allow development of individual alternative plans for shore protection. The New Jersey shoreline has been divided up into 16 reaches (13 ocean, 2 bay and one river reach) based on an evaluation of natural punctuations in operative coastal processes. The importance of the inlets in punctuating the coastal processes is reflected in the fact that most of the ocean reaches are defined by inlet positions.

The reaches that have been developed for the Master Plan are presented on Figure I.B-1, and in Table I.B-3 together with the affected counties and political subdivisions within each reach. The reaches designated on Table I.B-3 and Figure I.B-1 form the basic, discrete planning units for the alternative shore protection plans presented in Chapter II, as well as the basis for discussions of shore erosion, socioeconomic, and environmental characteristics discussed in this and subsequent chapters.

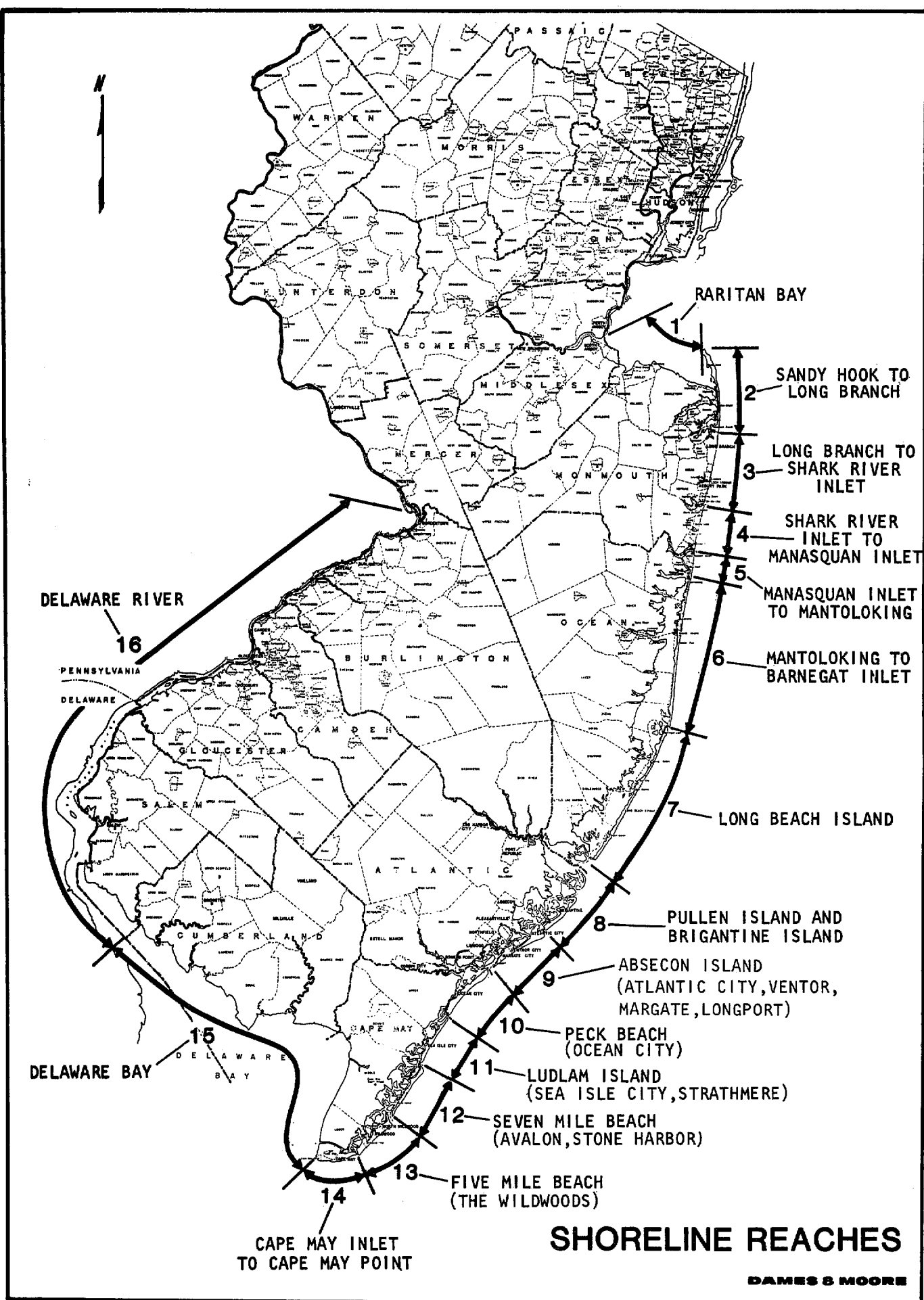


TABLE I.B-1

MUNICIPALITIES AFFECTED BY THE MASTER PLAN

County/ Political Subdivision	SHORE TYPES				
	Atlantic Ocean	Inlet	Open Bay (Raritan or Delaware Bay)	Backbay, Inland Waterways, Tidal Tributaries	Major Tidal River (Delaware River)
ATLANTIC COUNTY					
*Absecon City	—	—	—	X	—
*Atlantic City	X	X	—	X	—
*Brigantine City	X	X	—	X	—
*Egg Harbor Township	—	—	—	X	—
Estell Manor City	—	—	—	X	—
*Galloway Township	—	—	—	X	—
*Linwood City	—	—	—	X	—
*Longport Borough	X	X	—	X	—
*Margate City	X	—	—	X	—
*Mullica Township	—	—	—	X	—
*Pleasantville City	—	—	—	X	—
Port Republic City	—	—	—	X	—
*Somers Point	—	—	—	X	—
*Ventnor City	X	—	—	X	—
BURLINGTON COUNTY					
Bass River Township	—	—	—	X	—
*Beverly, City of	—	—	—	—	X
*Bordentown City	—	—	—	—	X
*Bordentown Township	—	—	—	—	X
*Burlington City	—	—	—	—	X
*Burlington Township	—	—	—	—	X
*Cinnaminson Township	—	—	—	—	X
*Delanco Township	—	—	—	—	X
Delran Township	—	—	—	—	X
*Edgewater Park Township	—	—	—	—	X
Fieldsboro, Borough	—	—	—	—	X
*Florence Township	—	—	—	—	X
Mansfield Township	—	—	—	—	X
Palmyra Borough	—	—	—	—	X
Riverton Borough	—	—	—	—	X
*Washington Township	—	—	—	X	—
CAMDEN COUNTY					
Camden City	—	—	—	—	X
Gloucester City	—	—	—	—	X
*Pennsauken Township	—	—	—	—	X
CAPE MAY COUNTY					
*Avalon Borough	X	X	—	X	—
*Cape May City	X	—	—	X	—
*Cape May Point Borough	X	—	X	—	—
*Dennis Township	—	—	X	X	—
*Lower Township	X	—	X	X	—
*Middle Township	—	—	X	X	—
*North Wildwood City	X	X	—	X	—
*Ocean City	X	X	—	X	—
*Sea Isle City	X	X	—	X	—
*Stone Harbor Borough	X	X	—	X	—
*Upper Township (Strathmere)	X	X	—	X	—
*West Cape May	—	—	—	X	—
*West Wildwood	—	—	—	X	—
*Wildwood City	X	—	—	X	—
*Wildwood Crest Borough	X	—	—	X	—
CUMBERLAND COUNTY					
*Commercial Township	—	—	X	—	—
*Downe Township	—	—	X	—	—
*Fairfield Township	—	—	X	—	—
*Greenwich Township	—	—	X	—	—
Lawrence Township	—	—	X	—	—
*Maurice River Township	—	—	X	—	—
GLOUCESTER COUNTY					
Greenwich Township	—	—	—	—	X
*Logan Township	—	—	—	—	X
*National Park Borough	—	—	—	—	X
*Paulsboro Borough	—	—	—	—	X
*West Deptford Township	—	—	—	—	X
Westville Borough	—	—	—	—	X
MIDDLESEX COUNTY					
*Old Bridge Township	—	—	X	—	—
*Perth Amboy City	—	—	X	—	X
*Sayreville Borough	—	—	X	—	X
*South Amboy City	—	—	X	—	X

TABLE I.B-1 (Continued)

County/Political Subdivision	SHORE TYPES				
	Atlantic Ocean	Inlet	Open Bay (Raritan or Delaware Bay)	Backbay, Inland Waterways, Tidal Tributaries	Major Tidal River (Delaware River)
MONMOUTH COUNTY					
*Aberdeen Township	—	—	X	—	—
*Allenhurst Borough	X	—	—	—	—
*Asbury Park City	X	—	—	—	—
*Atlantic Highlands Borough	—	—	X	—	—
*Avon-by-the-Sea Borough	X	X	—	X	—
*Belmar Borough	X	X	—	X	—
*Bradley Beach Borough	X	—	—	—	—
*Brielle Borough	—	—	—	X	—
*Deal Borough	X	—	—	—	—
*Fair Haven Borough	—	—	—	X	—
*Hazlet	—	—	—	X	—
*Highlands Borough	—	—	X	X	—
*Keansburg Borough	—	—	X	—	—
*Keyport Borough	—	—	X	X	—
*Little Silver Borough	—	—	—	X	—
*Loch Arbour	X	—	—	—	—
*Long Branch City	X	—	—	X	—
*Manasquan Borough	X	X	—	X	—
*Middletown Township	—	—	X	X	—
*Monmouth Beach Borough	X	—	—	X	—
*Neptune City Borough	—	—	—	X	—
*Neptune Township (Ocean Grove)	X	—	—	X	—
*Oceanport Borough	—	—	—	X	—
*Red Bank Borough	—	—	—	X	—
*Rumson Borough	—	—	—	X	—
*Sea Bright Borough	X	—	—	X	—
*Sea Girt Borough	X	—	—	—	—
*Spring Lake Borough	X	X	—	—	—
*Shrewsbury Borough	—	—	—	X	—
*Union Beach Borough	—	—	X	X	—
*Wall Township	—	—	—	X	—
OCEAN COUNTY					
*Barnegat Light Borough	X	—	—	X	—
Bayhead Borough	X	—	—	X	—
*Beach Haven Borough	X	—	—	X	—
*Beachwood Borough	—	—	—	X	—
*Berkeley Township	X	—	—	X	—
*Brick Township	X	—	—	X	—
*Dover Township	X	—	—	X	—
*Eagleswood Township	—	—	—	X	—
Egg Harbor City	—	—	—	X	—
Galloway Township	—	—	—	X	—
Great Egg Harbor Township	—	—	—	X	—
*Harvey Cedars Borough	X	—	—	X	—
*Island Heights Borough	—	—	—	X	—
*Lacey Township	—	—	—	X	—
*Lavallette Borough	X	—	—	X	—
*Little Egg Harbor Township	—	—	—	X	—
*Long Beach Township	X	—	—	X	—
*Mantoloking Borough	X	—	—	X	—
*Ocean Gate Borough	—	—	—	X	—
*Ocean Township	—	—	—	X	—
*Pine Beach Borough	—	—	—	X	—
*Point Pleasant Beach Borough	X	X	—	X	—
Point Pleasant Borough	—	—	—	X	—
*Sea Side Heights Borough	X	—	—	X	—
*Sea Side Park Borough	X	—	—	X	—
*Ship Bottom Borough	X	—	—	X	—
*South Toms River Borough	—	—	—	X	—
*Stafford Township	—	—	—	X	—
*Surf City Borough	X	—	—	X	—
*Tuckerton Borough	—	—	—	X	—
*Union Township	—	—	—	X	—
SALEM COUNTY					
*Carneys Point Township	—	—	—	—	X
*Elsinboro Township	—	—	—	—	X
Lower Alloways Creek Township	—	—	—	—	X
Oldmans Township	—	—	—	—	X
*Penns Grove Borough	—	—	—	—	X
*Pennsville Township	—	—	—	—	X

*Municipalities which have requested or received assistance in shore protection matters from the NJDEP — Bureau of Coastal Engineering.

TABLE I.B-2

OTHER SHORE AREAS AFFECTED BY THE MASTER PLAN

County/Open Space, Parks, Preserves and Dedicated Lands	SHORE TYPES				
	Atlantic Ocean	Inlet	Open Bay (Raritan or Delaware Bay)	Backbay, Inland Waterways, Tidal Tributaries	Major Tidal River (Delaware River)
ATLANTIC COUNTY					
Absecon Wetlands State Wildlife Mgt. Area	--	--	--	X	--
Brigantine National Wildlife Refuge	X	X	--	X	--
Corbin City (Tuckahoe State Wildlife Mgt. Area)	--	--	--	X	--
North Brigantine State Natural Area	X	X	--	X	--
Whirlpool Island County Recreation Area	--	--	--	X	--
CAPE MAY COUNTY					
*Cape May Point State Park	X	--	--	--	--
Cape May Wetlands State Wildlife Mgt. Area	--	--	--	X	--
Corsons Inlet State Park	X	X	--	--	--
Dennis Creek State Wildlife Mgt. Area	--	--	X	--	--
Higbee Beach State Wildlife Mgt. Area	--	--	X	--	--
Fishing Creek County Conservation Recreation Area	--	--	X	--	--
Strathmere State Natural Area	X	X	--	--	--
U.S. Coast Guard Receiving Center (Sewall's Point)	X	X	--	X	--
U.S. Coast Guard Reservation Wildwood Electronic Engineering Center	X	X	--	X	--
CUMBERLAND COUNTY					
Corsons Tract State Wildlife Mgt. Area	--	--	X	--	--
Dix State Wildlife Mgt. Area	--	--	X	--	--
Egg Island - Berrytown (Turkey Point) State Wildlife Mgt. Area	--	--	X	--	--
Fortescue State Wildlife Mgt. Area	--	--	X	--	--
Heislerville State Wildlife Mgt. Area	--	--	X	--	--
MONMOUTH COUNTY					
Fort Monmouth (U.S. Army)	--	--	--	X	--
Hartshorne County Park	--	--	--	X	--
*Manasquan River State Wildlife Mgt. Area	--	--	--	X	--
Naval Weapons Station Earle (Leonardo)	--	--	--	X	--
New Jersey National Guard Camp (Sea Girt)	X	--	--	--	--
*Sandy Hook - Gateway National Park	X	--	X	--	--
*Sandy Hook Coast Guard Station	X	--	--	--	--
Shark River County Park	--	--	--	X	--
OCEAN COUNTY					
*Barnegat Light State Park	X	X	--	X	--
Barnegat National Wildlife Refuge	--	X	--	X	--
Brigantine National Wildlife Refuge	--	X	--	X	--
Cattus Island County Park	--	--	--	X	--
Great Bay Boulevard State Natural Area	--	X	--	X	--
*Island Beach State Park, Research Area and Wildlife Sanctuary	X	X	--	X	--
*Manahawkin State Fish & Wildlife Mgt. Area	--	--	--	X	--
Swan Point State Natural Area	--	--	--	X	--
SALEM COUNTY					
Artificial Island Disposal Area (USACOE)	--	--	--	--	X
*Fort Mott State Park	--	--	--	--	X
Killcohook National Wildlife Refuge	--	--	--	--	X
Killcohook Federal Spoil Disposal Area (USACOE)	--	--	--	--	X
Mad Horse Creek State Wildlife Mgt. Area	--	--	--	--	X
Pedricktown Disposal Area (USACOE)	--	--	--	--	X
Supawana Meadows National Wildlife Refuge	--	--	--	--	X

*Areas which have received assistance in shore protection matters from the NJDEP - Bureau of Coastal Engineering.

TABLE I.B-3
SHORELINE REACH CLASSIFICATION

SHORELINE ZONE**	REACH NUMBER	REACH DESCRIPTION	COUNTY	POLITICAL SUBDIVISION (MUNICIPALITIES/PARKS, ETC.)	VILLAGE*, PARK UNIT, ETC.
Raritan Bay	1	Raritan Bay	Middlesex	Perth Amboy City South Amboy City Sayreville Borough Old Bridge Township	Melrose South Amboy Junction Morgan Lawrence Harbor
			Monmouth	Aberdeen Township Keyport Borough Union Beach Borough Keansburg Borough Middletown Township Naval Weapons Station Earle (Leonardo) Atlantic Highlands Borough Highlands Borough	Cliffwood Beach Port Monmouth Belford Leonardo
Northern Barrier Spit	2	Sandy Hook to Long Branch		Gateway National Recreation Area and U.S. Coast Guard Station Sea Bright Borough Monmouth Beach Borough	Sandy Hook Unit Highland Beach Navesink Beach Low Moor Galilee
Headland	3	Long Branch to Shark River Inlet		Long Branch City Deal Borough Allenhurst Borough Loch Arbour Asbury Park City Neptune Township Bradley Beach Borough Avon by the Sea	North Long Branch Long Branch City West End Elberon Ocean Grove
	4	Shark River Inlet to Manasquan Inlet		Belmar Borough Spring Lake Borough Sea Girt Borough State Arsenal and Camp Ground Manasquan Borough	
	5	Manasquan Inlet to Mantoloking	Ocean	Point Pleasant Beach Borough Bay Head Borough	
Northern Barrier Island Complex	6	Mantoloking to Barnegat Inlet	Ocean	Mantoloking Borough Brick Township Dover Township Lavallette Borough Sea Side Heights Borough Sea Side Park Borough Berkeley Township Island Beach State Park	South Mantoloking Beach Normandy Beach Chadwick Ortley Beach South Sea Side Park
	7	Barnegat Inlet to Little Egg Inlet (Long Beach Island)		Barnegat Lighthouse State Park Barnegat Light Borough Harvey Cedars Borough Surf City Ship Bottom Borough Long Beach Township Beach Haven Borough Brigantine National Wildlife Refuge	Holly Lagoons Lighthouse Park South Loveladies North Beach Brant Beach Beach Haven Crest Brighton Beach Peahala Beach Haven Park Haven Beach The Dunes Beach Haven Terrace Beach Haven Gardens Spray Beach North Beach Haven Beach Haven Manor Holgate South Branch Haven Beach Haven Heights Holgate Unit

*Village as presented here are the non-governmental (non-taxable) entities occurring within a particular shore municipality
 **Shoreline Zones are discussed in Chapter II, Section B.

TABLE I.B-3 (Sheet 2 of 3)

SHORELINE ZONE	REACH NUMBER	REACH DESCRIPTION	COUNTY	POLITICAL SUBDIVISION (MUNICIPALITIES/PARKS, ETC.)	VILLAGE*, PARK UNIT, ETC.
Southern Barrier Island Complex	8	Little Egg Inlet to Absecon Inlet (Pullen Island and Brigantine Island)	Atlantic	Brigantine National Wildlife Refuge North Brigantine State Natural Area Brigantine City	Little Beach Unit (Pullen Island)
	9	Absecon Inlet to Great Egg Harbor Inlet (Absecon Island)		Atlantic City Ventnor City Margate City Longport Borough	
	10	Great Egg Harbor Inlet to Corson Inlet (Pecks Beach)	Cape May	Ocean City Corson Inlet (Ocean Crest) State Park	
	11	Corsons Inlet to Townsends Inlet (Ludlam Island)		Strathmere State Natural Area Upper Township Sea Isle City	Strathmere Whale Beach
	12	Townsends Inlet to Hereford Inlet (Seven Mile Beach)		Avalon Borough Stone Harbor Borough	
	13	Hereford Inlet to Cape May Inlet (Five Mile Beach)		North Wildwood City Wildwood City Wildwood Crest Borough Lower Township (East) U.S. Coast Guard, Wildwood Electrical Engineering Center	Wildwood Gables
Southern Headlands	14	Cape May Inlet to Cape May Point		U.S. Coast Guard Receiving Area Cape May City Cape May Point State Park Lower Township (South) Cape May Point Borough	
Delaware Bay	15	Delaware Bay Cape May Point to Stow Creek	Cape May	Lower Township (West) Higbee Beach State Wildlife Mgt. Area Middle Township Dennis Creek State Wildlife Mgt. Area Dennis Township	Sunset Beach North Cape May Town Bank Wildwood Highlands Beach North Highlands Beach Villas Miami Beach Sunray Beach Highs Beach Pierces Point Kimbles Beach Reeds Beach
			Cumberland	Maurice River Township Corson Tract State Fish and Wildlife Mgt. Area Heislerville State Wildlife Mgt. Area Commercial Township Downe Township Egg Island-Berrytown (Turkey Point) State Wildlife Mgt. Area Fortescue State Wildlife Mgt. Area Lawrence Township Fairfield Township Dix State Wildlife Mgt. Area Greenwich Township	Moores Beach Thompsons Beach Fortescue Beach Gandy's Beach Sea Breeze Bayside

TABLE I.B-3 (Sheet 3 of 3)

SHORELINE ZONE	REACH NUMBER	REACH DESCRIPTION	COUNTY	POLITICAL SUBDIVISION (MUNICIPALITIES/PARKS, ETC.)	VILLAGE*, PARK UNIT, ETC.
Delaware River	16	Delaware River Stow Creek to Crosswicks Creek	Salem	Lower Alloways Creek Township Mad Horse Creek State Wildlife Mgt. Area Artificial Island Federal Disposal Area Elsinboro Township Supawna Meadows National Wildlife Refuge Fort Mott State Park Killecohook National Wildlife Refuge Killecohook Federal Dredge Disposal Area Pennsville Township Carneys Point Township Penns Grove Borough Oldmans Township Pedricktown Federal Disposal Area U.S. Military Reservation	Fort Elfsdorf Oakwood Beach Penns Beach Church Landing Deepwater Dolbews Landing
			Gloucester	Logan Township Greenwich Township Paulsboro Borough West Deptford Township National Park Borough Westville Borough	Billingsport
			Camden	Gloucester City Camden City Pennsauken Township	
			Burlington	Palmyra Borough Riverton Borough Cinnaminson Township Delran Township Delanco Township Beverly, City of Edgewater Park Township Burlington Township Burlington City Florence Township Mansfield Township Fieldsboro Township Bordentown Township Bordentown City	

C. THE NEW JERSEY SHORE: CONDITIONS, FEATURES, AND PROCESSES

1. Introduction

The New Jersey coastline represents a dynamic interface between the land and the sea. The shoreline has been gradually moving and changing its configuration from the time sea level began to rise on the continental shelf at the end of the glacial age some 12,000 to 15,000 years ago. Although the native Americans summered at the shore as the present inhabitants do, coastal erosion was not a problem until development of major shore resorts began in the mid-1800's and early 1900's. Towns such as Long Branch, Asbury Park, Ocean City, Atlantic City and Cape May, easily accessible by railroads from the population centers of New York and Philadelphia, rapidly developed with hotels, restaurants, boarding houses, bath houses and boardwalks. The major goal was to build as near the ocean as possible and very little consideration was given to natural coastal processes in the planning or layout of the resorts. Thus, very early the stage was set for erosion to threaten buildings and, therefore, to be a major problem along the New Jersey coast.

As early as the turn of the century, following the example of the railroads which first built protective devices to keep their rail lines open, civic authorities advocated construction of protective measures such as jetties, groins, seawalls, and breakwaters to protect their ever-appreciating shore recreation property and industry. All of these measures represented major capital expenditures on all governmental levels. Each municipality had different erosion problems and limited resources so that attempts to cope with erosion focused on short-term, stop-gap measures tailored to each locality instead of considering the region as a whole and the underlying natural causes of shoreline erosion and change.

2. Erosional Conditions

Only relatively recently have coastal residents and governmental agencies begun to focus on shoreline erosion as more than a series of short-term crises at a series of independent locations. The U.S. Army Corps of Engineers in 1971, as part of the National Shoreline Inventory, classified the U.S. coast as critical, non-critical or non-eroding. In its effort to determine where significant erosion occurs, rates of erosion were considered in conjunction with economic, industrial, recreational, agricultural, navigational, demographic, ecological, and other relevant factors to identify those areas where action to halt such erosion may be justified. Areas so identified were considered critical. Other areas undergoing significant erosion were classified as non-critical. For the Atlantic coastal shoreline of New Jersey, 81 percent (101 miles) was considered critical, 9.7 percent (12 miles) was considered non-critical, and 8.8 percent (11 miles) was considered non-eroding.

In 1977, the Center for Coastal and Environmental Studies (CCES) at Rutgers University completed a study commissioned by the NJDEP, entitled Coastal Geomorphology of New Jersey. That study analyzed the problems of shoreline erosion, classified the shoreline and identified thirteen specific examples of high risk erosion areas:

- o Cumberland County — Delaware Bay Shore (developed portions along bay-shore)
- o Middle Township (developed portions of bayshore), Cape May County
- o Cape May City
- o Northern Wildwood (where Hereford Inlet fronts beach)

- o Strathmere (Putnam Avenue to end of developed island)
- o Ocean City (3rd St. to 18th St.)
- o Ocean City (E. Atlantic Blvd. to Newcastle Rd.)
- o Atlantic City (where Absecon Inlet fronts beach, Oriental Ave. to Parkside)
- o Barnegat Light (8th to 4th St.)
- o Loch Arbour to Elberon
- o Long Branch
- o Sea Bright and Monmouth Beach
- o Raritan Bay (developed portions along bayshore)
- o Sea Isle City (southern half)

In preparation of the Shore Protection Master Plan, an inventory of the shoreline geomorphic character and erosion condition was performed to update earlier assessments of coastal erosion and damage, or the threat of damage, to the shore areas of the State. This task was accomplished through literature review, aerial and ground reconnaissance, aerial photo analysis, and workshop discussion with engineers and planners representing the affected municipalities. Literature search activities included a review of references on file with the Philadelphia District Corps of Engineers, the New Jersey Department of Environmental Protection, and the U.S. Army Coastal Engineering Research Center.

The method of analysis consisted of a thorough evaluation of the condition of the New Jersey shoreline using the above sources of information as primary data and the classification of the shoreline according to severity of erosion. The classification of erosion conditions below represents a refinement of erosion severity for developed portions of the New Jersey shoreline and differs from the U.S. Army Corps of Engineers' National Shoreline Inventory Study in three ways; 1) it considers only physical parameters as a measure of the severity of the erosion process, 2) it is uniformly applied to developed areas, and 3) the range of erosion severity is further classified (I, II, and III).

As discussed in Section I.B.2 above, reaches were defined on the basis of coastal forms and processes. Within each reach definitive erosion patterns exist that can be classified according to severity. By virtue of the predominant erosion or accretion trend, a particular area of developed shoreline was classified into one of the following categories:

Category I	-	Critical erosion
Category II	-	Significant erosion
Category III	-	Moderate erosion
Category IV	-	Non-eroding

The classification for a given area of shoreline is directly related to the degree and magnitude of existing and potential erosional damage. The degree and magnitude of this damage was estimated with respect to the criteria listed in Table I.C-1.

TABLE I.C-1
CRITERIA FOR EROSION CLASSIFICATION

- o Beach width
- o Presence of dunes
- o Littoral transport budget
- o Shoreline mobility
- o Presence of shore protection structures
- o Condition of shore protection structures
- o Functional performance of shore protection structure
- o Proximity of development and infrastructure to mean high water line
- o Wave climate

The severity of shoreline erosion was evaluated by combining the criteria in Table I.C-1 with a temporal consideration. Category I areas are characterized as having the least suitable natural and man-made protection from the operating erosive forces. These are areas presently receiving significant erosive attack and damage to protective features, or areas which are threatened with imminent attack by small or moderate storms. Category II areas are areas where a low to moderate level of protection exists, but where erosive forces are expected to reduce this level in time thus posing a longer term threat of significant damage to developed areas than exists for Category I areas. Category III represents an area which has a moderate to high degree of protection (natural and/or man-made) for the level of erosive processes that are operative. The temporal occurrence of significant damage from erosion is not expected for a period longer than that for Category II. Category IV areas are those which are presently non-eroding or are considered stable. This classification is based on long-term trends and does not account for extreme storm events such as a hurricane or intense extratropical storm such as a northeaster.

As pointed out by Nordstrom and others (1977), and as indicated by a review of the Proceedings of the National Conference on Coastal Erosion (FIA, July, 1977), reliable quantified methodologies based on erosion rates do not presently exist for precisely delineating future erosional trends. This is especially true for areas such as the New Jersey shoreline where the wide distribution of shore protection structures and other development further complicate the problem. Therefore, the application of the above criteria required professional judgement in the evaluation of the data. Assignment of ocean shore areas into the various erosion categories represents qualitative determinations as to the relative severity of the erosion.

The results of the classification of the developed ocean shores is presented in Table I.C-2 and the distribution of the erosion classification for the reaches is presented in Figures I.C-1 to I.C-4. For the ocean shores as a whole, 32.9 percent of the total length is considered as Category I (critical erosion), 18.0 percent as Category II (significant erosion), 38.5 percent as Category III (moderate erosion) and 10.6 percent as non-eroding, Category IV. The percentage of each reach which is classified as Categories I and II, and the percentage that each reach represents of the total category for the New Jersey shoreline for both Category I and for I plus II, is presented in Table I.C-3. Reaches which have a significant portion of their shoreline classified as Category I or I plus II, and also represent a significant portion of the total New Jersey I plus II, include Reach 2 (Sandy Hook to Long Branch), Reach 3 (Long Branch to Shark River Inlet), Reach 9 (Absecon Island), Reach 10 (Pecks Beach), Reach 11 (Ludlam Island), and Reach 14 (Cape May Canal to Cape May Point). These areas thus represent the most seriously threatened reaches in New Jersey.

TABLE I.C-2

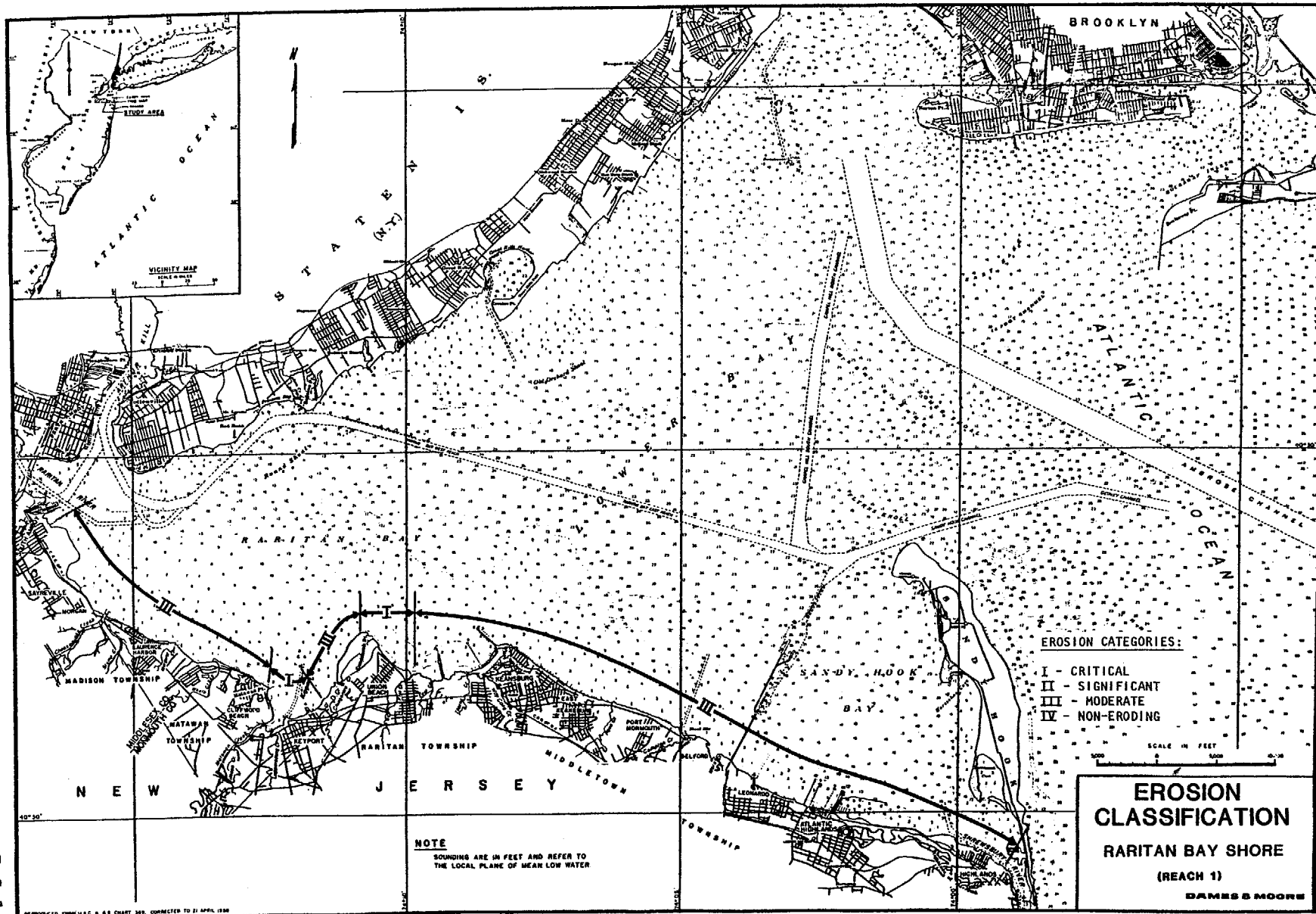
OCEANFRONT EROSION CLASSIFICATION RESULTS BY REACH*

Reach Number	Reach Name	Length in Category (ft)			
		I Critical Erosion	II Significant Erosion	III Moderate Erosion	IV Non- Eroding
2	Sandy Hook to Long Branch	31,900	10,700	—	17,700
3	Long Branch to Shark River Inlet	22,200	19,500	8,700	—
4	Shark River Inlet to Manasquan Inlet	—	14,300	16,200	—
5	Manasquan Inlet to Mantoloking	—	—	11,250	5,400
6	Mantoloking to Barnegat Inlet	—	—	86,000	—
7	Long Beach Island	—	10,200	86,000	—
8	Brigantine Island	7,800	3,750	5,100	4,650
9	Absecon Island	8,700	17,600	16,500	—
10	Pecks Beach	41,400	2,400	—	—
11	Ludlam Island	35,000	1,200	—	—
12	Seven Mile Beach	19,100	4,500	—	—
13	Five Mile Beach	—	10,800	9,300	12,300
14	Cape May Inlet to Cape May Point	18,700	6,100	7,800	—
Total		184,800	101,050	216,200	59,850
% Total		32.9%	18.0%	38.5%	10.6%

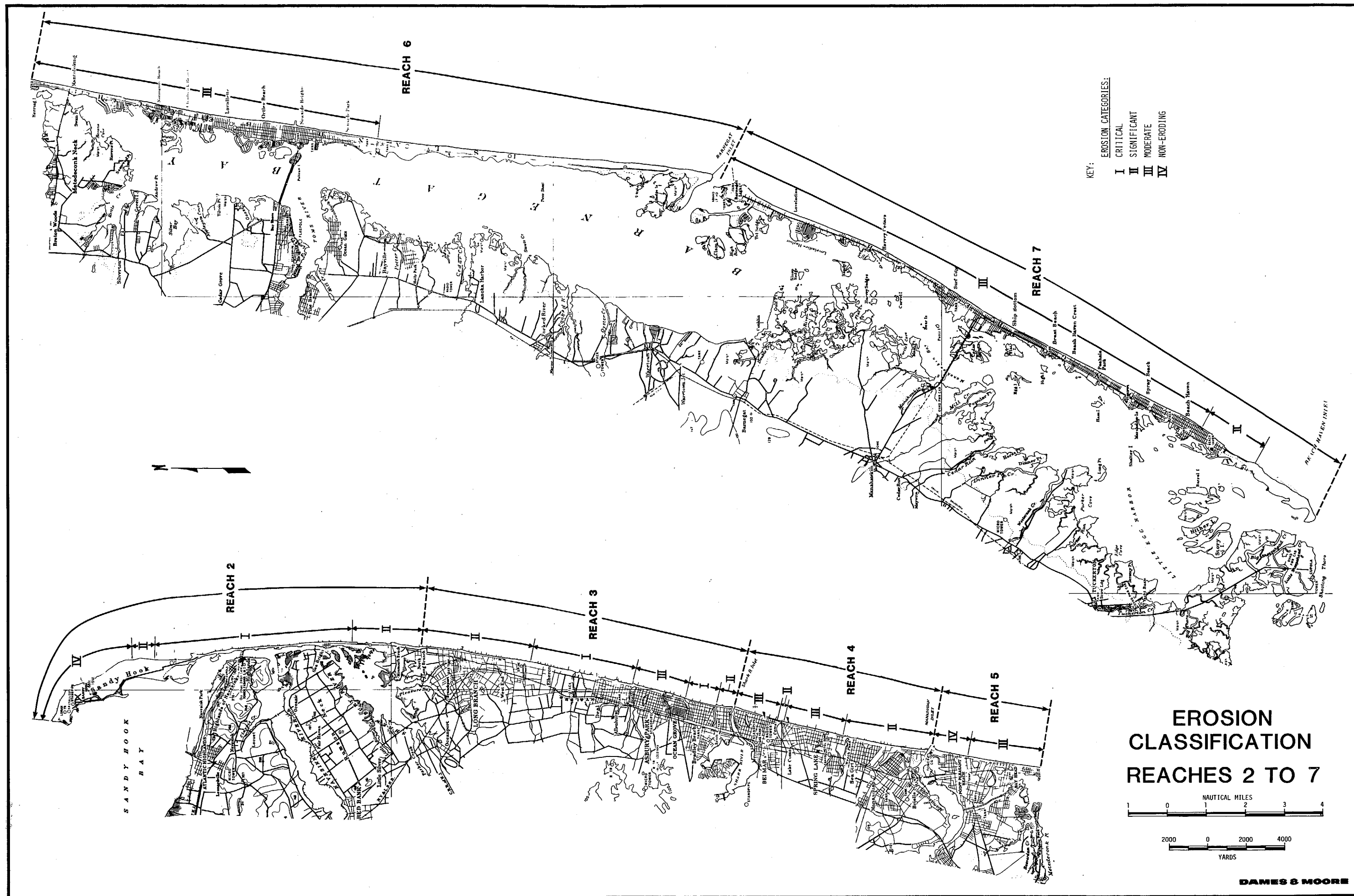
*Excluding Island Beach State Park in Reach 6, Brigantine National Wildlife Refuge and North Brigantine State Natural Area in Reach 8, Raritan Bay (Reach 1), and Delaware Bay and River (Reaches 15 and 16).

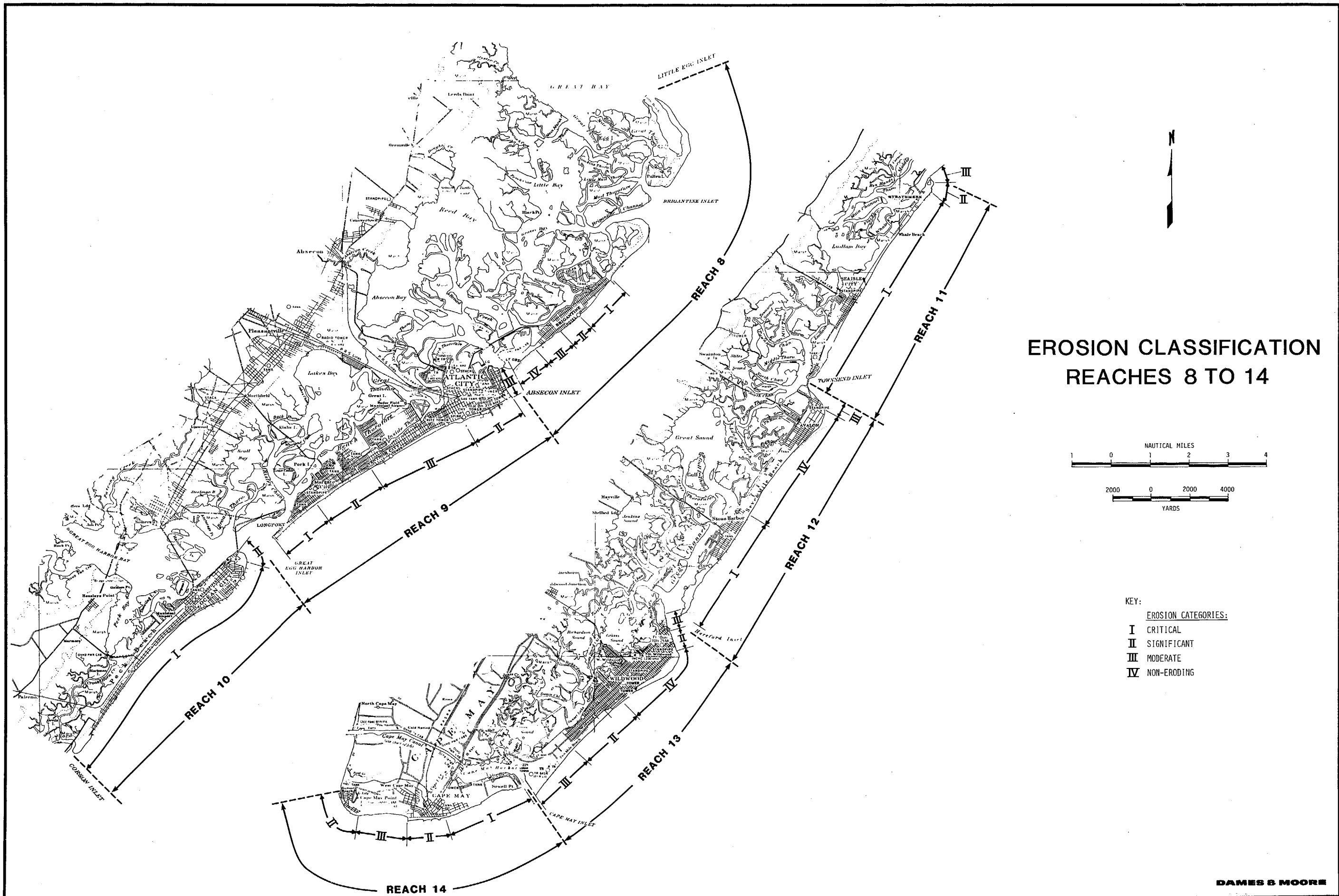
I-15

FIGURE I.C-1



REPRODUCED FROM U.S.C. & G.S. CHART 349, CONNECTED TO 31 APRIL 1950





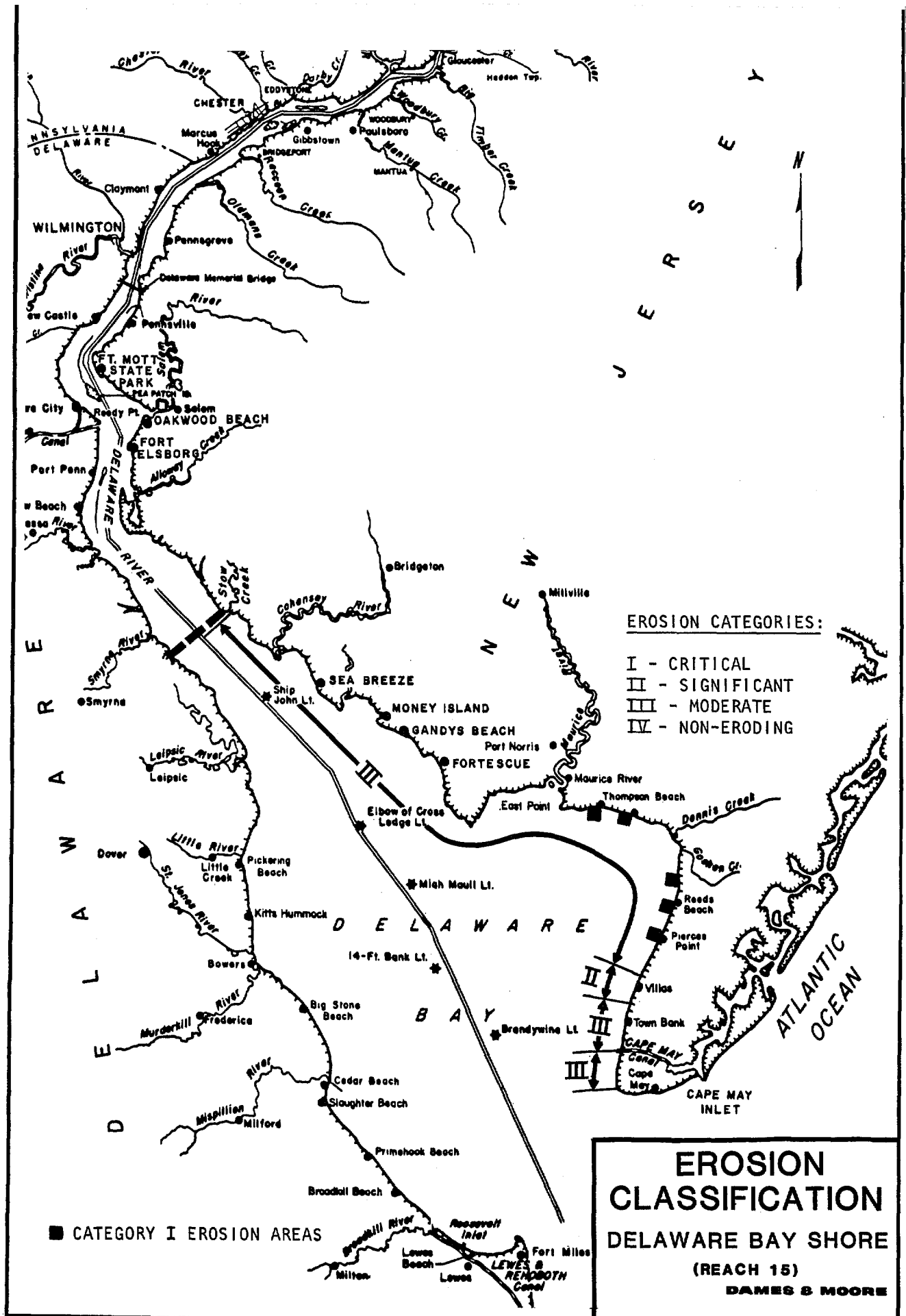


TABLE I.C-3

SUMMARY EROSION CLASSIFICATION OF OCEAN SHORELINE BY REACH

Reach Number	Reach Name	Percent I & II Of Total Reach	Percent of Total I For N.J. Shoreline	Percent of Total I & II For N.J. Shoreline
2	Sandy Hook to Long Beach	70.6	17.3	14.9
3	Long Branch to Shark River Inlet	82.7	12.0	14.6
4	Shark River Inlet to Manasquan Inlet	46.9	0.0	5.0
5	Manasquan Inlet to Manatoloking	0.0	0.0	0.0
6	Mantoloking to Barnegat Inlet	0.0	0.0	0.0
7	Long Beach Island	10.6	0.0	3.6
8	Brigantine Island	54.3	4.2	4.0
9	Absecon Island	61.4	4.7	9.2
10	Pecks Beach	100.0	22.5	15.3
11	Ludlam Island	100.0	18.9	12.6
12	Seven Mile Beach	54.4	10.3	8.3
13	Five Mile Beach	33.3	0.0	3.8
14	Cape May Inlet to Cape May Point	76.1	10.1	8.7
			100.0	100.0

In addition to the developed ocean shore areas, local erosion problem areas (Category I) are also found on the bay Reaches 1 and 15. Inlet shores at the north end of Reaches 9, 12 and 13 also have localized erosion problem areas of varying severity. The south shores of Absecon Inlet (Reach 9), Townsend Inlet (Reach 12) and Hereford Inlet (Reach 13) have historically experienced erosion problems resulting from the dynamic migration of the inlet systems. Attempts to stabilize these inlet shores are evident in the presence of bulkheads, revetments, groins, and jetties installed at various times by the State and local municipalities. Despite these measures, the problems persist in some areas, especially where structures are inadequate or are in need of repair. Similar erosion problems on the south shores of Great Egg Harbor Inlet (Reach 10) and Corsons Inlet (Reach 11) have been restabilized by the State utilizing beach fill and groins.

Based on the above analysis, portions of shoreline within ten reaches (8 ocean and 2 bay reaches) have been identified as Category I — critical erosion areas. In general, for all Category I areas, the probability of significant damage to vital shore protection structures, private or public buildings, or the infrastructure is high.

Engineering measures must consider not only the critical portions of a reach, but the entire reach, including lesser eroding areas, to ensure that any alternative does not adversely affect any other portion of the reach. This is the rationale of planning by reach and is the fundamental principle of the Master Plan as discussed in Section II.B.1 of this Volume. In Volume 2, Section II.B., each reach having critical erosion problems is briefly discussed in terms of the magnitude of erosion and existing structures.

3. Coastal Features and Processes

The natural dynamics of the coastal system must be evaluated in any study of shoreline erosion to determine potential hazards and mitigation measures. In New Jersey, about 80 percent of the open ocean coast consists of barrier island and spits; the remaining 20 percent is headlands. Dolan and others (1980) have recently summarized the natural processes of the coastal barrier systems as they relate to the hazards associated with this environment.

This section describes the New Jersey shore forms and reviews the shoreline processes and geomorphic response of the shore segments in time and space, with particular attention to the barrier system. This information will facilitate an understanding of beach erosion as related to development in the coastal areas and as input to the evaluation of alternative mitigation measures. Additional summary information on coastal, estuarine, and barrier island processes is available in annotated bibliographies by Sinha and McCosh (1974) and Gulf South Research Institute (1978).

a. Description of Shore Forms

The geomorphology of the New Jersey coastal forms has been reviewed by Nordstrom (1977) and Yasso and Hartman (1975), who recognize the following major geomorphic components of the shore (Figure I.C-5):

- o Raritan Bay, 22 miles long
- o Northern Barrier Spit (Sandy Hook), 10 miles long
- o Northern Headlands, 19 miles long
- o Northern Barrier Island Complex, 42 miles long
- o Southern Barrier Island Complex, 48 miles long

- o Southern Headland (Cape May), 5 miles long
- o Delaware Bay, 91 miles long
- o Delaware River, 60 miles long (south of Trenton).

Except for the presence of the small Southern Headlands component at Cape May, the New Jersey coastal geomorphic pattern is strikingly similar to the other major coastal compartments in the mid-Atlantic region (Cape Cod, Long Island, Delmarva Peninsula, and North Carolina). Each of these compartments is characterized by: (1) a northern or cusped spit, (2) an eroding headland, (3) a southern-barrier island, and (4) a southernmost barrier island chain (Fisher, 1967, in Swift, 1969).

In New Jersey, the Northern Headlands area (most of Monmouth County) is characterized by narrow beaches at the base of subdued bluffs which have been eroded from the unconsolidated Coastal Plain formations. The beach sands are coarse-to-medium in size, with a characteristic mineral composition whose source can be traced to the Coastal Plain formations (McMaster, 1954). Coarser grain sands and this distinctive mineralogy also characterize the Sandy Hook spit to the north and the Northern Barrier Island Complex to the south. The coarser sand sizes in this northern sector result in steeper beaches and offshore profiles. The Northern Headlands extend from Monmouth Beach on the north through Long Branch, Asbury Park, and Point Pleasant to Bay Head on the south. The low headlands for this area have elevations of 15 to 25 feet and terminate in a low bluff line which borders the narrow beach. Headland elevations diminish and the beach widens progressively to the southern terminus of the headlands.

The Northern Barrier Island Complex consists of two long barrier elements: (1) the south-prograding Barnegat barrier which extends 21 miles from Bay Head to Barnegat Inlet and (2) Long Beach Island, 20 miles to the south. The tidal lagoons or backbays behind these barriers are quite wide, ranging from 3 to 4 miles in most places.

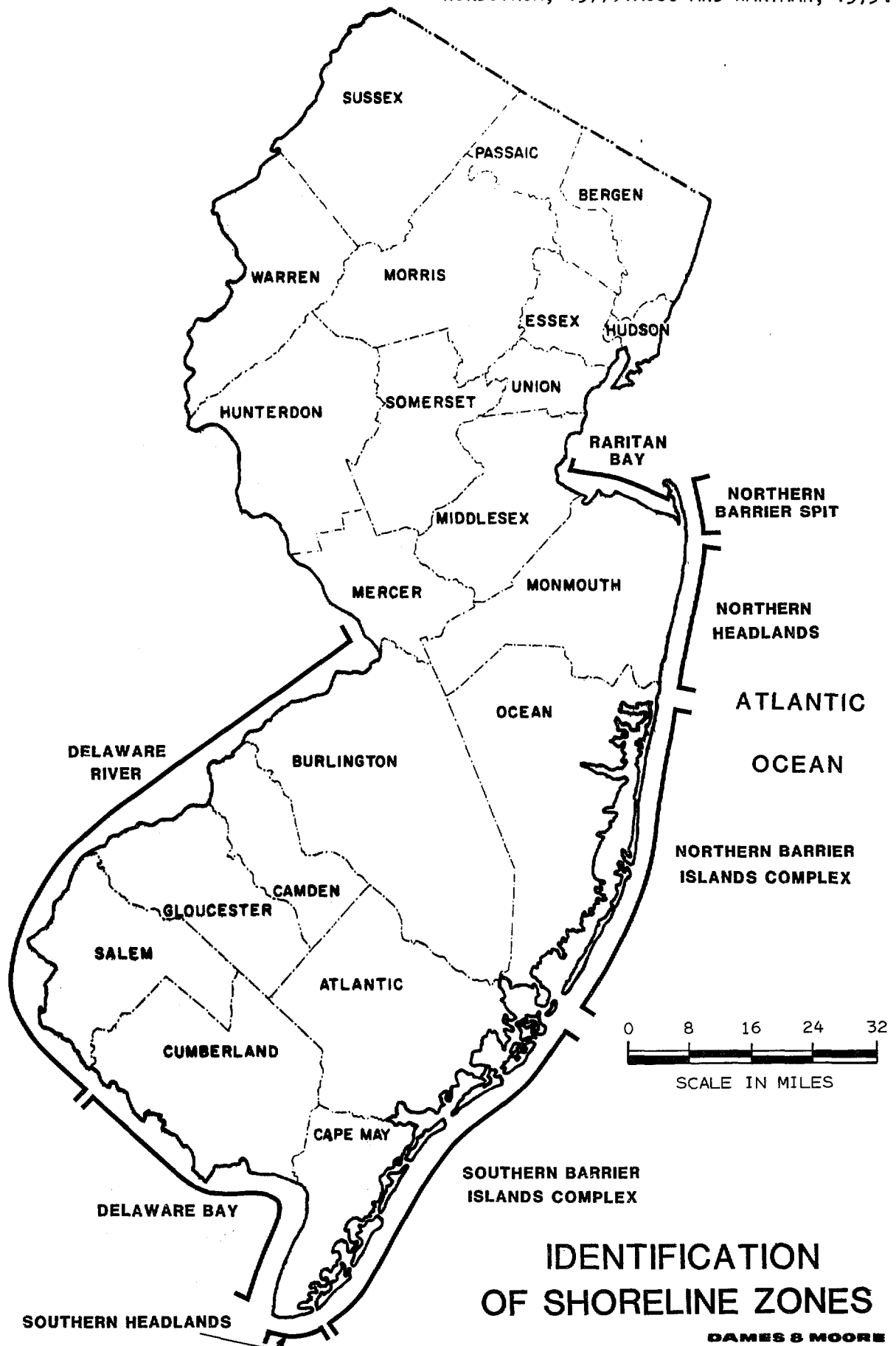
The Southern Barrier Island Complex consists of a chain of smaller islands separated by seven inlets. This complex is separated from the Northern Complex by the large double inlet system of Beach Haven-Little Egg Inlet. The beaches of the Southern Barrier Island Complex are characterized by fine-grain sand sizes and the resulting flatter beach slopes, as well as a heavy mineral assemblage distinctive from the northern beaches (McMaster, 1954). The Beach Haven-Little Egg Inlet system represents a sharp boundary between the compositional and textural characteristics of the northern beaches (medium-to-coarse sizes and opaque heavy minerals) and the beaches to the south (fine sizes and hornblende-garnet heavy minerals).

The islands and inlets of the Southern Barrier Island Complex, listed from north to south, are:

- | | |
|---------------------|---------------------------------|
| o Pullen Island | o Brigantine Inlet |
| o Brigantine Island | o Absecon Inlet |
| o Absecon Island | o Great Egg Inlet |
| o Peck Beach | o Corson's Inlet |
| o Ludlum Island | o Townsend's Inlet |
| o Seven Mile Island | o Hereford Inlet |
| o Five Mile Island | o Cape May (Cold Spring) Inlet. |

Except for Pullen Island, which is only about 2 1/2 miles long, the average length of the islands in the Southern Complex is 5 to 6 miles. The northern islands are characteristically larger.

REFERENCE:
NORDSTROM, 1977; YASSO AND HARTMAN, 1975.



The terrain along the Raritan Bay shore between Perth Amboy and the Shrewsbury River ranges from high bluffs near the west and east ends to low marshlands which are partially inundated by high tides. Present beaches are low and narrow, and a number of tidal creeks intersect the shoreline. The offshore hydrography is mostly very shallow and flat, with the 12-foot-depth contour generally located over a mile offshore, except in the eastern portion of the bay shore where depths are greater. Much of the shoreline is structurally stabilized with groins, bulkheads, and revetments, except for the artificially filled areas between Port Monmouth and Sayreville. Where structures exist, they have generally been effective in controlling shoreline erosion. However, as is the case along the Atlantic shore, most beaches seaward of these structures have been lost by erosion. Locally, artificially filled beaches, as at Keansburg, have provided a measure of protection as well as a recreational beach.

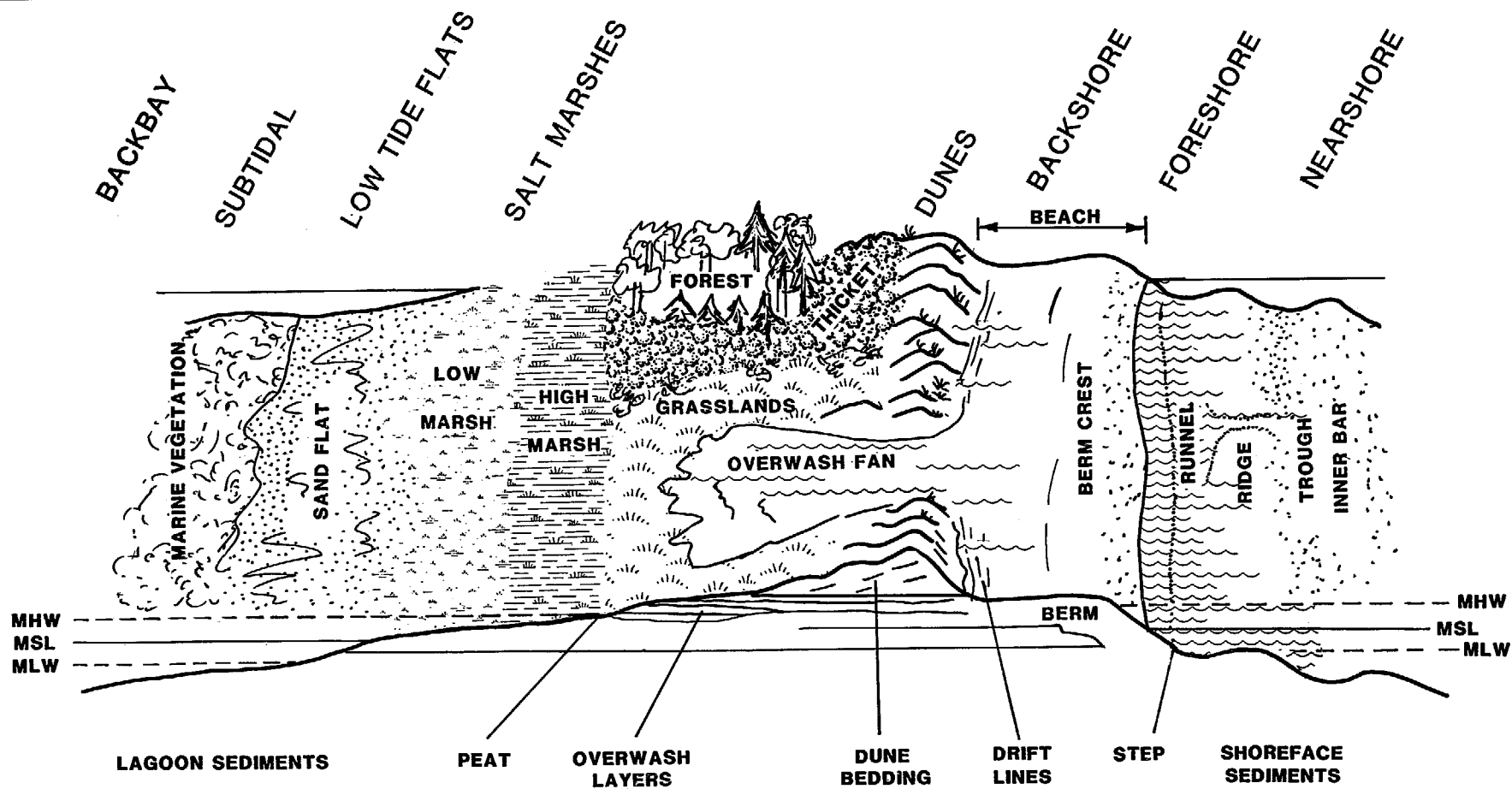
The Delaware Bay shore is naturally divided into two rather distinct geomorphic sections. From Cape May Point to Bidwell Creek (approximately 11 miles), the shore is characterized by low bluffs fronted by a low narrow strip of eroding coarse sandy beach. From Bidwell Creek to Stow Creek (approximately 80 miles), the bay shore is characterized as an irregular, low, eroding salt marsh coast with isolated small beaches backed by low dunes and firm ground. The irregular salt marsh coast continues to dominate the shoreline up the Delaware River to the mouth of Salem River. The Delaware Bay and lower Delaware River shore are drained by small tidal tributary streams and creeks, many of which have been improved under Federal navigation projects.

The main stem of the Delaware River begins at the confluence of the West Branch and East Branch near Hancock, New York, about 197 river miles above Trenton (where the river becomes tidal). From Trenton south, the river has been improved under Federal navigation projects. The river shore from Salem River to Trenton is highly developed and industrialized, with port commerce at Camden, Gloucester, and Paulsboro.

b. Shoreline Dynamics

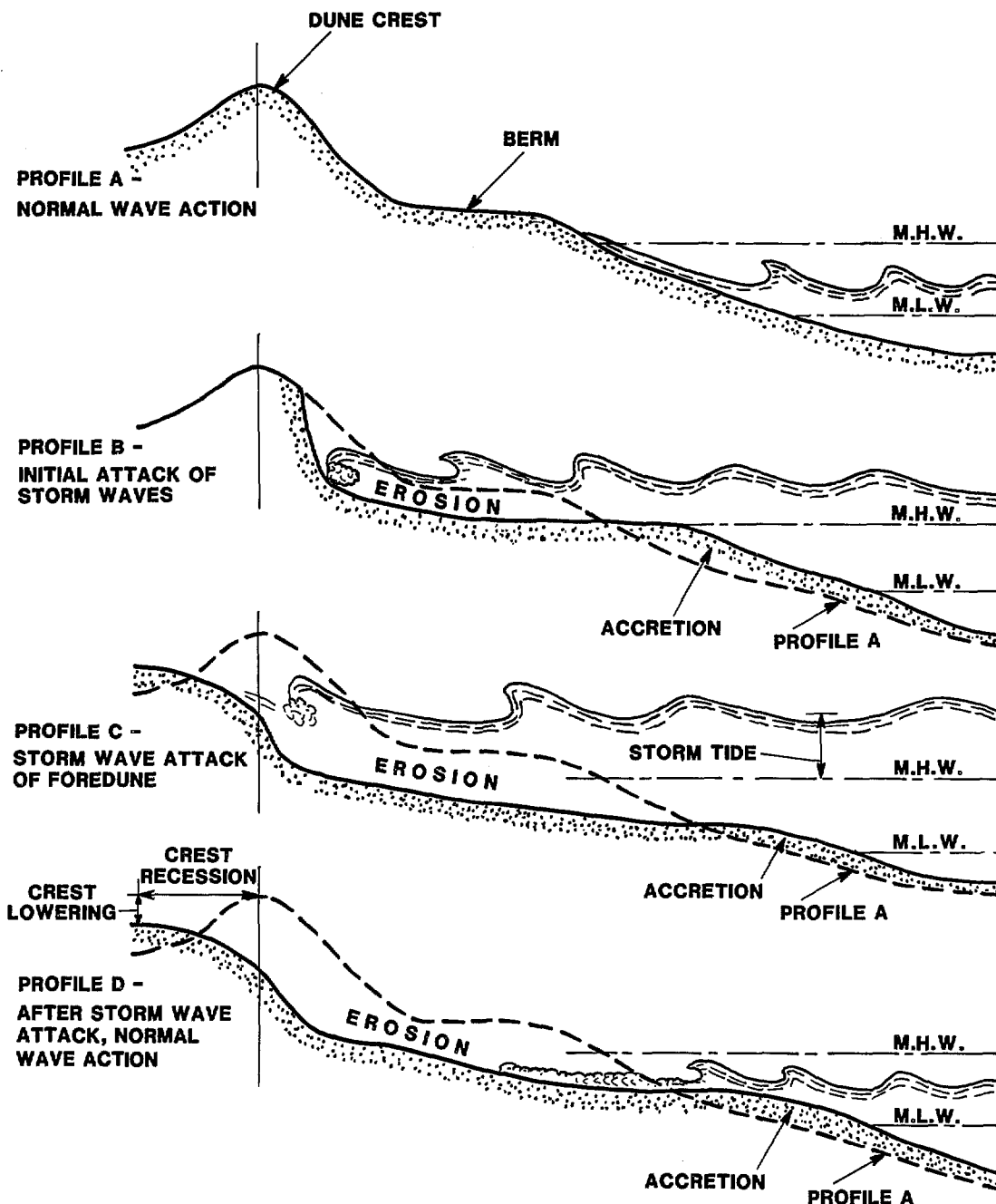
(1) Components of the Barrier System (Islands and Spits). For convenience, both the barrier islands and barrier spits will be referred to here as barrier islands. Each island is an elongated, narrow landform consisting primarily of unconsolidated sand. The islands represent a dynamic response to the surrounding wind, wave, and tidal forces that cause the constant shifting of sand along the beach and through the dune system. The basic features of a barrier island are presented in Figure I.C-6, which presents a generalized model for an undeveloped barrier island and is used to illustrate the major elements of the natural barrier's response to the dynamics of the environment.

A typical beach is divided into the foreshore and backshore zones. The foreshore is the sloping portion of the beach which absorbs wave energy. The backshore is characterized by a berm, which is the least stable portion of the system. Natural storm berms, created by storm waves, may be present in the inner portion of the backshore. The berm crest is marked by a ridge of sand at the top of the wave uprush. The flat berm area or backshore beyond this crest forms the main area of the dry beach. Wind blowing inland from the foreshore and berm transports the fine size sand to form dunes. Sand is also transported from the barrier flats and overwash areas by winds blowing from the bay side. As dunes build up, they provide both a natural protection line against storm wave attack and a reservoir of sand that "sacrifices itself" while dissipating storm wave energy (Figure I.C-7).



MODEL OF AN UNDEVELOPED BARRIER ISLAND

REFERENCE: ADOPTED FROM GODFREY, 1976.



SCHEMATIC DIAGRAM OF STORM WAVE ATTACK ON BEACH AND DUNE

REFERENCE: ADAPTED FROM USACOE, CERC, 1977.

DAMES & MOORE

Almost all beaches are in a constant state of flux. The rise in tidal levels which accompanies a storm event results in the concentration of wave energy in a higher zone on the normal beach profile. This results in the flattening of the overall profile due to erosion of the berm and dune areas and deposition of the eroded material offshore. The beach is subsequently rebuilt by the transport of this offshore sand by waves associated with calmer periods. The rising water levels may be capable of breaching the dune system in low areas and transporting sand to the back portion of the barrier as overwash deposits.

Longer term beach erosion and accretion occur with changes in the general wave climate associated with seasonal storms. During stormy seasons, usually in winter to spring, the larger short-period waves and more frequent storms tend to move sand off the beach, depositing it in shallow offshore sand bars. During the calm weather, the typical long-period ocean swell waves tend to move sand inshore, rebuilding the beaches.

Although the Raritan Bay, Delaware Bay, and backbay shores are also being eroded by waves and high tides associated with storms, they are generally sheltered from the constructive long-period ocean swell waves. Despite the relatively low average wave energies that characterize the bay-shore areas, normal and storm erosion deplete the shores by depositing eroded materials offshore without allowing for the replenishment of the beach by natural processes. This problem is further intensified where shore erosion control structures have been constructed, thus depleting potential new sources of beach material.

(2) Littoral Drift. The barrier islands and headlands along the coast represent a dynamic response to the forces of wind, waves, and tides. Waves impinge on the shore and move the sand along as littoral drift when they approach at an angle to the shore. The direction, angle of approach, and wave size and shape vary from place to place, and with time or season, depending on the characteristics of prevailing and storm-related winds in the offshore areas and the refracting effects of bottom configuration as the waves approach the shore.

At certain times, depending on wave direction, littoral drift at a location may move to the north, while at other times the wave approach and resulting littoral drift may move to the south. The net balance of these opposing movements summed over a yearly period is referred to as the annual littoral drift. An area which has a zero net littoral drift is referred to as a nodal zone. Historically the nodal zone of zero net littoral drift on the New Jersey shore was thought to be located on the northern portion of the Barnegat barrier between Seaside Heights and Normandy Beach. Recent studies and analyses of long term trends around Barnegat Inlet indicate the nodal zone may shift as far south as Ship Bottom on Long Beach Island (S.D. Halsey, NJDEP, personal communication). As indicated in Figure I.C-8, the net littoral drift on the New Jersey Atlantic coast is to the north for the areas north of the nodal zone and to the south for the areas south of the nodal zone.

Operative littoral processes along the shorelines of the Raritan Bay, Delaware Bay, and coastal backbay areas include prevailing and storm-related wind-driven waves and currents and tidal currents. The general irregularities of these open and backbay shorelines are indicative of the lower average wave energies acting on them as compared to the ocean shoreline.

Predominant littoral processes acting on the shoreline of the Delaware River and navigable tidal tributaries around the coast of New Jersey include tidal currents, high tide levels associated with storms, and locally generated ship and boat wakes.

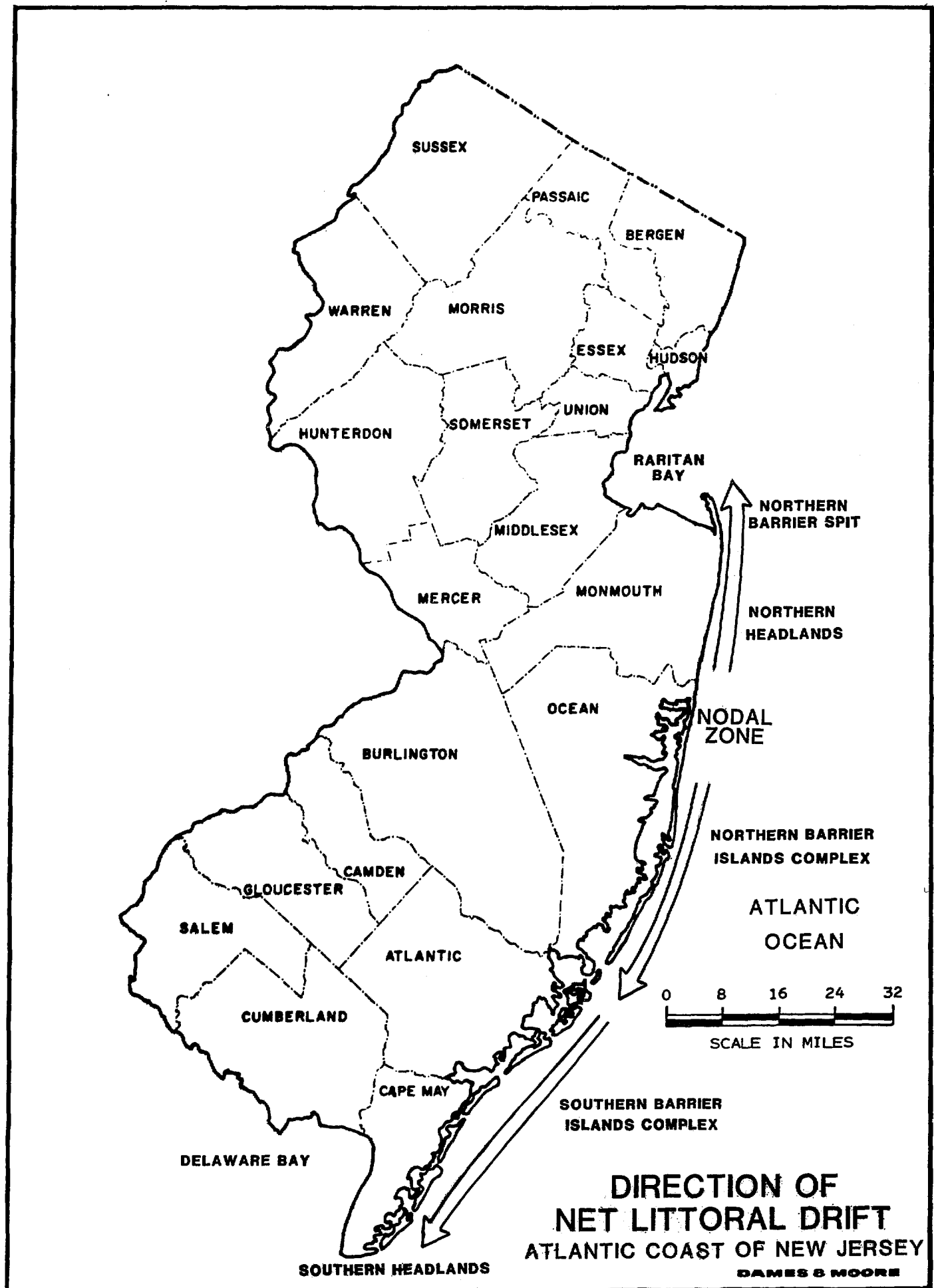


FIGURE I.C-8

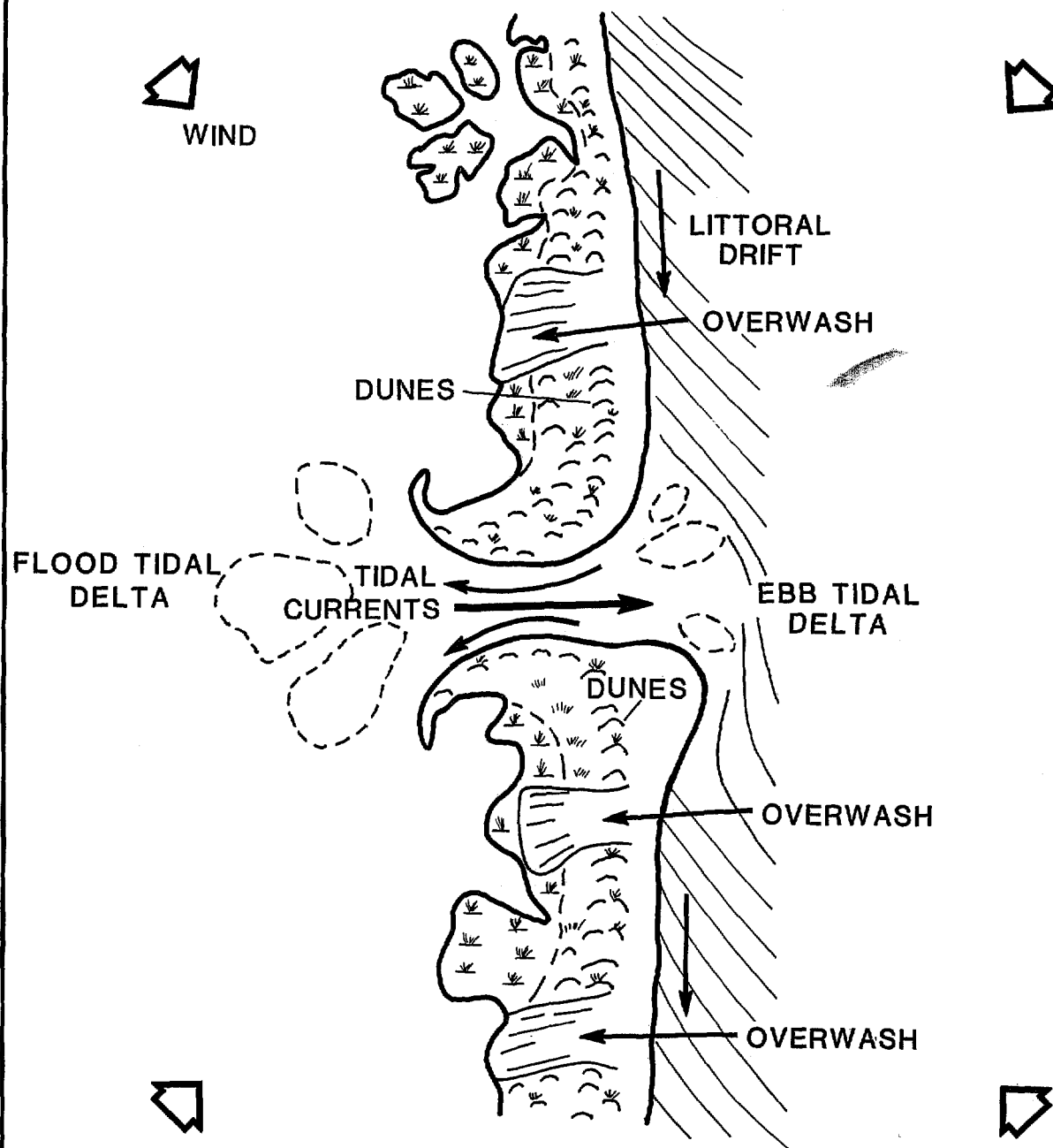
(3) Wind Effects. In addition to its influence on waves and the related effects of transport in the shore zone, wind is also important in the transport of sand above the high water line, where it contributes to dune formation and the transfer of sand along and between the dune and beach systems. Sand transport begins when the wind velocity reaches a certain threshold level which varies as a function of the sand grain size. Bagnold (1954) suggests that the basic threshold value for the initiation of sand movement by wind is approximately 14 ft/sec. or 10 mph. As the wind velocity increases beyond the necessary threshold level, so does the capacity of the wind to transport the sand (CCES, 1979). Substantial sand movement is only accomplished by sustained high wind velocities.

Over a given period of time, the total amount of sand transported in a particular direction is primarily dependent on the duration and direction of the wind. Other factors influencing sand transport in the beach and dune areas include rainfall, salt spray, drying, stabilizing vegetation, local topography, the degree of development, and human activities.

(4) Tidal Inlets. Tidal inlets, another major element of the coastal system (Figure I.C-9), are short, narrow waterways which hydraulically connect the backbays and estuaries with the open ocean. Natural inlet channels are primarily maintained by tidal currents, which help to prevent shoaling of the inlet. Inlets generally scour to a maximum depth in the area of greatest constriction, usually in the central part immediately between the barrier islands or land masses which contain them.

As illustrated on Figure I.C-9, broad shoals are common at the landward and seaward ends of the inlet. These shoals, known as tidal deltas, are formed by sand of the littoral drift system and the declining velocities of tidal currents. Ebb tidal deltas or shoals form in the offshore areas at the inlet mouth in response to deposition of sediment, and flood tidal deltas form on the bay side of the inlet from flood tidal currents. The ebb tidal shoals cause significant refraction, especially of waves from the east or northeast. This results in a reversal in net littoral drift from the general southerly net drift in the Southern Barrier Island Complex to a northerly net drift on the northern portions of the islands (Hayes, 1975; Dames & Moore, September 1974). This action and the movement of sand to the south around the outer edge of the ebb shoal result in the bulbous accretional configuration which characterizes the northern portion of most of these barrier islands.

As with barrier islands, the tidal inlets are in a state of "moving equilibrium" because tidal current flow, waves, and littoral drift are constantly changing. Depending on the combination of these coastal processes, inlets may remain stationary and open, closed, or migrate laterally. The migration of inlets is generally a one-directional movement, following the net littoral drift. In the migration process, the drift system deposits sediments on the updrift side of the inlet, causing the tidal currents to erode the downdrift side (Bruun, 1978). Several instances of such continuous lateral migration have been documented along the east coast of the United States. Lucke (1934) reported that Barnegat Inlet has migrated a significant distance south during the past century. Recent work at Fire Island Inlet, on Long Island, has revealed that the inlet has migrated west along the barrier for a total distance of 5 miles in the past 115 years (Kumar, 1972).



MECHANISMS OF SAND TRANSPORT ON BARRIER BEACHES

REFERENCE: ADAPTED FROM GODFREY, 1976.

DAMES & MOORE

Due to changes in the equilibrium conditions, an established inlet may become constricted or closed completely by deposition of large quantities of littoral sediments. Such changes could be caused by increased littoral drift or by a reduction of tidal hydraulic pressures (Bruun, 1978). Conversely, an inlet may stabilize and remain at one location for a long time. Stabilizing factors could be natural, such as reduced drift, increased tidal flow, or an erosion-resistant downdrift shore, or artificial, such as dredging and jetty protection. The locations of existing and reported extinct inlets on the Atlantic coast of New Jersey are presented in Table I.C-4 and on Figures I.C-10 and I.C-11, respectively.

New inlets are commonly created and old inlets eliminated by intense storm-related changes in equilibrium conditions. Formation of a new inlet by breaching may result from one or a combination of the following:

- o Storm wave overtopping from the seaward side of the barrier.
- o Storm surge reflux on the landward side (a high storm water level in the backbay which drains out over low areas of the barrier).

Temporary, storm-changed hydraulic patterns accompanied by an increased littoral drift may result in closure of new inlets. Due to the continued dynamic conditions of the barrier system, the inlets eroded by storm conditions may remain as the tidal connections between the backbay and ocean, replacing the less hydraulically favorable inlets.

An example of the dynamic nature of an inlet system in response to littoral forces is provided by a study of the Beach Haven-Little Egg Inlet system (Dames & Moore, 1975; DeAlteris et al., 1976). Maps and charts dating to 1685 show varying configurations of a single and combined inlet system. In 1685, the Beach Haven Inlet was located about 14,000 feet north of its 1974 position (Figure I.C-12). The position recorded on a 1743 map located the inlet several thousand feet south of the 1685 position. U.S. Coast and Geodetic Survey Charts from 1840 show that the southern tip of Long Beach Island and the adjacent Beach Haven Inlet had migrated over 20,000 feet to the south by 1903, at which time the Beach Haven Inlet merged with the Little Egg Inlet to form "New Inlet." This configuration lasted until 1920 when Long Beach Island was breached once again in the vicinity of Holgate and began a new cycle of southerly migration. This migration was driven by the infilling of the channel on its northern margin by south-moving littoral drift. To maintain its hydraulic equilibrium, the inlet eroded its channel on the southern margin and thus migrated south by cut-and-fill processes. Such processes result in the complete reworking of the south segment of Long Beach Island with each cycle. The natural process of southerly migration of the inlet will continue until the dual inlet configuration comparable to the 1903-1920 position is reached. Once again the hydraulic shortcut will reoccur in the future, with breaching in the Holgate vicinity repeatedly initiating the cycle.

Other inlets on the New Jersey coast have fluctuated slightly from an average position, but have not migrated as extensively as the Beach Haven-Little Egg complex. This fluctuation of channel position, however, results in periodic erosion and accretion of the terminal segments of the barrier islands adjacent to the inlets. The historical variations for the Brigantine and Wreck Inlets to the south of Pullen Island are shown in Figure I.C-12.

The breaching of a new inlet can have a significant effect on littoral transport in the adjacent shoreline zones. Sediment normally transferred downdrift becomes trapped in the inlet system and is generally stored in the flood or ebb tidal

TABLE I.C-4

EXISTING AND EXTINCT INLETS ON THE ATLANTIC COAST OF NEW JERSEY
(Refer to Figure I.C-10 and I.C-11 for Inlet Locations)

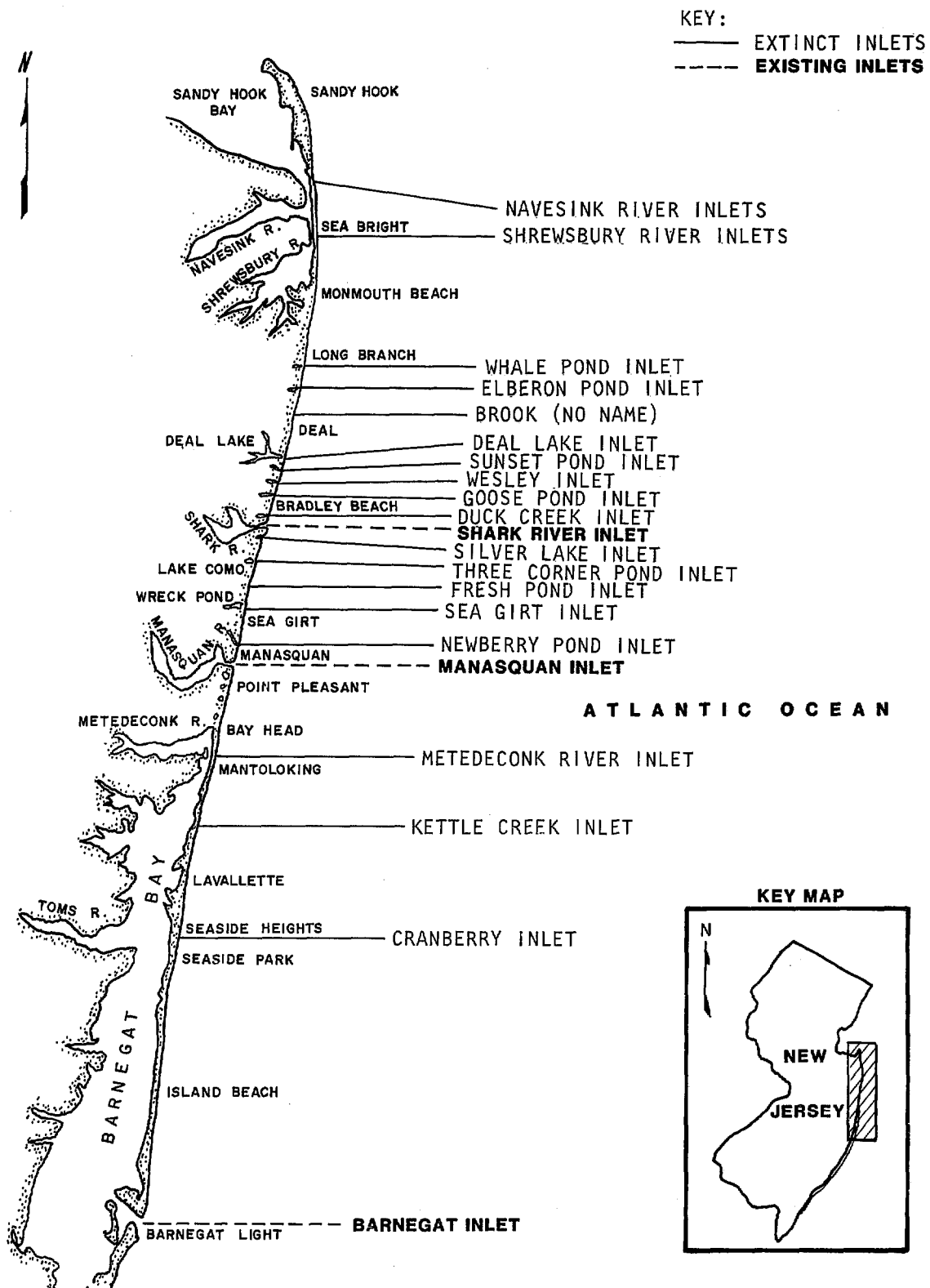
<u>Inlet Name</u>	<u>Status</u>	<u>Remarks</u>
Navesink River Inlet	Closed	Sandy Hook was connected to the Highlands in 1835-1836. The river emptied directly into ocean. Inlet closed by railroad in 1856. Later broke through in 1896-1897. Closed artificially 1900-1901.
Shrewsbury River Inlet	Closed	Closed by railroad 1856.
Whale Pond Inlet	Closed	Closed naturally.
Elberon Pond Inlet	Closed	Closed naturally.
Brook (no name)	Closed	Seepage to beach.
Deal Lake Inlet	Closed	Seepage to beach.
Sunset Pond Inlet	Closed	Seepage to beach.
Wesley Inlet (Long Pond)	Closed	Seepage to beach.
Goose Pond Inlet	Closed	Seepage to beach.
Duck Creek Inlet	Closed	Seepage to beach.
Shark River Inlet	Open	Artificially maintained with jetties.
Silver Lake Inlet (Perch Pond)	Closed	Seepage to beach.
Three Corner Pond Inlet (Lake Como)	Closed	Seepage to beach.
Fresh Pond Inlet (Spring Lake)	Closed	Seepage to beach.
Sea Girt Inlet (Wreck Pond)	Closed	Seepage to beach.
Newberry Pond Inlet	Closed	Old mouth of Manasquan (Squan River).
Manasquan River Inlet	Open	Artificially maintained with jetties.
Metedeconk River Inlet	Closed 1755	
Kettle Creek Inlet	Closed	
Cranberry Inlet	Open 1750 Closed about 1812	Opposite Toms River at present north border of Seaside Heights Borough.

TABLE I.C-4 (Continued)

<u>Inlet Name</u>	<u>Status</u>	<u>Remarks</u>
Barnegat Inlet	Open	Artificially stablized by jetties. Presently being modified by COE.
Temporary Inlet Harvey Cedars	Closed	Island breached at Harvey Cedars by inlet during March 1962 storm. Closed by COE.
Temporary Inlet Holgate	Closed	Inlet breach at Holgate during March 1962 storm. Closed by COE.
Beach Haven Inlet Little Egg Inlet	Open	Highly migratory, not stabilized. Beach Haven and Little Egg Inlets merged about 1903 to form "New Inlet." In 1920, breach at Holgate reformed Beach Haven Inlet. Tuckers Island separated it from Little Egg Inlet. Tuckers Island steadily eroded to a shoal by 1953.
Wreck Inlet	Merged	Drained about 1905. Great Thorofare merged with Brigantine Inlet in 1963.
Brigantine Inlet	Open	Relatively stable in position since about 1840.
Brigantine Island Breach	Closed	1.5 miles north of Absecon Inlet in 1870.
Absecon Inlet	Open	Artificially stabilized.
Dry Inlet	Closed 1855	Absecon Island divided by shallow inlet at location of Jackson Avenue.
Great Egg Harbor Inlet	Open	Not stabilized.
Corsons Inlet	Open	Not stablized.
Townsend Inlet	Open	Artificially stabilized.
Hereford Inlet	Open	Artificially stabilized.
Turtle Gut Inlet	Closed	Located approximately 2 miles north of Cold Springs Inlet. Closed naturally in 1909. Later closed artificially 1917.
Cape May Inlet (Cold Springs Inlet)	Open	Artificially stabilized with jetties constructed during the 1908-1911 period.

Sources:

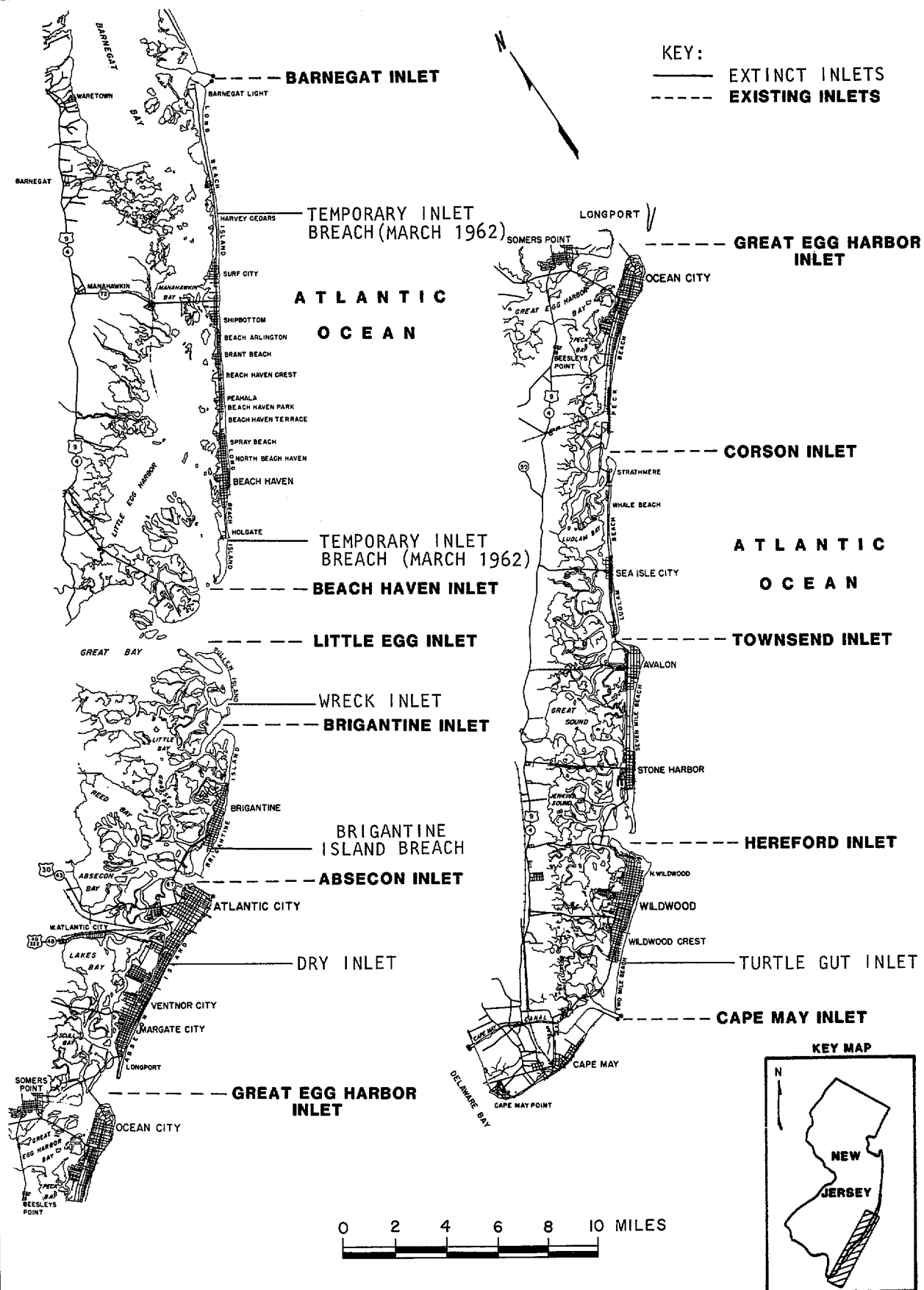
Moss (1964); Lucke (1934); Dames & Moore (September 1974); State of New Jersey Board of Commerce and Navigation (1922).



0 2 4 6 8 10 MILES

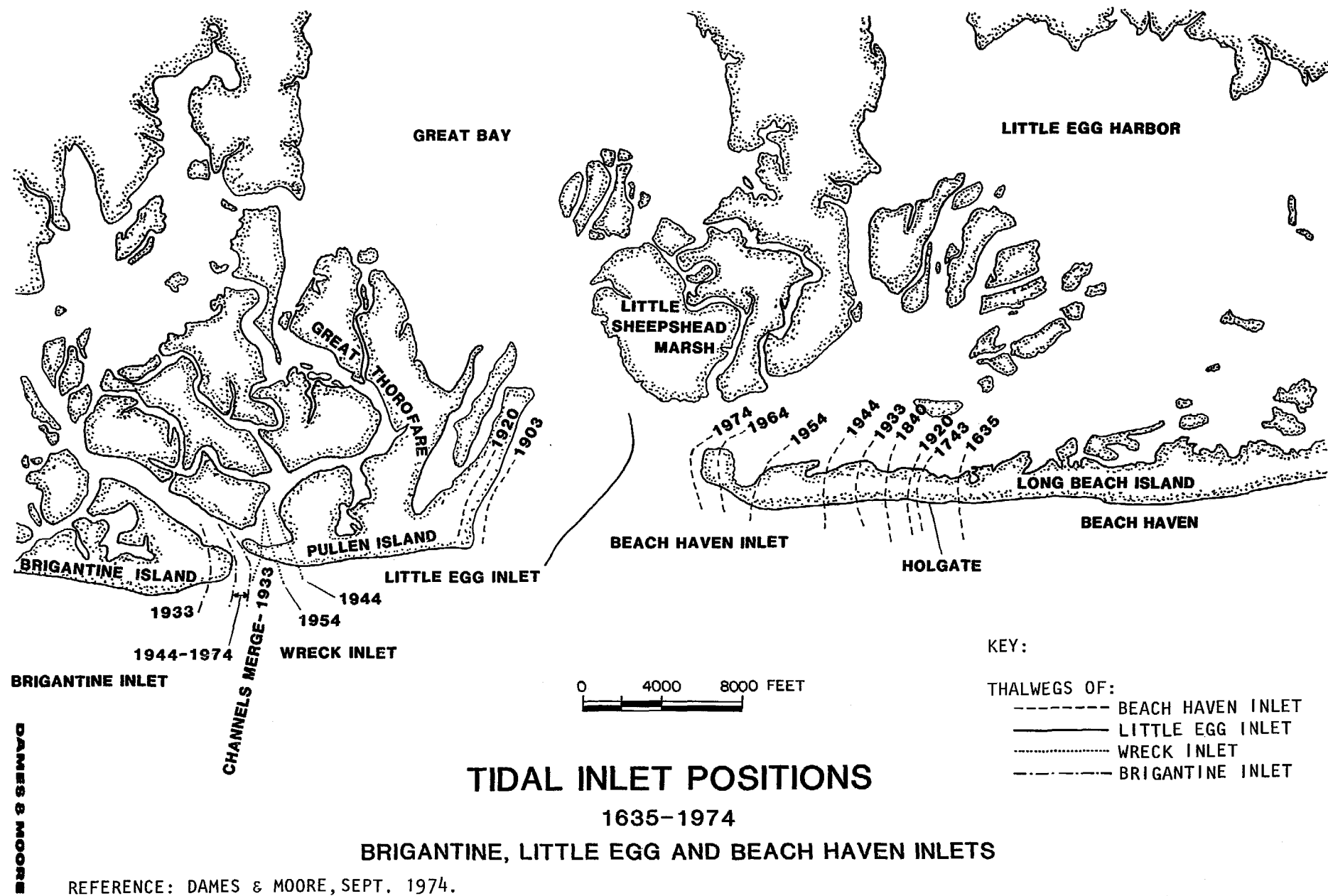
EXISTING AND EXTINCT INLETS SANDY HOOK TO BARNEGAT INLET

DAMES & MOORE



EXISTING AND EXTINCT INLETS BARNEGAT INLET TO CAPE MAY POINT

DAMES & MOORE



shoals. Changes in adjacent updrift shores usually accompany the formation of new inlets. Similarly, the artificial stabilization of existing inlets (e.g., Shark River, Manasquan, and Cape May Inlets) with structures, such as jetties, or through repeated maintenance dredging typically results in the entrapment or removal of littoral drift materials that would normally pass into and through the natural inlet system. Although inlet stabilization reduces channel infilling and the need for inlet maintenance dredging to some degree, it may also result in downdrift littoral starvation and subsequent shoreline erosion.

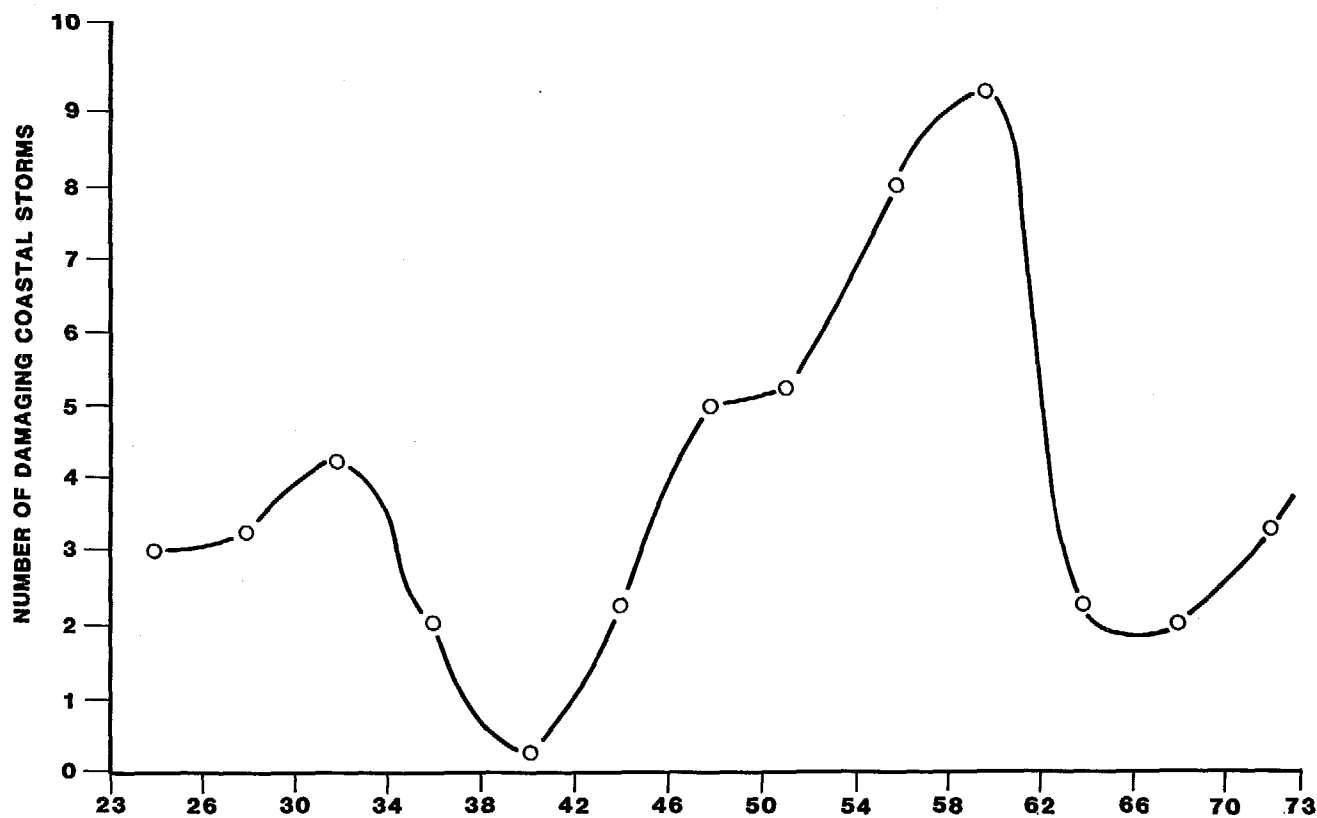
Shore areas adjacent to the inlets thus represent highly transitory areas due to inlet dynamics. Where inlets of the Southern Barrier Island Complex have been artificially stabilized with terminal and shore protection structures, the shores are continually subject to erosion caused by the dynamic fluctuations of the inlet system. In particular, the southern shore of each inlet is a persistent problem area because erosion threatens inlet and shore stabilizing structures and the developed areas behind them.

(5) Coastal Storms. The most dramatic example of the effect of the dynamic forces of nature on the shore zone is the impact of severe storms. Hurricanes and northeasters traveling along the New Jersey coast have damaged beaches and shore development throughout recorded history. Since 1900, the Atlantic and Gulf coast barrier islands have been affected by more than 100 hurricanes. Although hurricanes account for most of the damage along the New Jersey coast, 35 to 40 winter storms (northeasters) each year have enough force to erode beaches (Hayden, 1975).

Mather and others (1964) have classified storms for the east coast of the United States according to the extent of coastal damage (light, moderate, and severe) from 1921 to 1962. New Jersey recorded 25 light, 26 moderate, and five severe storms for this period, with an average recurrence interval for moderate and severe storms of one every 1.4 years. This recurrence interval is low compared to other coastal sectors, indicating a lower frequency of damaging storms. Mather and others point out that once in every 30 years, a very severe storm will bring extensive damage not only to a particular area but to the entire coast.

Figure I.C-13 illustrates the number of damaging coastal storms for the east coast as shown by the variation in the 4-year running average (3-year average for 1970 to 1973 period). This figure is compiled from Mather and others (1964) for the period up to 1962 and from Richardson (1977) for the period from 1962 to 1973. Because Richardson's data exclude hurricanes or extratropical storms in the March through October period, hurricane occurrences were added to provide a data base comparable to that of Mather and others (1964). Figure I.C-13 illustrates a general cyclical pattern to the frequency of damaging coastal storms, with low frequency periods from 1938 to 1942 and 1964 to 1968. The increased winter storm activity of 1977 to 1979, including Hurricane David in 1979 and the blizzard of 1978, may represent the beginning of a period to be characterized by an increased frequency of damaging storms comparable to that of the late 1950's to early 1960's. The last major hurricane to hit the Atlantic coast was Donna in 1960; thus, less than 20 percent of the residents of the Atlantic coast have ever experienced the impact of such a severe storm (Dolan et al., 1980).

In light of the nature of coastal development and the characteristics of coastal surges from hurricanes and northeasters, structures located directly along the beach and properties landward of these areas are subject to a high risk of damage from floating debris carried inland by storm surges.



**NUMBER OF DAMAGING COASTAL STORMS
EASTERN UNITED STATES
(4 YEAR AVERAGE-1923 TO 1973)**

REFERENCE:

1923 TO 1962 MATHER ET AL.(1964);
1962 TO 1973 RICHARDSON (1977)

NOTE: 1970-1973 IS A THREE YEAR AVERAGE.

The great northeaster of March 6-8, 1962, is an example of the severest type of storm along the mid-Atlantic coast (Mather et al., 1964). It was a complex, unexpected storm of sustained direction and intensity, combined with high spring tides. Although the water level was generally higher during the September 1960 hurricane (Donna), the storm of March 1962 was more widespread and inflicted substantially greater overall damage and loss of life. This was primarily due to its duration — the damaging high waters and destruction waves generated by gale force winds occurred on five successive high tides over a period of 2 days. Each succeeding tide had less beach or dune or bulkhead to dissipate its force and could reach farther inland, until in some cases the sea was able to cut completely through the barrier islands (USACOE, Philadelphia District, August 1963).

The damages resulting from the 1962 storm were unequalled by any storm in history along the New Jersey coast. In New Jersey alone, the storm was responsible for killing 14 persons and injuring more than 1300. Property damages in New Jersey exceeded \$120 million (1962 dollars). A summary of fatalities, injuries, and estimated property damages is presented in Tables I.C.5 and I.C.6. The intensity of damage along the New Jersey coast is illustrated in Figures I.C-14 through I.C-19.

Unfortunately, the devastation of the March 1962 storm was soon forgotten, and population and development have continued to increase in shore areas, much of it within the actual overwash zones of the storm. Since present population and development levels of the State's barrier islands exceed pre-1962 levels, future severe storms will undoubtedly result in far heavier tolls in lives, injuries, and property damage.

The demand for oceanfront properties directly on barrier islands or onshore areas with ready access to beaches remains high, despite the history of hurricanes, northeasters, and other storms, the costly damages, and the inevitable risk. This holds true for the time prior to and since Federal flood insurance became available to New Jersey residents living in coastal flood hazard areas.

(6) Sediment Sources and Budget. Potential sources of sand for supply to the littoral drift system of a coastal area include: (1) river sediment supplied to the coast, (2) material eroded from coastal cliffs or headlands, and (3) material from within the barrier island (especially from the beach, dune, and shoreface areas). For the New Jersey coast, no riverborne sediment is supplied to the shoreline. Due to the low gradient of the coastal plain and the flooding of estuaries and bays as a result of the sea level rise since the last glacial ice age (Wisconsin Age) some 15,000 years ago, sediment reaching the nearshore area is fine grained and is trapped in the bays, lagoons, and estuaries. Thus, the only significant natural sand sources for the New Jersey shore are the headlands and the front (seaward) edges of the barrier islands (Figure I.C-20).

The erosion of the front edge of the barrier (shoreface erosion), together with the transport of sediment in the system to the interior of the barrier through deposition in flood tidal shoals and overwash deposits, result in the constant recycling of the barrier sediment from front to back and the gradual migration of the barrier island toward the mainland. Evidence of this process is the discovery of peats, tree stumps, and other remnants of backbarrier deposits on the ocean beaches (Kraft et al., 1976; Fisher and Simpson, 1979). In addition, this pattern of migration can be measured from historical shoreline maps and aerial photographs.

TABLE LC-5

**NEW JERSEY FATALITIES, INJURIES, AND ESTIMATED PROPERTY DAMAGE
DUE TO THE MARCH 1962 STORM**

<u>Category</u>	<u>Ocean County</u>	<u>Atlantic County</u>	<u>Cape May County</u>	<u>Cumberland County</u>	<u>Monmouth County</u>	<u>Totals</u>
Killed	5	4	0	2	3	14
Minor injuries	86	237	545	190	12	1,070
Major injuries	9	85	127	9	3	233
Hospitalized	8	9	72	9	1	99
Dwellings destroyed	267	24	634	5	2	932
Dwellings - major damage	907	243	2,519	6	11	3,686
Dwellings - minor damage	11,749	13,453	19,811	52	500	45,565
Other buildings destroyed	128	0	82	0	5	215
Other buildings - major damage	0	0	0	0	3	3
Other buildings - minor damage	253	854	814	4	0	1,925

Source: USACOE, Philadelphia District (August 1963)

TABLE I.C-6

SUMMARY OF ESTIMATED 1962 STORM DAMAGES IN NEW JERSEY
(in thousands of dollars at 1962 price levels)

Damage Category	Location							Totals
	Ocean County	Atlantic County	Cape May County	Cumberland County	Northern N.J. Inland Tidal Areas	Raritan and Sandy Hook Bays (Middlesex & Monmouth Co.)	Sandy Hook to Manasquan Inlet (Monmouth Co.)	
Residences and contents (private)	\$16,218	\$ 14,241	\$ 27,814	\$ 75	\$ 311	\$ 2,580	\$ 1,240	\$ 62,479
Commercial buildings and contents (private)	1,416	7,613	6,387	22	992	1,000	229	17,659
Public property (Federal, State or local installations)	1,963	552	2,007	—	538	140	575	5,775
Roads, bridges, railroads	1,304	614	1,332	—	91	5	7	3,353
Boats	169	87	51	—	7	180	161	655
Utilities losses	528	358	1,050	—	21	120	83	2,160
Wharves, docks, piers, bulkheads	116	—	—	—	—	—	—	116
Protective shorefront bulkheads, seawalls, groins, jetties	231	566	1,976	—	9	75	900	3,757
Boardwalks	207	979	1,818	—	—	—	375	3,379
Beaches and dunes	7,413	2,100	2,755	—	10	1,400	4,000	17,678
Navigation channels	200	—	—	—	—	—	—	200
Other losses	342	1,121	1,527	—	1,045	900	600	5,535
Totals	\$30,107	\$ 28,231	\$ 46,717	\$ 97	\$ 3,024	\$ 6,400	\$ 8,170	\$122,746*

*When inflated to 1980 dollars, this amount represents approximately \$334 million in damages.

Source: USACOE, Philadelphia District (August 1963).



(REACH 7) LOVELADIES, LONG BEACH TOWNSHIP, LONG BEACH ISLAND, MAR. 9, 1962, LOOKING NORTH

REFERENCE: USACOE, PHILADELPHIA DISTRICT, AUGUST 1963



(REACH 7) STORM BREACH AT HARVEY CEDARS, LONG BEACH ISLAND

REFERENCE: USACOE, PHILADELPHIA DISTRICT, AUGUST 1963



(REACH 11) SEA ISLE CITY, LUDLAM BEACH, MAR. 9, 1962

REFERENCE: USACOE, PHILADELPHIA DISTRICT, AUGUST 1963



(REACH 11) WHALE BEACH, UPPER TOWNSHIP, LUDLAM BEACH, MAR. 9, 1962
(NOTE HOMES WASHED INTO BACKBAY WETLANDS)

REFERENCE: USACOE, PHILADELPHIA DISTRICT, AUGUST 1963



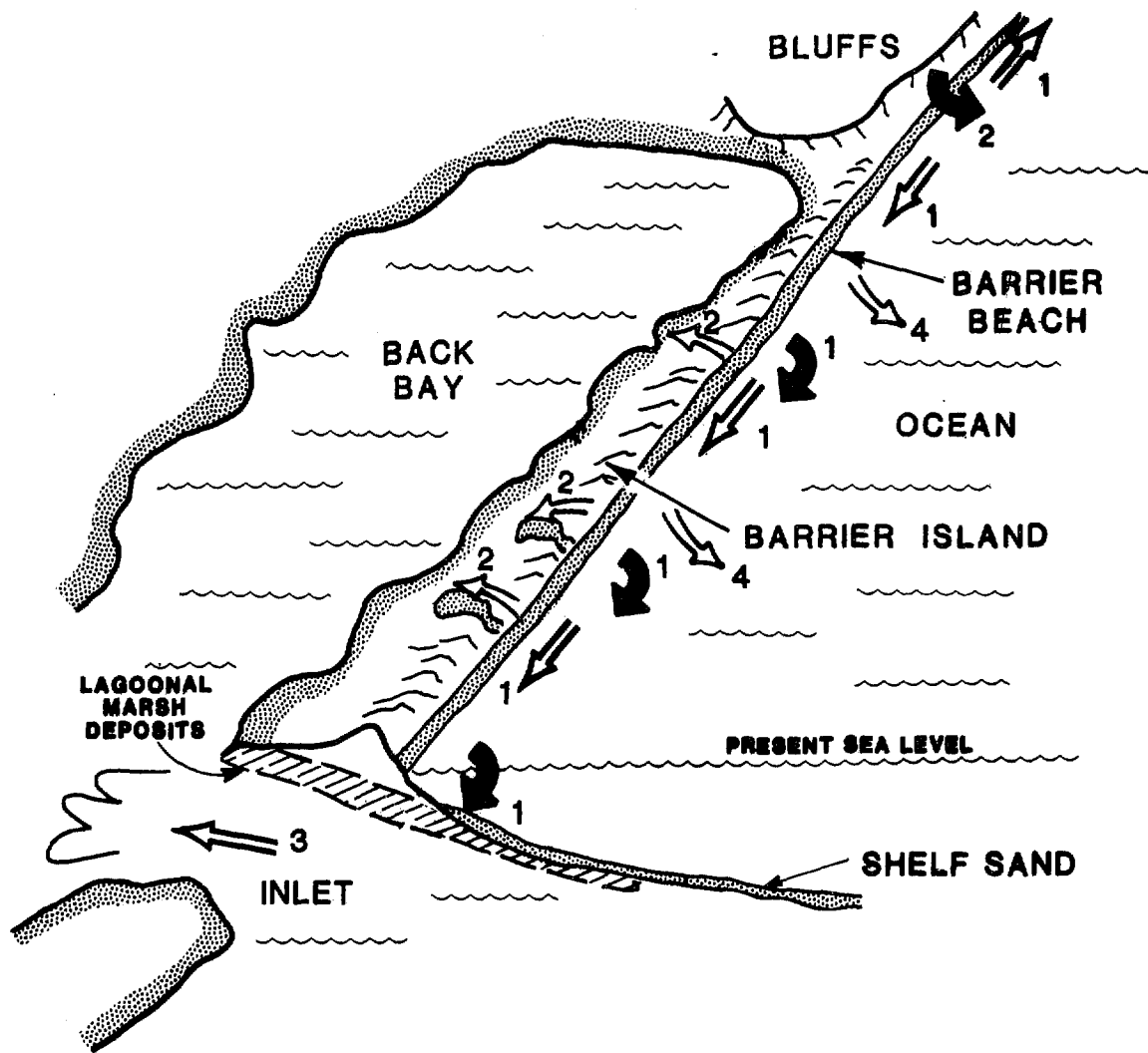
(REACH 7) AERIAL VIEW OF OVERWASH OF LONG BEACH ISLAND
AFTER THE MARCH 1962 STORM. NOTE HOMES WASHED INTO BACKBAY

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(REACH 12) 1962 STORM DAMAGE AT AVALON

REFERENCE: USACOE, PHILADELPHIA DISTRICT, AUGUST 1963



SCHEMATIC DIAGRAM OF COASTAL SEDIMENT BUDGET

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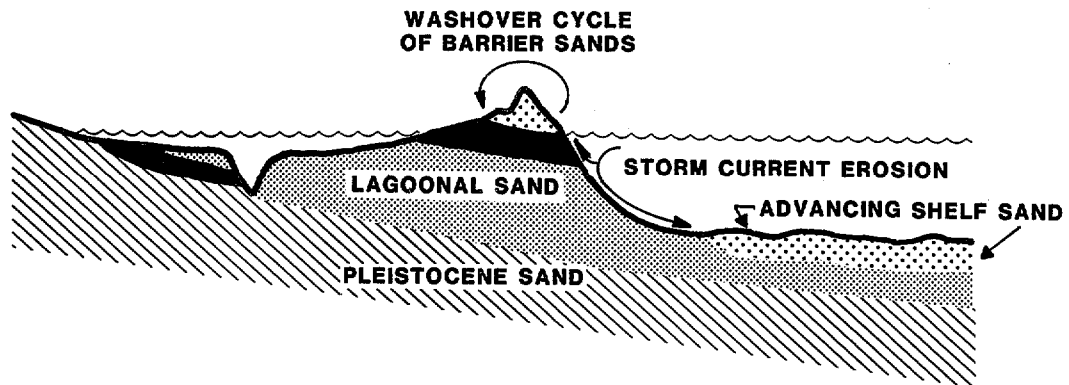
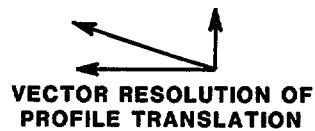
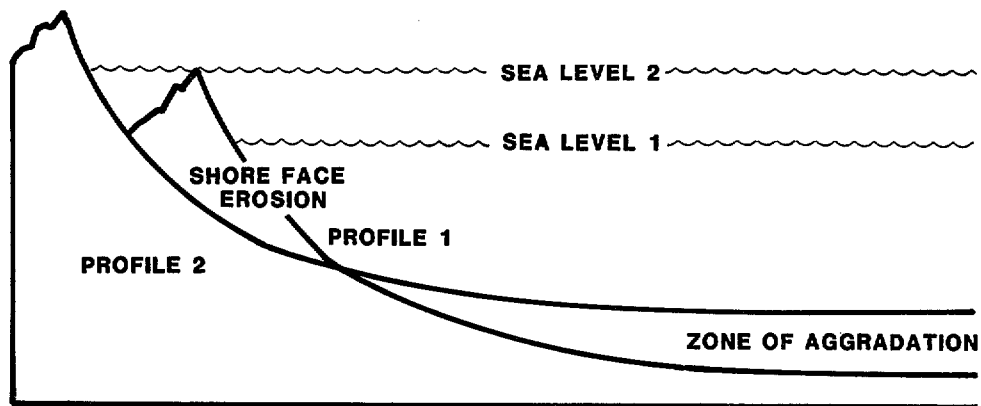
(7) Sea Level Rise. Barrier island migration and shoreface erosion is further compounded by the continued and gradual sea level rise which has been occurring since the melting of the glaciers at the end of the Wisconsin Age. Geologic evidence suggests that about 35,000 years ago, sea level may have been near its present level. During the peak of the Wisconsin glacial stage, about 15,000 years ago, water held in glaciers is believed to have been responsible for worldwide lowering of sea levels by 300 to 350 feet (Kraft, 1971) and possibly even by 430 feet (Milliman and Emery, 1968). This exposed a broad expanse of gently sloping continental shelf which, at that time, formed a low coastal plain. The shoreline was at the edge of the continental shelf, some 80 to 100 miles east of the present-day coast.

Bruun (1962) developed the concept that the characteristic exponential curve of the shoreface profile represented an equilibrium response to the prevailing hydraulic climate along the shore. As sea level rises, the equilibrium shoreface profile is translated upward and shoreward (Figure I.C-21). Erosion of the shoreface supplies the littoral zone with material necessary to maintain equilibrium profiles. In addition, material is transferred offshore; as transgression occurs, the blanket of sand which covers the continental shelf surface is formed.

Measurements of tide levels along the coastal United States for the period from 1940 to 1970 indicate that relative sea level is still rising. Figure I.C-22 illustrates the rise in sea level for three stations in the area — New York City at the Battery, Sandy Hook, and Atlantic City. The general trend over the last 30 years has been a level rise of about 1 foot per century. The somewhat greater rise at Sandy Hook may in part reflect land subsidence due to compaction of the coastal sediment (Yasso and Hartman, 1975). Yearly variations are significant in these data and reflect the influence of climatic changes, such as seawater density variations as a function of the amount of runoff for a coastal area.

Periods of high river discharge and areas characterized by high discharges have higher sea levels (Meade and Emery, 1971). The high erosion rate for the Headland segments of New Jersey, which have recessed relative to the adjacent coastal segments, may be related to an ambient sea level which is somewhat higher in these zones than in adjacent areas. These locally higher seas can be inferred from the fact that the headland areas are located adjacent to the coastal waters which receive the fresh water discharge plumes of major estuaries. The plumes emerge onto the continental shelf and are driven to the south by the general southerly drift of the coastal currents. The Hudson plume emanates from the Lower Harbor and tends to spread along the northern New Jersey shore area. These fresh water lobes, when pushed onto shore by coastal storm winds, would result in even higher local seas and in more extensive erosion due to their higher level of impact on the shore. Since the possibility of such local sea level effects on the patterns of shore erosion has not been systematically researched, it is largely an untested theory. However, these effects may be as important or even more important than the generally held concept that wave energy concentration in these zones, as a result of wave refraction effects, causes the high erosion.

The concept that increased sea level can be equated to increased erosion and littoral drift is suggested in the studies of beach and shoreline change in the vicinity of Beach Haven and Little Egg Inlets, discussed earlier (Dames & Moore, September 1974; DeAlteris et al., 1976). These studies demonstrated a close correlation between the rate of migration of the Beach Haven Inlet and the rise in sea level for the period from 1952 to 1972. The implication of this correlation is that periods of higher sea level resulted in greater erosion of the beach profiles, supplying

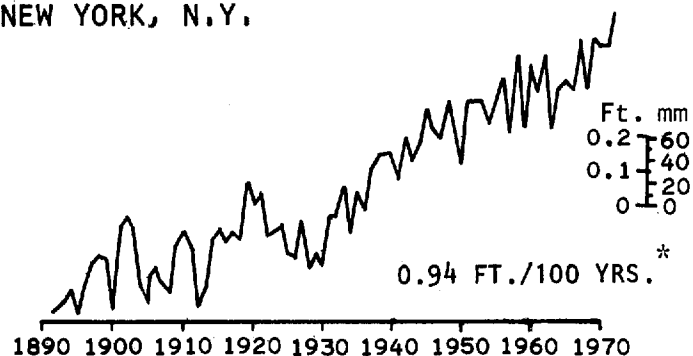


BRUUN'S CONCEPT OF SHORE FACE EROSION DUE TO SEA LEVEL RISE

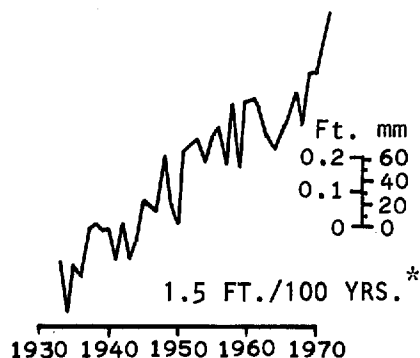
REFERENCE: AFTER STANLEY AND SWIFT, 1976.

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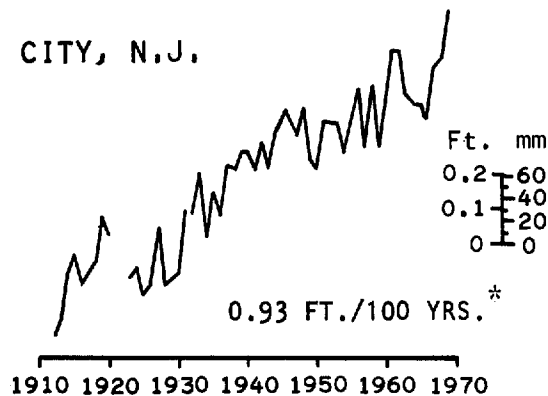
NEW YORK, N.Y.



SANDY HOOK, N.J.



ATLANTIC CITY, N.J.



YEARLY MEAN SEA LEVELS RELATIVE TO THE LAND

(*) 1940 - 1970 TREND

REFERENCE: HICKS (1972) AND SWANSON (1976)

DAMES & MOORE

more material to the littoral drift, which in turn caused more rapid infilling of the inlet on its northern margin and the greater rate of inlet migration to the south. Thus, it would appear that areas such as the Northern Headlands, which appear to be characterized by higher sea levels than adjacent areas, may actually have higher rates of erosion over a long period of time.

Bluff and shoreface retreat (erosion) are integral parts of the dynamics of the shoreline system. As this retreat takes place it supplies the beach and nearshore areas with the sediment necessary to maintain equilibrium profiles in balance with the wave climate.

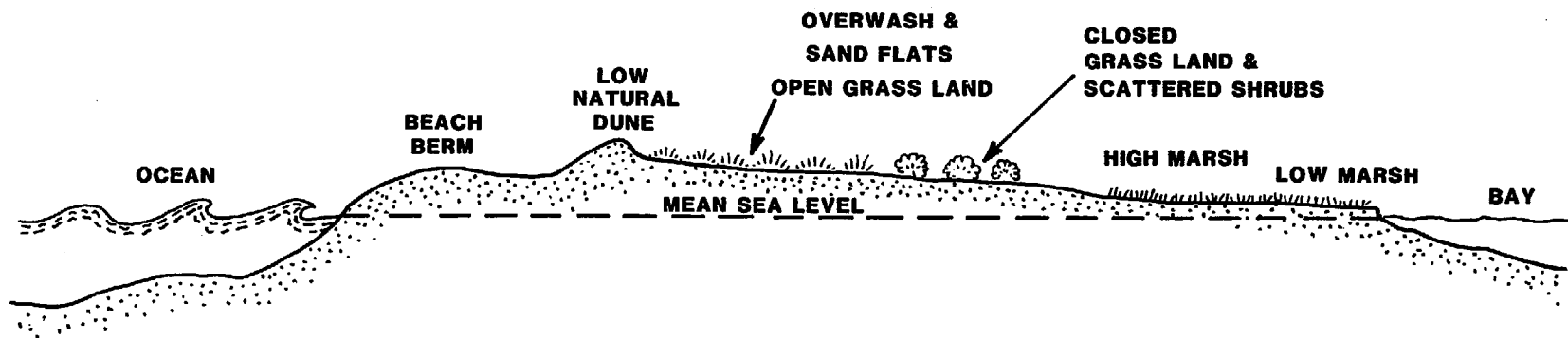
c. Beach Erosion — the Natural (Dynamic) and the Stabilized Shoreline Cases

In the natural system, where the internal sources of sediment for littoral drift are obtained by bluff retreat and barrier island migration, the translation of the shore profile in the landward direction occurs uniformly with no oversteepening or degradation on components of the profile. The beach at the toe of a bluff after retreat is the same width and slope as the earlier beach, but in a new location. The barrier island is uniquely designed to withstand storm flooding, overwash, and sea level rise and to maintain its overall profile without oversteepening or loss of the beach or nearshore profile.

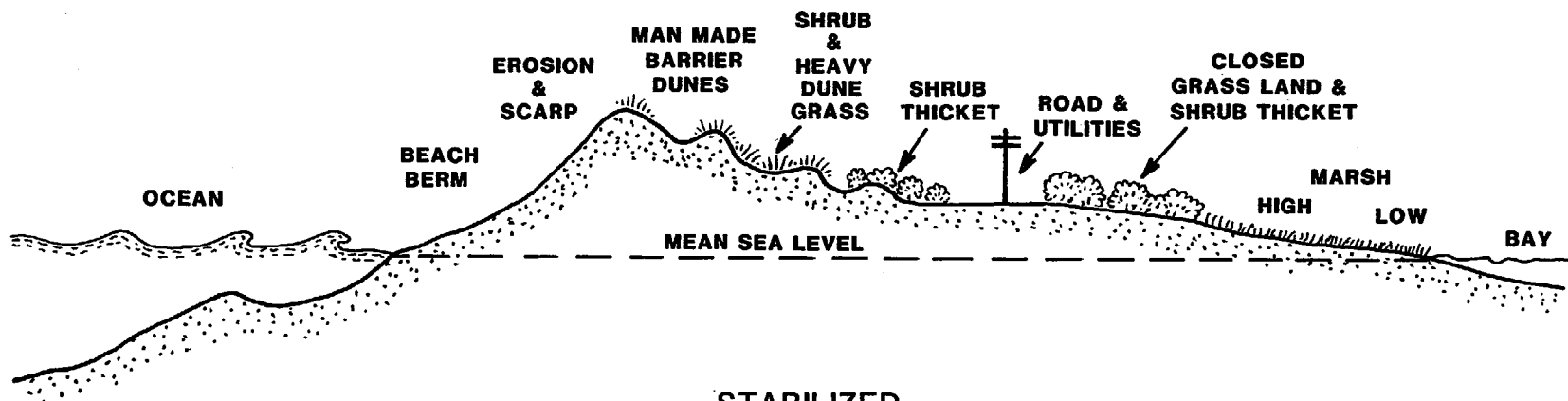
Studies supported by the National Park Service on the North Carolina barrier islands have clearly demonstrated the inherent advantage of the natural system in this regard (Dolan et al., 1973; Godfrey and Godfrey, 1973b; and Dolan and Godfrey, 1973). The profiles from a natural barrier, Core Banks, were compared with those from a barrier stabilized by development of manmade sand dunes at the Cape Hatteras National Seashore. Comparisons were made before and immediately after a major storm event, Hurricane Ginger, which struck the area on September 20, 1971. The natural barrier profile at Core Banks consists of a wide flat berm and low dunes, while at Hatteras, the dunes are high and stabilized with scrub growth in areas where natural sand flats previously occurred (Figure I.C-23). The overall effects of Hurricane Ginger were an increase in land elevation and general maintenance of the barrier profile on Core Banks and the severe erosion of the beach face at Hatteras. The Core Banks profile allowed the dissipation of the storm surge and wave effects across the whole profile, flattening of the beach face, and transportation across the dunes to overwash areas. In contrast, at Hatteras, the manmade dunes absorbed the full impact of the surge and waves and eroded rapidly, since the runup profile was restricted to the narrow beach face. The sands were transferred alongshore and offshore out of the system — not inland as at Core Banks.

Manmade barriers and attempts at maintaining a static shoreline position, either through impenetrable stabilized dunes, as at Hatteras, or through use of shore protection structures, result in the oversteepening of the profile and eventual loss of the beach. These effects are due to a sand budget deficit in the system. More energy is available than can be expended in moving materials through the littoral system. The natural system responds by island and bluff migration but not at the expense of the beaches (Figures I.C-24 and I.C-25). Where a static system is sought, the man-modified system must pay the price of continual resupply of the beach area.

Thus, beach erosion as a problem exists only where development has taken place, and where man has adversely affected the natural sand supply and attempted to impose a static shoreline. In the long run, the rising sea and wave forces will not cooperate (Figure I.C-26).



NATURAL

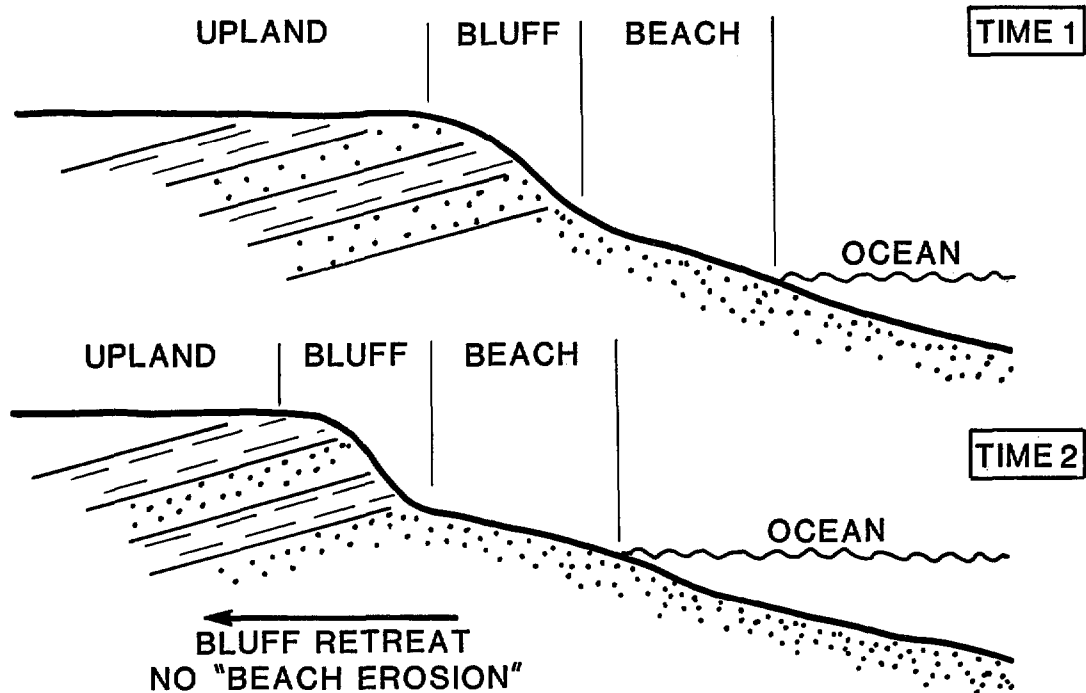


STABILIZED

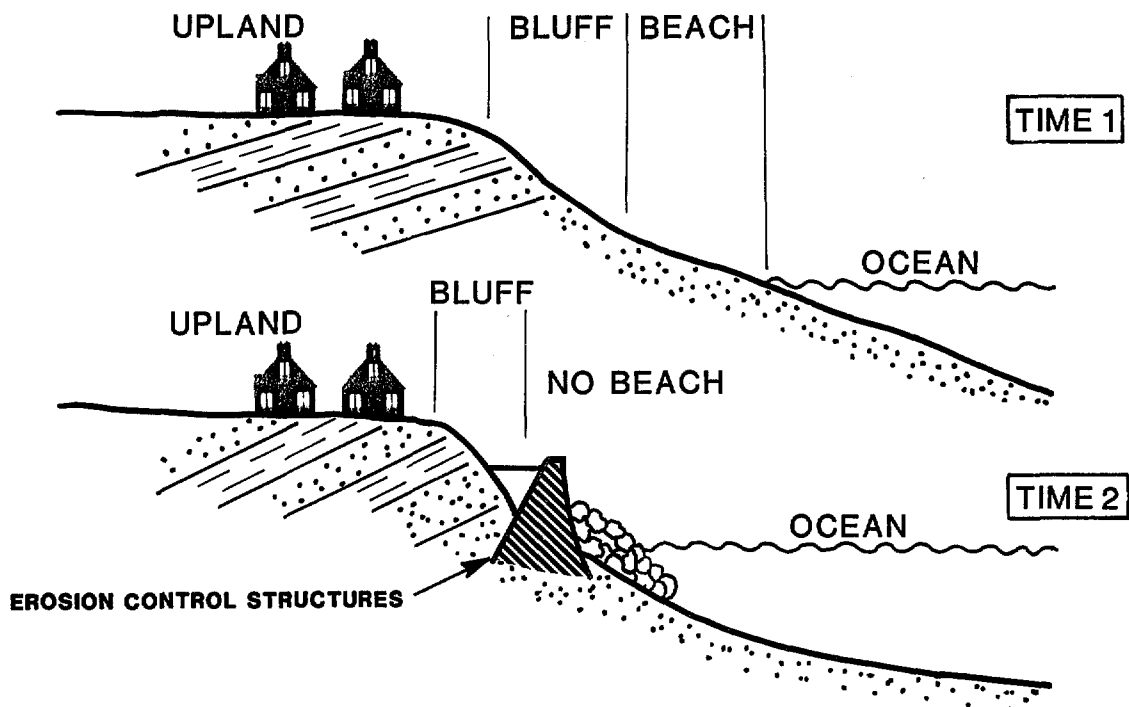
NATURAL AND STABILIZED BARRIER ISLANDS

REFERENCE: AFTER DOLAN ET AL, 1973

NATURAL BLUFF OR HEADLAND SYSTEM



DEVELOPED BLUFF SYSTEM

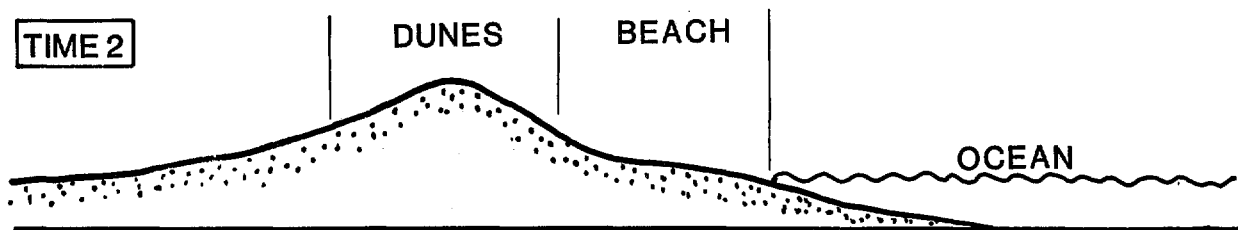
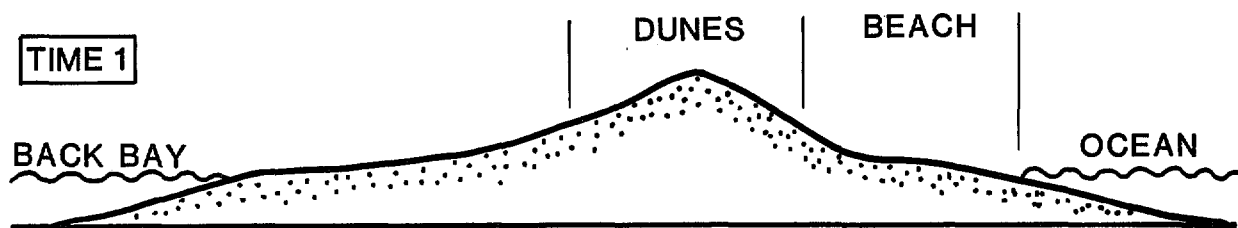


NATURAL VS. DEVELOPED BLUFF OR HEADLAND SYSTEM

REFERENCE: AFTER NORDSTROM ET AL, 1977.

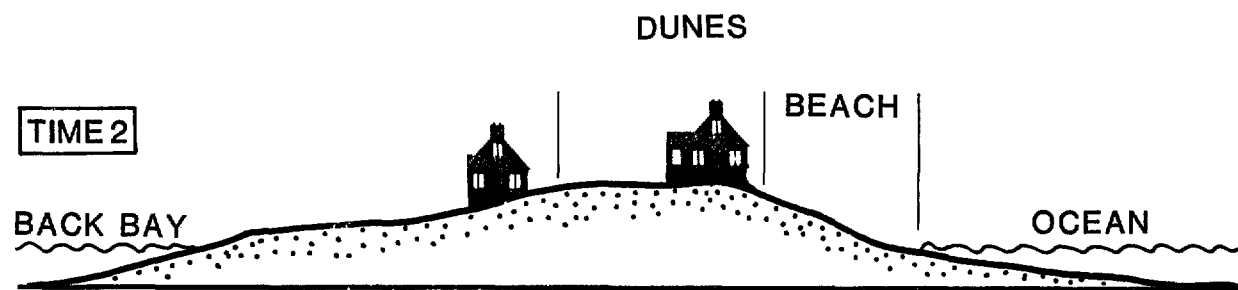
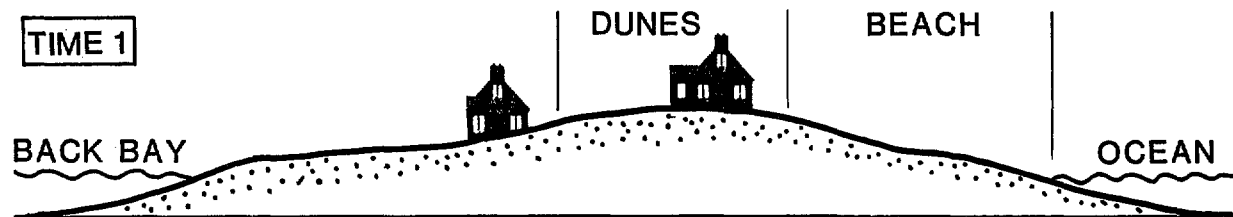
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NATURAL BARRIER SYSTEM



ISLAND MIGRATION
←
NO "BEACH EROSION"

DEVELOPED BARRIER SYSTEM

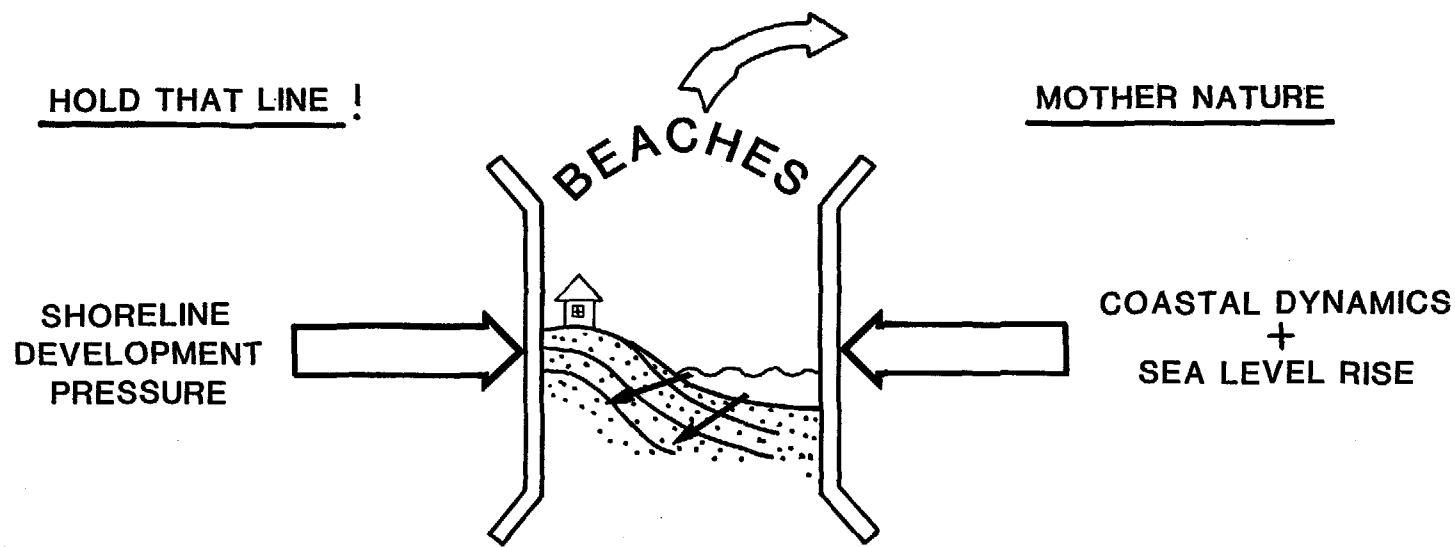


"BEACH EROSION"

NATURAL VS. DEVELOPED BARRIER SYSTEM

REFERENCE: AFTER NORDSTROM ET AL, 1977.

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SHORE RESOURCE EFFECTS

- LOSING BEACHES
- NATURAL ECOSYSTEM IMPACTS
- LOSING NATURAL PROTECTIVE ASPECTS OF DUNE/BEACH SYSTEM

4. Socioeconomic Setting

New Jersey's bay and ocean shore areas are extremely important economic assets and constitute unique social environments characterized by their seasonality and dependence on the tourism and resort industry. The economic and social importance of the coast is shown by the fact that in 1978 the Atlantic coast communities contained only 5.65 percent of the State's estimated population, but accounted for 8.4 percent of the State equalized value of real property. The population density for oceanfront communities from Sandy Hook to Cape May Point (Reaches 2-14) was estimated at 1,480 persons per square mile, as compared to the State average of 980 persons per square mile. The impact and importance of tourism on the coastal communities is reflected in the presence of several significant, seasonally based socioeconomic indicators. These include significant seasonal population and seasonal employment fluctuations, and a sizable seasonal housing component.

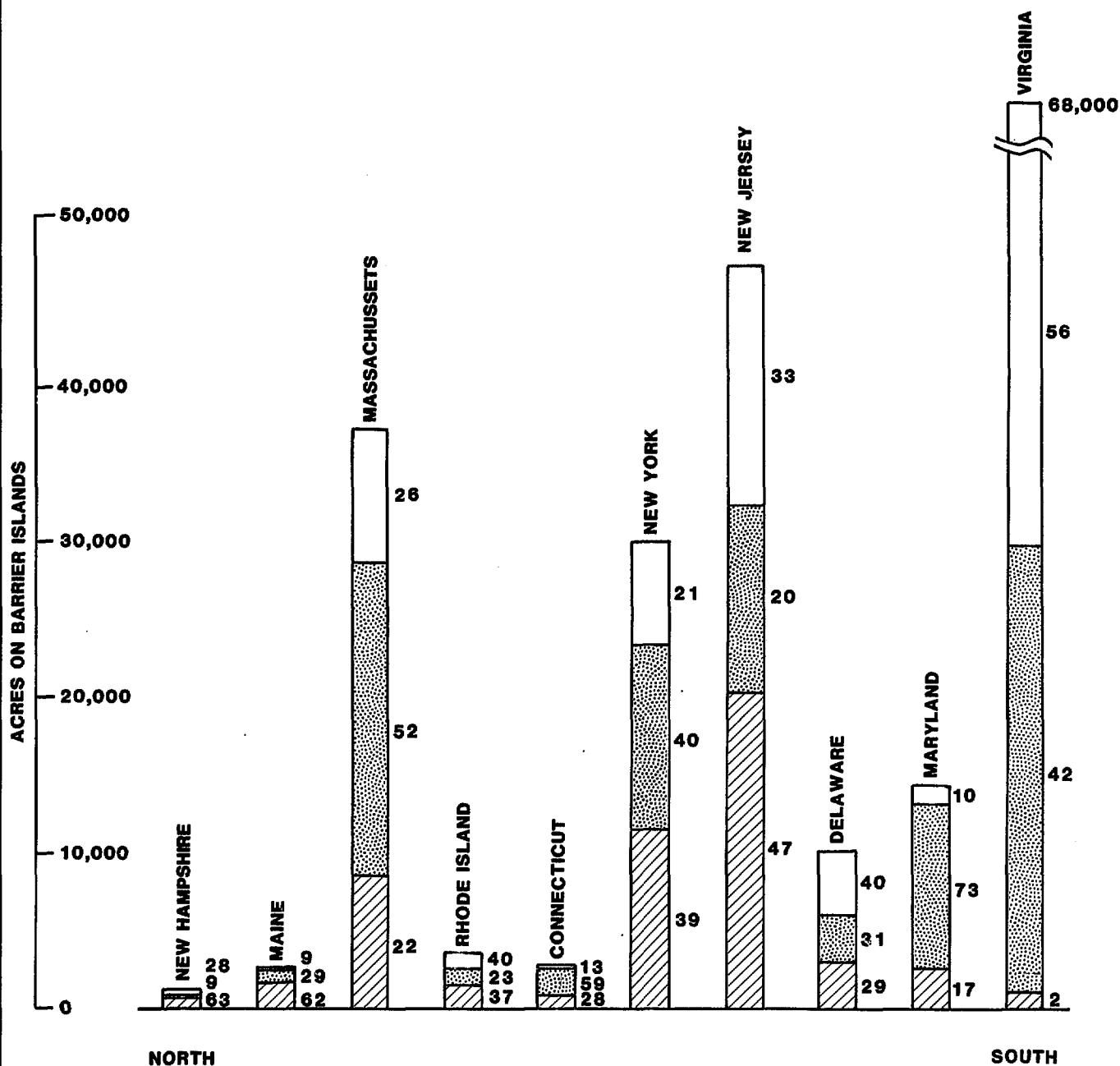
Figure I.C-27 shows the degree of development of New Jersey barrier islands as compared to barrier islands in adjacent New England and Mid-Atlantic states using the coarse data developed by the Heritage Conservation and Recreation Service (January 1980). Forty-seven percent of the total acres in New Jersey's barrier islands is classified as developed, slightly above the east and gulf coast average of 46 percent. What is significant is that only 20 percent of the acreage of New Jersey's barrier islands is classified as protected (e.g., parks, wildlife preserves, and conservation areas), lower than for any other adjacent state's barrier islands except New Hampshire's.

Figure I.C-28 provides the same breakdown for all of New Jersey's barrier islands. As expected, those barrier islands with substantial park areas are immediately recognizable. For example, Island Beach State Park is located in Reach 6 (Mantoloking to Barnegat). Some of the more recreationally-oriented reaches, such as Absecon Island (Reach 9), Peck Beach (Reach 10), and Long Beach Island (Reach 7), have fifty percent or more of their acreage classified as developed.

The tourism sector makes a major contribution to the State's economy. Most of this economic activity is concentrated in the four Atlantic coast counties. The concentration in these counties is shown by the fact that the trade (retail and wholesale) and service sectors accounted for 48.7 percent of the total labor and proprietor's income in the four Atlantic coast counties, as compared with 27.7 percent for the entire State (New Jersey Department of Labor and Industry, October 1979). This concentration is further shown in that employment in the above four counties, in the trade and service sectors, was 51.6 percent of total non-farm wage and salary employment, as compared to 41 percent statewide. (New Jersey Department of Labor and Industry, October, 1979).

The total amount of travel expenditures in New Jersey in 1976 was estimated at \$2.97 billion (U.S. Travel Data Center, 1976). This figure excludes day trips to destinations within 100 miles of home. Considering the significant proportion of day trips to the Ocean and Monmouth County beaches, this figure can be viewed as a minimum estimate of tourism expenditures in New Jersey. It is likely that most of this travel expenditure can be attributed to the resort economy, which is concentrated in the four Atlantic coast counties.

As a final indicator of the concentration of tourism economic activity in these counties, a comparison was made between median household effective buying income (MHEBI), which is essentially an approximate measure of disposable incomes as



KEY:



DEVELOPED



PROTECTED (PARKS, PRESERVES, ETC.)



UNPROTECTED/ UNDEVELOPED

52 % OF TOTAL STATE ACREAGE

EAST AND GULF COAST AVERAGES

46% DEVELOPED

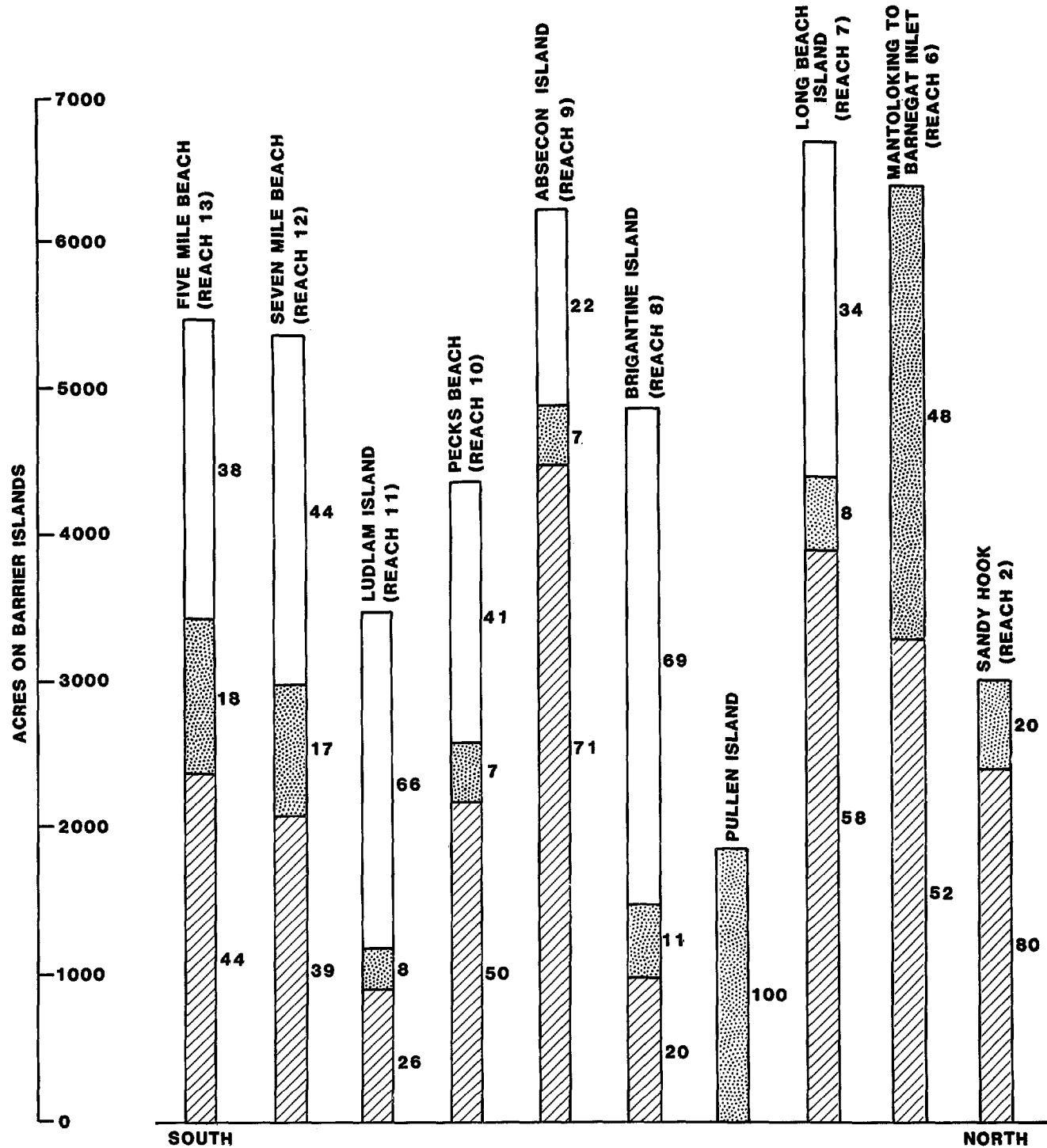
39% PROTECTED

15% UNPROTECTED/UNDEVELOPED

EXTENT OF DEVELOPMENT ON NEW ENGLAND AND MID-ATLANTIC COAST BARRIER ISLANDS

REFERENCE: DATA FROM HCRS, 1980.

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DEVELOPED
 PROTECTED (PARKS, PRESERVES, ETC.)
 UNPROTECTED/UNDEVELOPED

STATE REACH AVERAGE

47% DEVELOPED
 20% PROTECTED
 33% UNPROTECTED/UNDEVELOPED

71 % OF REACH ACREAGE

EXTENT OF DEVELOPMENT FOR NEW JERSEY BARRIER ISLAND REACHES

REFERENCE: DATA FROM HCRS, 1980.

DAMES & MOORE

compiled in Sales and Marketing Management Magazine (July 27, 1979), and the estimates of retail sales in New Jersey's counties. In a tourism oriented economy, the seasonal inflow of visitors will result in significantly greater retail sales within the local economy than can be attributed to the local, year round residents. The higher the ratio of total retail sales/MHEBI, the more likely the area is to be a destination of travelers and tourist. The top five ranked counties were coastal counties. The five counties with their respective ratios are: Cape May (0.73), Ocean (0.63), Cumberland (0.61), Atlantic (0.61), and Monmouth (0.60)

The New Jersey shore means different things to different people. In the past it has conveyed the impression of a homogeneous region. Although shore communities have many common characteristics, substantial differences do exist. A brief discussion of socioeconomic characteristics highlighting the commonalities and the differences in shore communities and reaches is provided in Volume 2, Section II.D.

To aid in the evaluation of direct and indirect socioeconomic impacts associated with the implementation of shore protection, the coastal municipalities and shoreline reaches have been classified into one of four categories — urban, rural, residential, or recreational/water dependent. The classification methodology, results, and discussion are provided in Volume 2, Section II.D.5.

5. Environmental Setting

This section briefly describes the similarities and differences of the ecological and biological resources along the New Jersey shoreline. The relative importance of these resources is considered in assessing the potential impacts which may result due to the implementation of different shore protection alternatives. A more detailed description of the ecological habitats (beaches, dunes, nearshore zone etc.), and cultural and biological resources (fisheries, shellfisheries etc.) along the New Jersey shoreline is presented in Volume 2, Section II.E.

Basically, two different types of shorelines are of concern: ocean beaches (Reaches 2-14); and bay beaches (Reaches 1, 15, 16, and the backbay areas). Generally, the reaches with common shoreline types are ecologically similar. Therefore, this section will address the key ecological concerns which were used in the impact assessment for each of the shore protection alternatives evaluated.

The sandy ocean beaches are primarily found from Sandy Hook to Cape May Point (Reaches 2 thru 14). They are bordered on the east by the Atlantic Ocean, and occur on both barrier islands and headland reaches. The organisms which inhabit the ocean beach are not directly considered of commercial importance, although many do serve as food sources for important commercial species. The species distribution for the ocean beach habitat is similar from Reach 2 through Reach 14. Therefore, no single sandy beach is considered more significant than another with respect to the invertebrate populations in the upper, middle, and lower tidal zones. Similarly, the populations associated with the artificial rocky zones, which occur along sandy beaches (e.g., groins and jetties), are also similar along the entire ocean coast with respect to faunal distribution. Their ecological significance is discussed in Volume 2, Section II.E.

Rocky structures provide suitable substrate for the attachment of algae and numerous invertebrates as well as for shelter for fish and crabs. Given this attraction for fish, areas with greater numbers of groins and jetties (such as Reaches 2-5) have a higher resident fish population than is normally found along a sandy beach.

Fish species utilizing the subtidal area of a sandy beach are typically migrating species such as striped bass, fluke, and bluefish. Although these three species are caught around groins and jetties, the rocky subtidal is also populated with numbers of black sea bass, tautog, and bergall. Considering the general distribution of important finfish, recreational fishing on a sandy beach is greater in areas with significant numbers of rocky structures, than in areas without such structures. This distribution can be quite variable given the seasonal migrations and other physical oceanographic conditions which can result in large numbers of fish being present off of a particular sandy beach. Such conditions are usually short-lived whereas recreational fishing in the vicinity of rocky structures might be more consistent.

Shellfish beds and finfish are the most significant resources in the nearshore zone off sandy beaches. The surf clam, which is the most important commercial shellfish resource in New Jersey, does occur near the beach in shallow water. Densities of the surf clam have been mapped by Haskins and Merrill (1972). They report that commercial densities of surf clam are found off all reaches with the exception of Reaches 3, 4, and 5. However, the most significant beds are found off Reaches 9, 11, 12, 13, and 14, and in the vicinity of most coastal inlets.

With respect to most finfish resources in the nearshore zone, as discussed above, their distribution is spatially and temporally variable. More resident populations are found around shipwrecks, artificial reefs, and in the area of the Shrewsbury Rocks. Shipwrecks occur off of all reaches and appear to be most numerous around Reaches 2, 3, 5, 8, 9, and 12. The State's two artificial fishing reefs and the Shrewsbury Rocks are located off Reaches 2 and 4.

Landward of the beach area is the dune zone. Much of the dune system along the New Jersey coast has been disturbed by man's activity. Such activity has included the destruction of or flattening of the primary dune line due to construction activities. At the present time, few undisturbed dune areas exist in developed areas.

Also of importance in the beach/dune area are colonial waterbird nesting areas. The occurrence of colonial waterbirds along the New Jersey coast has been reported by Gali (1978). Beach nesting locations for colonial waterbirds have been reported in Reaches 2, 11, 12, 13, and 14.

Like the ocean beaches, the bay beaches which occur along the Raritan Bay, Delaware Bay, and Delaware River (Reaches 1, 15, 16, respectively), and in all coastal back bay areas, are made up of different ecological habitats (beach, wetland, etc.) These habitats do not exhibit significant uniqueness within the geographic area affected by the Master Plan. For example, wetland marshes along Raritan Bay resemble other wetland marshes which occur along Delaware Bay and backbay wetlands along Great Bay or Barnegat Bay. Bay beach habitat types are discussed in more detail in Volume 2, Section II.E.