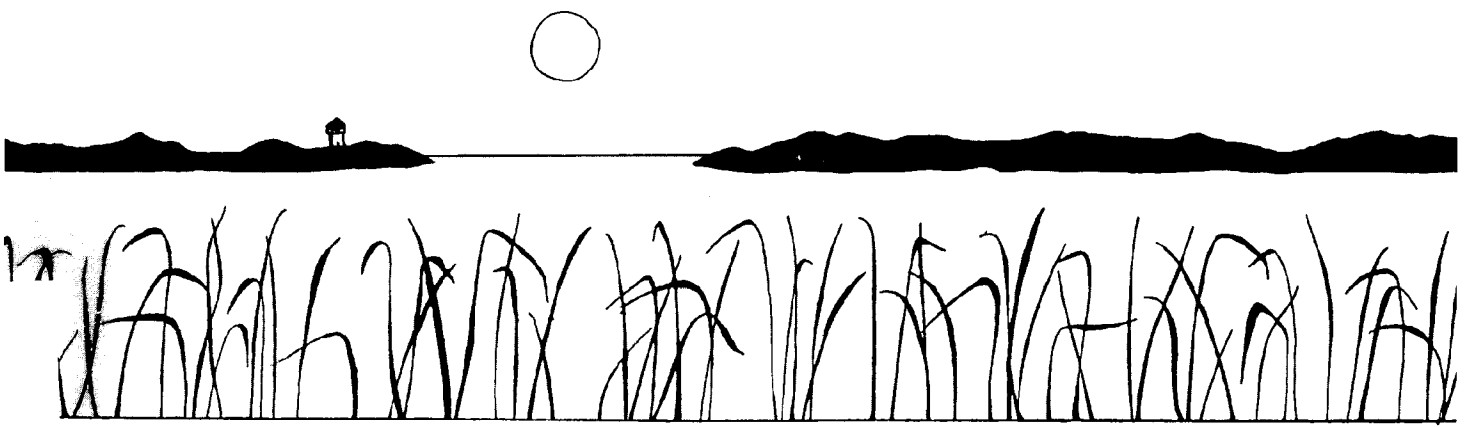
BARRIER BEACH MANAGEMENT SOURCEBOOK



Acknowledgements

Smith, Lester B., Jr., Editor, 1983, *Barrier Beach Management Sourcebook.* Massachusetts Coastal Zone Management Office, Boston, 48 pp.

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MASSACHUSETTS COASTAL ZONE MANAGEMENT OFFICE – 1983

BARRIER BEACH MANAGEMENT SOURCEBOOK

Executive Office of Environmental Affairs
Massachusetts Coastal Zone Management
Richard F. Delaney, *Director*

Provincetown Center for Coastal Studies
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Michael S. Dukakis, Governor
James S. Hoyte, Secretary

Table of Contents

Introduction

Hundreds of barrier beaches make up much of the Massachusetts coastline. These coastal landforms are narrow low-lying strips of land that consist of beach and dunes and extend roughly parallel to the trend of the coast. They are separated from the mainland by a water body or wetland. Barrier beaches were formed and are constantly changed by coastal processes such as beach erosion, storm overwash, dune movement, and inlet formation and migration. Structures on barrier beaches are flooded, battered and sometimes destroyed by these natural processes. Costs for these damages are high: over 300 million dollars for the Blizzard of '78 alone. Most of these costs are bourne by the taxpayer through the many subsidized programs for disaster relief, flood and erosion structures, and utilities and roads. Many coastal residents recognize that barriers are protective features which shelter mainland development and productive wetlands and bays. Yet barrier beaches are more widely known by the public as recreational and summer resort areas. How can recreational areas be managed so that the natural resources of barrier beaches are maintained? How can the large storm damage losses and economic costs to the taxpayer associated with developed barriers be reduced? What future physical changes can be expected for specific barrier beach areas? The purpose of this book is to answer some of these questions and to provide the reader with information to seek out the answers to the rest.

In 1978 "A Guide to the Coastal Wetlands Regulations" was published by the Massachusetts Department of Environmental Quality Engineering with the assistance of the Coastal Zone Management Office. The wetland guide discusses the values and processes of all coastal wetlands and provides guidance in the design of projects for wetland areas and areas bordering on wetlands. Barrier beaches are briefly discussed in the wetland guide and a preliminary list of Massachusetts barrier beaches is provided.

After the publication of the wetland guide, the management of barrier beaches received increased attention when Governor King signed Executive Order No. 181 for Barrier Beaches in 1980, and federal legislation was proposed to help manage the nation's undeveloped barriers. The Massachusetts Coastal Zone Management Office is carrying out the Executive Order by mapping all of the state's barrier beaches and by providing informational materials such as this sourcebook on barrier beaches.

This sourcebook builds on the information supplied in the wetland guide; it is not meant to replace it or to represent state wetland policy. The purpose of this book is to give public officials, interest groups, developers, homeowners, and interested citizens additional background and tools to use in making management decisions. Techniques to reduce hazards and protect the resources of these important coastal areas are presented.

How to use the sourcebook

This sourcebook consists of three chapters: Chapter 1, Identification of Barrier Beaches, Chapter 2, Characteristics of Barrier Beaches, and Chapter 3, Management of Barrier Beaches. Chapters 1 and 2 give essential background information necessary for effective management of barrier beaches. Techniques to manage barrier beaches are described in Chapter 3. The Table of Contents is brief because each chapter begins with an outline of the material covered within that chapter.

The book is designed to review all aspects of barrier beach management for the general reader and to provide references to more detailed books and guides. These sources of information are given at the end of each chapter and at the end of key subsections within each chapter.

The appendices include: Appendix A, the Executive Orders for Barrier Beaches and Off-Road Vehicles; Appendix B, Technical and Educational Assistance; Appendix C, the bibliography; and Appendix D, the glossary. Italicized words in the text are defined in the glossary.

To assist in using the sourcebook, the following sets of commonly asked questions and a key for locating answers to these questions are listed below. The first set of questions might be asked by the general public. The remaining sets of questions might be asked by user groups.

GENERAL QUESTIONS — Page Numbers

HOMEOWNER AND BEACH ASSOCIATION QUESTIONS

TOWN OFFICIAL QUESTIONS — Page Numbers

CONSERVATION COMMISSION QUESTIONS

STATE OR FEDERAL OFFICIAL QUESTIONS

Chapter 1: Identification of Barrier Beaches

Description of Barrier Beaches

A barrier beach is a narrow low-lying strip of land consisting of *beach* and *dunes*, trending parallel to the coast and separated from the mainland by a water body or wetland. Barrier beaches range from natural landforms with well developed vegetated dunes and few alterations to developed/altered barrier landforms with houses, roads, artificial filling, and coastal engineering structures. Barrier beaches are composed of sand and other loose *sediments* moved and deposited by waves, winds, tidal currents, and storm overwash. They are always changing their form and shifting landward as they respond to these coastal forces and the gradual rise in sea level that is submerging and eroding the Massachusetts coastline.

Types of barrier beaches

Barrier beaches take different forms depending on how they are connected to the mainland (figures 1.1 and 1.2). A barrier connected to the mainland at both ends is a *bay barrier*. A barrier connected at only one end is a *barrier spit*, and an unconnected barrier is a *barrier island*. A barrier that connects an island to the rest of the coast is known as a *tombolo*. The Massachusetts coast has each of these types of barrier beach (figures 1.3 to 1.6).

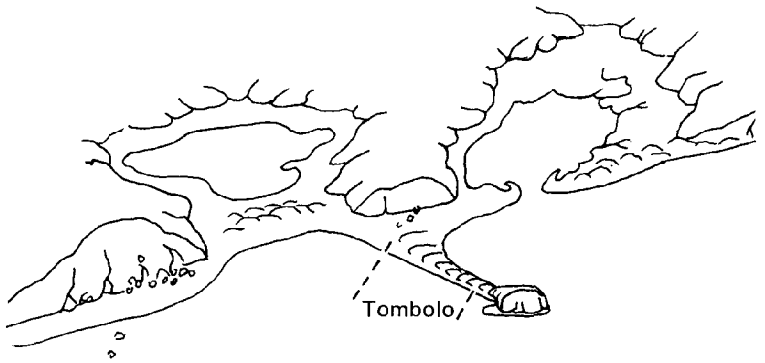


Figure 1.2 Illustration of tombolo

Location of Barrier Beaches

Over 600 barrier beaches are located on the Massachusetts shoreline exposed to the open ocean and in large tidal bays (table 1.1).

Figure 1.1 Illustration of bay barrier, barrier spit, barrier island

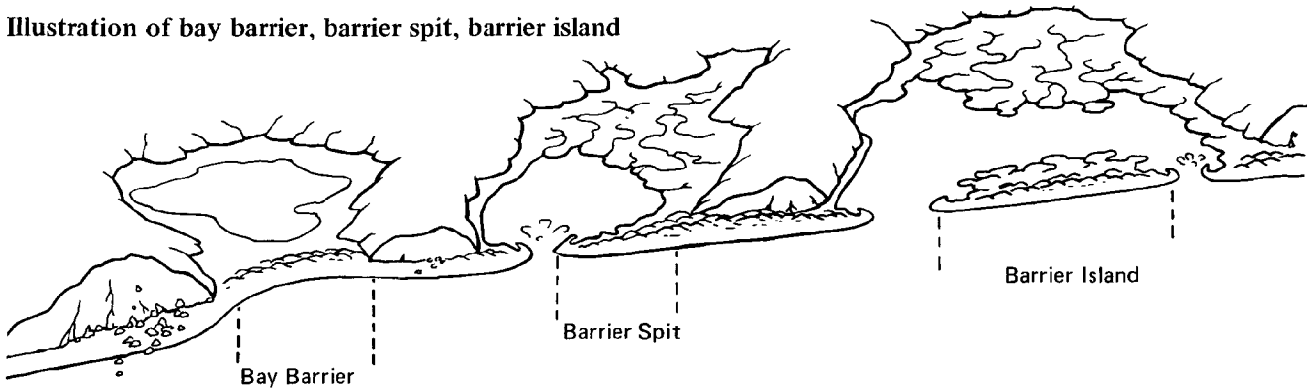


Figure 1.3 Photo of bay barrier

Figure 1.4 Photo of barrier spit

Figure 1.5 Photo of barrier island

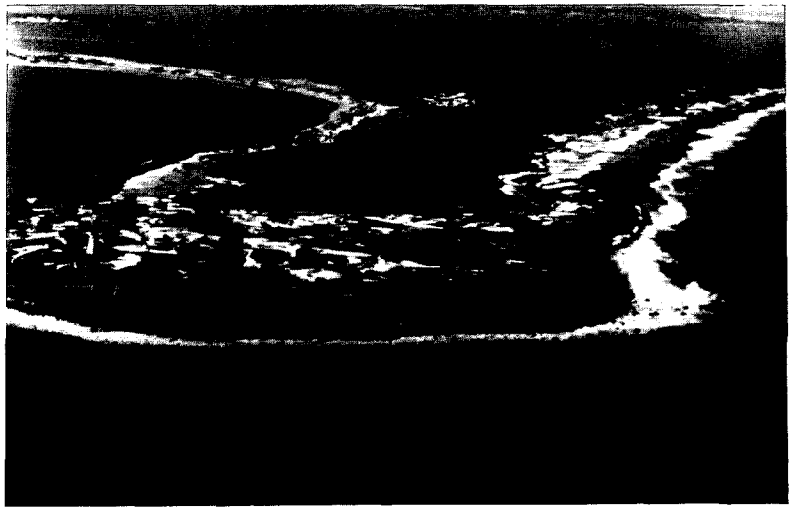


Figure 1.6 Photo of tombolo

Table 1.1

Distribution of Barrier Beaches by Massachusetts Coastal Region

Region	Approximate Number of Barrier Beaches
North Shore	32
Boston Harbor	29
South Shore	30
Cape Cod	213
Martha's Vineyard & Nantucket	233
Buzzards Bay & Mt. Hope Bay	120

They form much of the Massachusetts coast that is exposed to the open ocean. Other coastal areas of the state are formed of solid rock (bedrock), such as Cape Ann, or glacial sediments such as the sea cliffs of Cape Cod or the low-lying uplands that surround Buzzard's Bay.

Barrier beach maps published by the Massachusetts Coastal Zone Management Office are available for all coastal areas of the state. An index to these maps is provided in figure 1.7.

Identification Criteria of Barrier Beaches

A barrier beach is distinguished from another coastal feature by using the following criteria which have been developed from the coastal wetland regulations: narrow low-lying, parallel to the trend of the coast, separated from the mainland by a water body or wetland, composed of beach and dunes, and affected by dynamic processes.

narrow low-lying

A barrier beach landform is generally a narrow low-lying strip of land due to numerous factors which include: sediment supply, storm frequency, sediment transport patterns and rates, and human alterations. In Massachusetts, barrier beaches range in width from small barriers tens of feet wide to large barriers with beach and dunes up to a half mile wide.

parallel to the trend of the coast

Barrier beaches are oriented parallel to the trend of the coast. However, in some areas the Massachusetts coast is not straight due to the variable distribution of geological features. In these

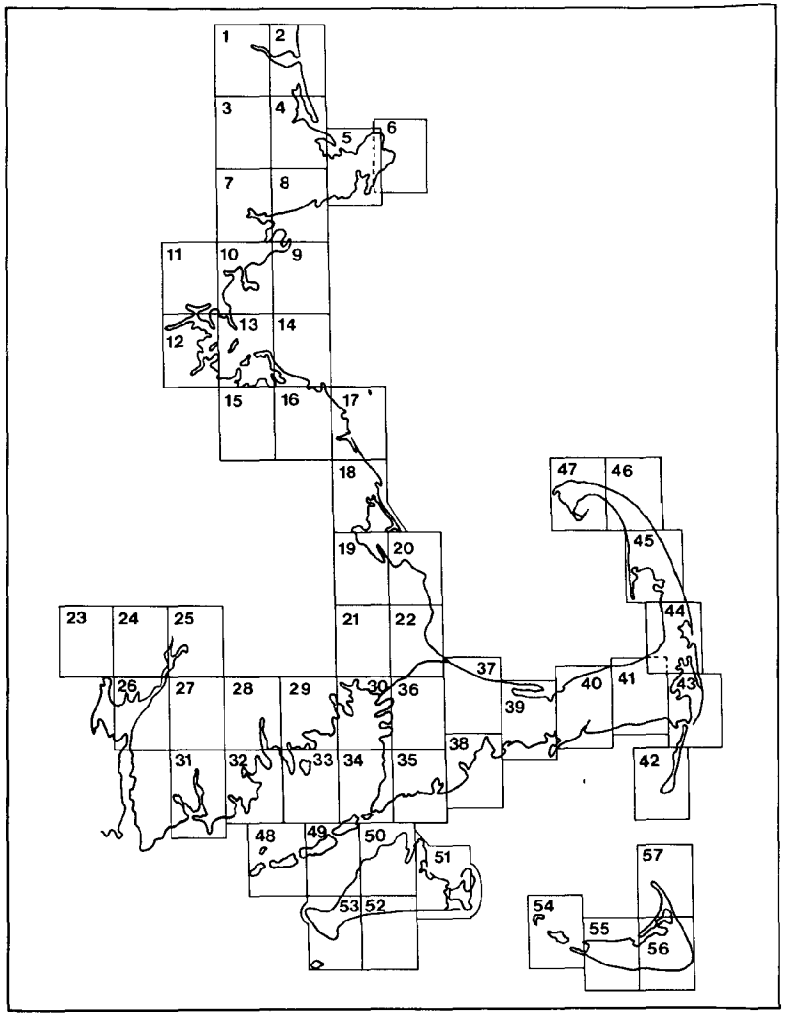


Figure 1.7 Index to barrier beach maps

irregular coastal areas barrier beaches typically fill the openings between bedrock or glacial geological features (figure 1.8). Thus, barrier beaches tend to straighten these otherwise irregular coastlines.

separated from the mainland by a wetland or water body

A wetland or water body is always found between a barrier beach and the mainland. Fresh, salt, or brackish water can be present in the wetland or water body.

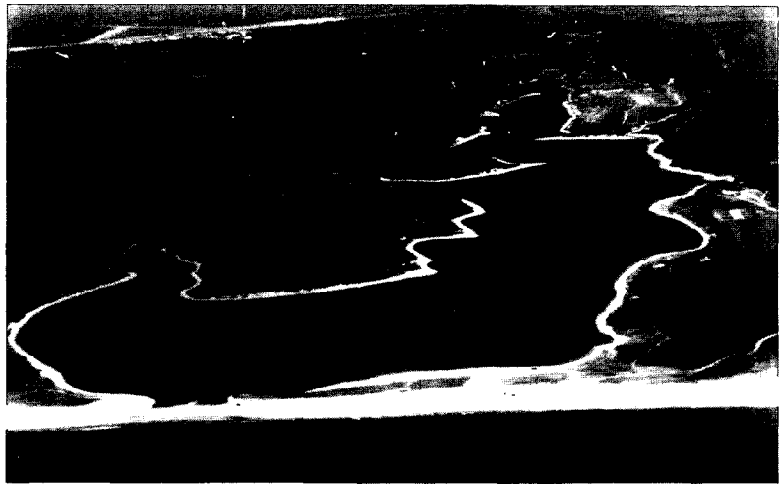


Figure 1.8 Photo of barrier between irregular shoreline of glacial deposits

composed of beach and dunes

The two major components of a barrier beach are the beach and dunes. These features are present on both unaltered and altered barrier beaches. The beach portion of the barrier beach consists of loose sand and gravel, known as sediment, and slopes from the waterline landward to the dune, *storm ridge,* or coastal engineering structure (figures 1.9 and 1.10).

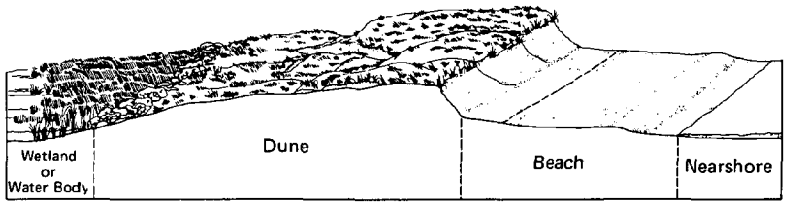


Figure 1.9 Illustration of unaltered barrier beach

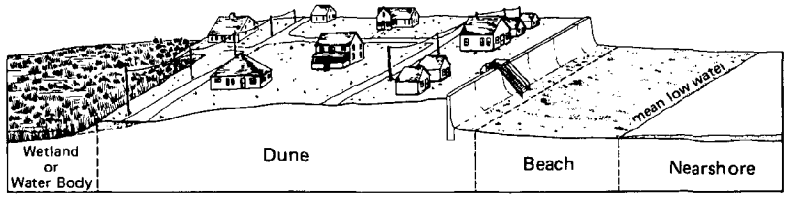


Figure 1.10 Illustration of altered barrier beach

The coastal dune portion of the barrier beach is located landward of the beach where sand carried by the wind is deposited and builds a hill or ridge. Vegetation, especially beachgrass, plays an important role in dune formation, growth and stability. On barriers with *gravel-* or *boulder*-sized sediment, the dune is replaced by a storm ridge deposited or carried to this height by storm waves (figure 1.11). Storm ridges are similar to coastal dunes and they are protected to the same degree by the state Wetlands Protection Act.

Figure 1.11 Photo of storm ridge

Altered or developed barrier beaches with coastal dunes that are modified by houses, roads, coastal engineering structures, or other alterations (figure 1.10) are protected by the Wetlands Protection Act because these features buffer landward areas from storms and they are hazardous locations for development.

affected by dynamic processes

Barrier beaches are constantly reshaped by waves, tides, winds, coastal storms, and sea level rise. During major storms, dunes are eroded and at times washed over by storm-elevated seas. Inlets may form or shift position during storms as tidal waters seek the most efficient route to the ocean. With time, due to the gradual rise of the level of the sea, sediment is carried to the landward side of the barrier by *overwashing* and inlet migration. This results in the landward shift of the barrier beach. Other coastal features, such as glacial banks and bedrock do not shift landward with rising sea level but gradually disappear as they are submerged. Old charts and maps of coastal areas show that the shoreline was farther seaward than the present shoreline.

Barrier beaches, if left unaltered, usually do not decrease in width, but the entire landform moves landward.

Delineation of Barrier Margins

The determination of where a barrier beach ends and consequently where another coastal feature begins is important for accurate delineation of a barrier beach. The boundaries that define a barrier beach include the seaward and landward margins and the two lateral margins.

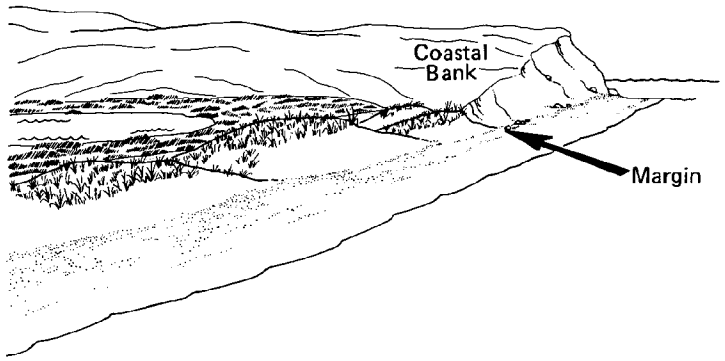
seaward and landward margins

A barrier beach's seaward margin is located at *mean low water*. Its landward margin is located at mean low water when the water body is affected by tides and at the annual water line for fresh water areas not affected by tides. When salt marsh or tidal flats are located immediately behind the dunes of a barrier beach, then they are included as part of the barrier landform (figure 1.9).

lateral margins

Lateral margins terminate at uplands, water bodies, or wetlands. A water body or wetland margin is usually a straightforward determination. However, the upland margin delineation can be difficult to determine when the sediments of the upland are similar to those of the barrier beach. The three basic types of upland margin are: *coastal bank, dune-upland,* and *bedrock.*

Figure 1.12 Illustration of coastal bank lateral margin



coastal bank margin: Most coastal bank margins in Massachusetts consist of glacial sediment. Glacial deposits, which were formed by the last major ice advance over New England, the Wisconsin Ice Sheet, are variable in composition and texture in contrast to the homogenous barrier beach deposits. Examples of a coastal bank margin are shown in figures 1.12–1.14.

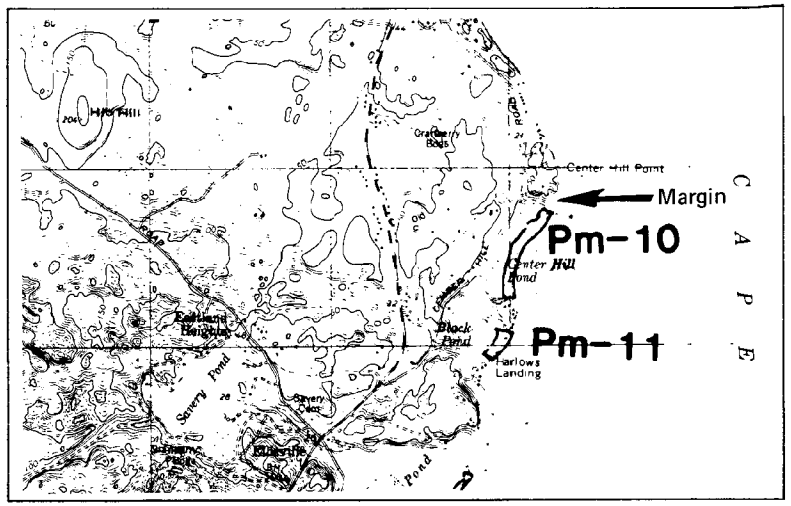


Figure 1.13 Map of coastal bank lateral margin

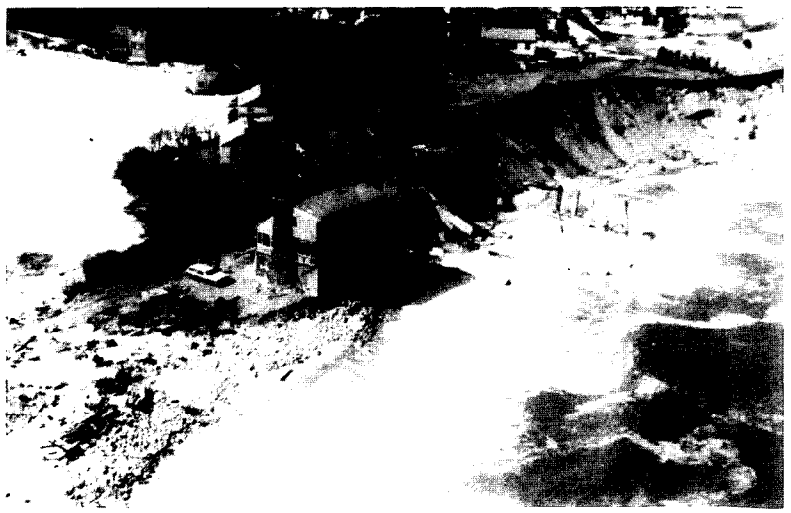
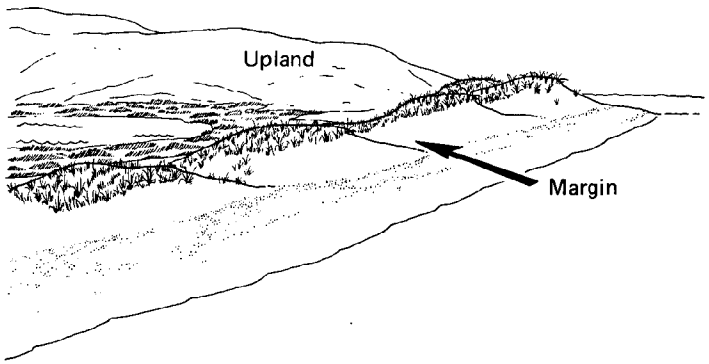


Figure 1.14 Photo of coastal bank lateral margin

dune-upland margin: This boundary, which is shown in figure 1.15, occurs when coastal dunes are present on top of or seaward of an *upland.* The upland may consist of glacial sediment, bedrock, or artificial fill. The dune-upland margin can form when a barrier beach builds laterally in front of an upland or when a barrier shifts landward and attaches itself to an upland (figures 1.16 and 1.17). This margin also occurs when the landward marsh or water body behind a barrier has changed to upland as a result of artificial filling of a portion of the marsh/wetland area. An example of this type of margin is shown in figures 1.18 and 1.19.

Figure 1.15 Illustration of dune-upland lateral margin



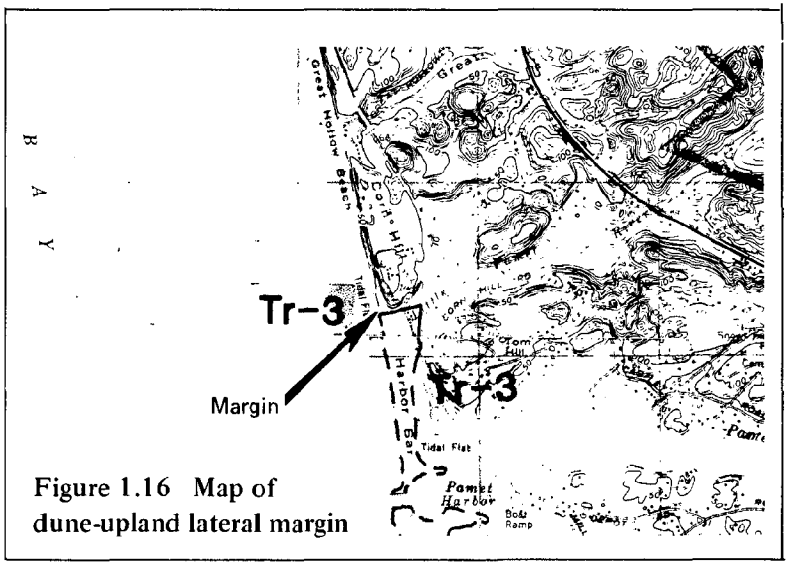


Figure 1.16 Map of dune-upland lateral margin

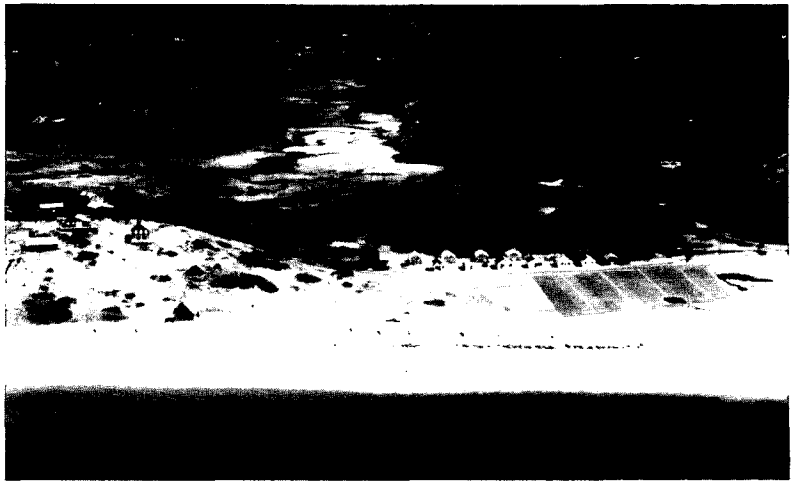


Figure 1.17 Photo of dune-upland lateral margin

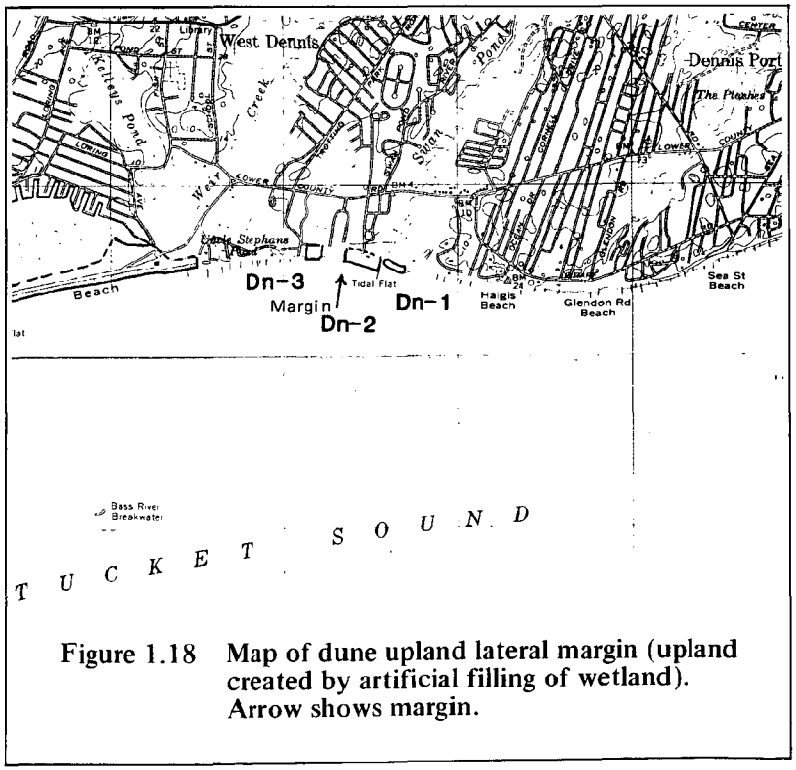
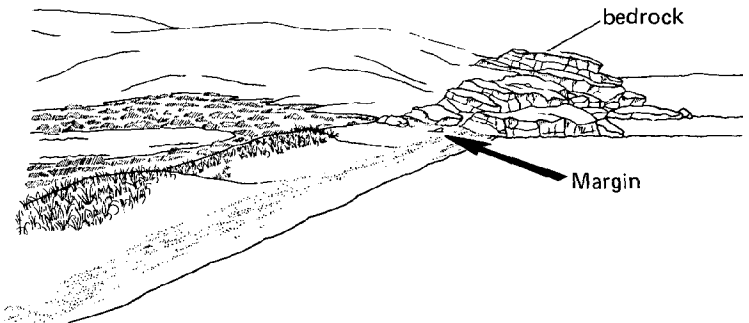


Figure 1.18 Map of dune upland lateral margin (upland created by artificial filling of wetland). Arrow shows margin.

Figure 1.19 Photo of dune-upland lateral margin (upland created by artificial filling of wetland)

bedrock margin: The lateral margin of a barrier beach can terminate at bedrock, which is massive rock material formed by metamorphic, igneous, or sedimentary processes. Bedrock can be found in numerous areas of the coast of Massachusetts including Cape Ann, Manchester, Marblehead, Swampscott, Boston, Dartmouth, and New Bedford. An illustration of bedrock barrier beach margin is shown in figure 1.20. Cape Hedge Beach in Rockport is an example of this type of margin (figures 1.21 and 1.22).

Figure 1.20 Illustration of bedrock lateral margin



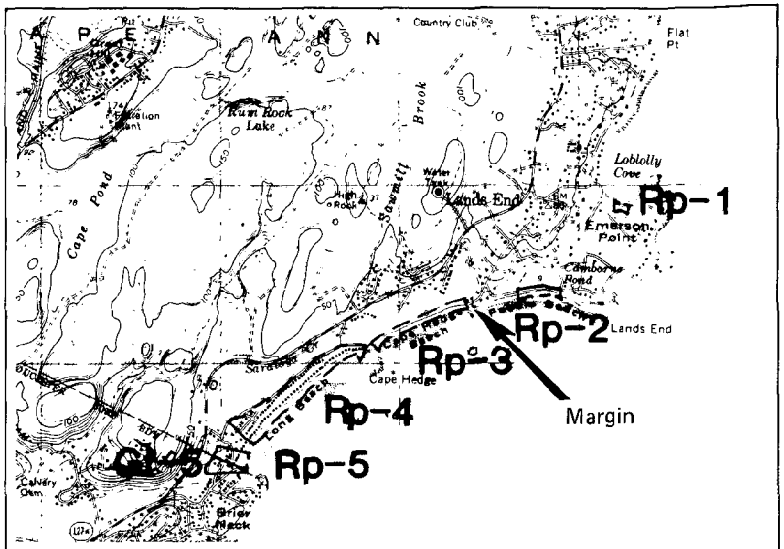


Figure 1.21 Map of bedrock lateral margin

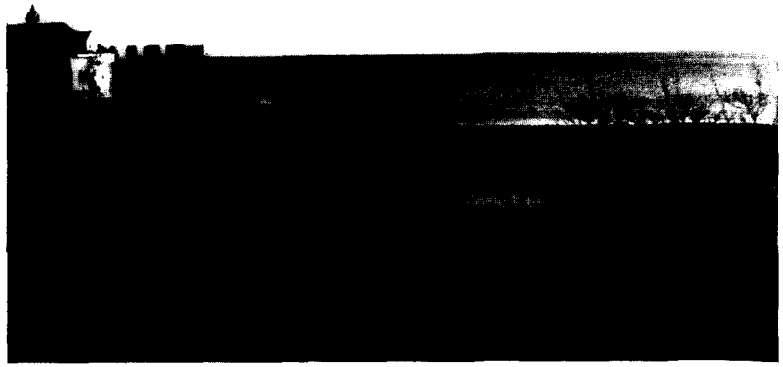


Figure 1.22 Photo of bedrock lateral margin

Chapter 2: Characteristics of Barrier Beaches

Introduction

The purpose of this chapter is to provide the reader with a basic understanding of the physical, biological, and land use properties of a barrier beach. This is important so that these characteristics can be recognized in a specific barrier beach situation. Once these characteristics are understood then the reader is prepared to decide which management techniques, as described in Chapter 3, are appropriate for a particular barrier beach.

Natural Characteristics

Physical Characteristics

Barrier beaches are always moving. Changes occur every day as the tide ebbs and flows and as waves strike the beach. Seasonal and long-term changes also occur. It is important to understand all of these changes because they all bear on how barrier beaches should be managed.

Day to Day Changes

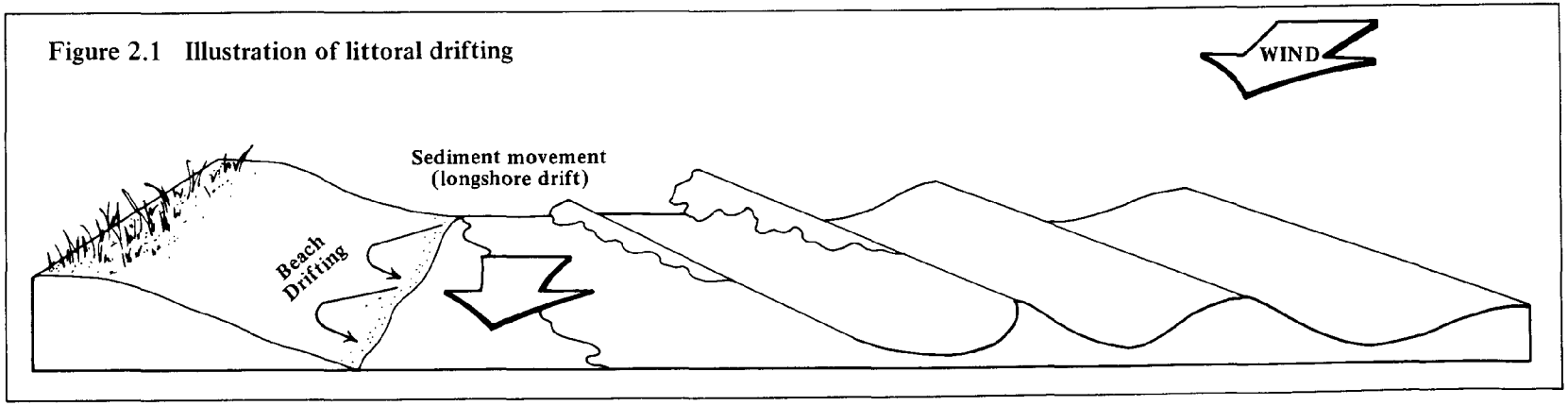
Sediment is constantly being moved by waves. When waves strike the beach at an angle sand and gravel is picked up and moved along the beach in the same direction as the waves break (figure 2.1). The movement of sediment along the shore is known as littoral drifting. When sediment is moved by waves from one portion of the beach it must be replaced by sediment from adjacent updrift areas so that the volume of sediment in any one area is maintained. Ultimately there must be a continuous source of sediment available to feed this littoral drifting process. In Massachusetts, eroding coastal banks are a major source of this beach sediment.

Another important type of sediment transport that occurs on barrier beaches is due to winds which pick sand up off the beach and carry it landward to build dunes. Beachgrass helps build the dune by trapping wind-blown sand and stabilizing its surface.

Seasonal and Storm Changes

In the course of a year, seasonal changes of the barrier beach are quite evident. In the summer, when waves are low and long, the beach builds up, becoming higher and wider (figure 2.2). Sand is moved from the offshore bar to the beach. The seaward edge of the dune may also grow and extend onto the beach. Storms that occur in the fall, winter, and early spring produce large steep waves which cut into the beach and cause it to narrow and flatten. This sand is moved seaward to build the offshore bar. Storms can narrow the beach to the extent that the dunes begin to erode and a dune scarp is formed. Large storms, especially those which coincide with higher than average tides, can cause extensive erosion to the beach and dunes, and at times the entire

Figure 2.1 Illustration of littoral drifting



barrier can be overwashed (figure 2.3).

When storm overwash occurs, sand eroded from the beach is carried landward by the surging water. This sand is dropped on the landward side of the barrier in a fan-shaped deposit known as a washover fan. Beachgrass vegetation usually grows up on washover fans and initiates the formation of new dunes.

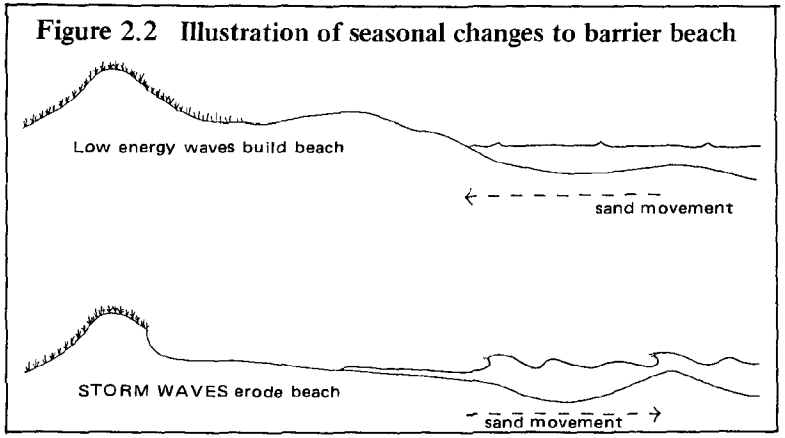
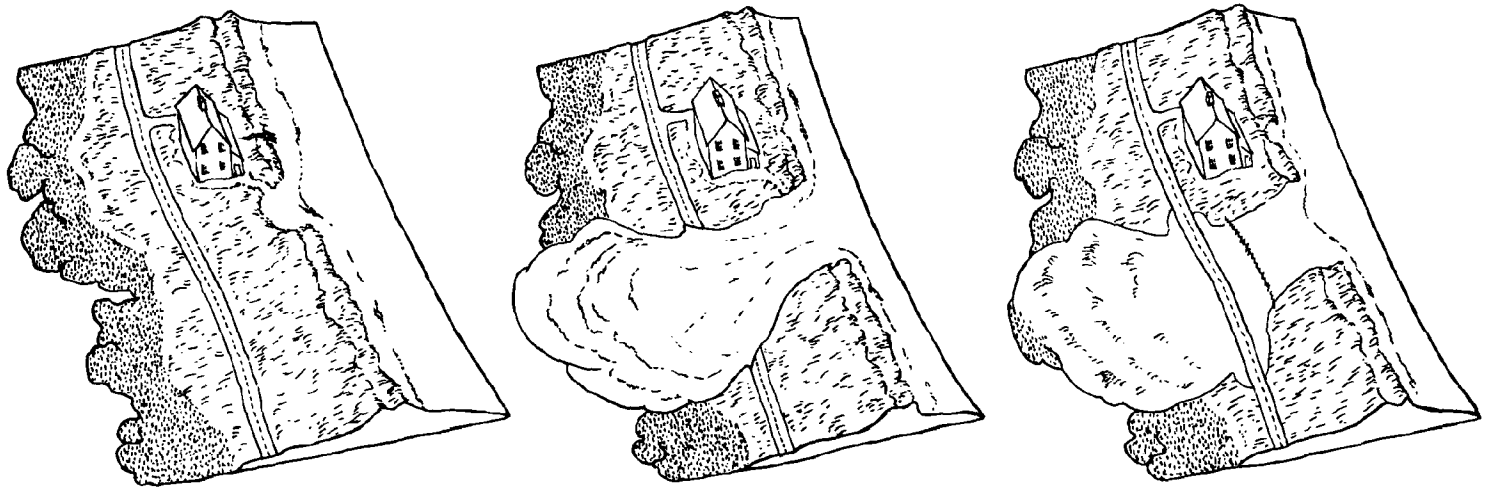


Figure 2.2 Illustration of seasonal changes to barrier beach

During large storms, erosion of the barrier beach can be so extensive that the barrier is entirely breached and a tidal inlet can form. During the Blizzard of '78 a large inlet formed which cut Monomoy Island into two separate barrier islands (figure 2.4). An inlet such as this is kept open by tidal currents that

Figure 2.4 Photo of Monomoy Island Inlet, 1978

Figure 2.3 Illustration of storm overwash



A
Eroded dune

B
Overwash

C
Revegetation of washover fan to start the formation of new dunes.

scour the inlet channel. Sand moving along the beach, however, can fill the inlet if this sand movement exceeds the amount eroded by tidal scour (figure 2.5).

Long-term Changes

Rising sea level is gradually submerging the Massachusetts coast. Mean sea level has risen 350–400 feet during the last 12,000 to 15,000 years and the shoreline has retreated many miles over that time period as shown in figure 2.6. Today the rate of sea level rise is approximately one foot every 100 years as determined from measurements taken of the level of the sea at tide gauges. This rise produces shoreline retreat on the average of three feet per year on Outer Cape Cod. The rate of retreat varies for other areas of the Massachusetts coast depending on several factors such as: exposure and frequency of storms, type of shoreline material, and extent of shoreline alterations.

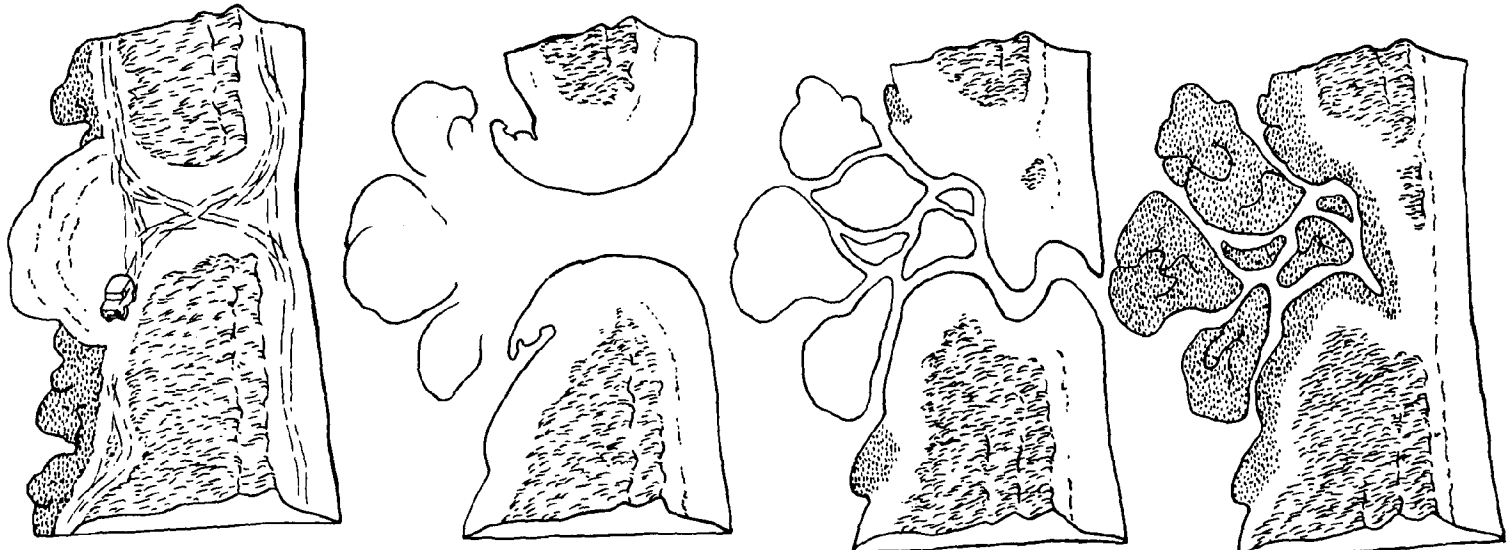
While coastal banks may gradually erode and disappear with rising sea level, barrier beaches move landward by storm overwash and inlet processes. Through this landward shifting, barrier beaches retain their general volume and form as sea level rises whereas other coastal features such as glacial banks and bedrock areas are submerged.

Inventory of Shoreline Change

Past shoreline changes may be used to predict future changes in position of the shoreline. For many areas of the coast, historical charts and maps may be used to reconstruct how the shoreline has changed in position over time. For example, figure 2.7 shows barrier beach changes for Nauset Beach and Monomoy Island from 1770 to 1970. Based on geological interpretation of these changes, future shoreline positions for 1985, 1995, and 2005 can be predicted. Shoreline trend analysis is very useful for communities situated behind a barrier system because these predicted changes should influence the present and future management of the barrier beach.

Shoreline change determination based on historical charts, maps, surveys, and aerial photographs requires technical expertise in the specialized field of coastal geomorphology. Many factors must be considered when shoreline positions are compiled such as the scale and precision of maps and the distortions and tidal positions on aerial photographs. Fortunately historic shoreline change maps for many areas of the Massachusetts coast have already been compiled and are available from the U.S. Army Corps of Engineers and the Massachusetts Coastal Zone Management Office (see Appendix B, Technical and Educational

Figure 2.5 Illustration of inlet formation and closing



A
Lowered Dune

B
Breach occurs during storm to form inlet

C
In some instances inlets will close naturally

D

Assistance and Sources of Information at the end of this section).

Since many factors determine the rate of shoreline retreat, a coastal geomorphologist should be consulted to assist in the interpretation of these maps.

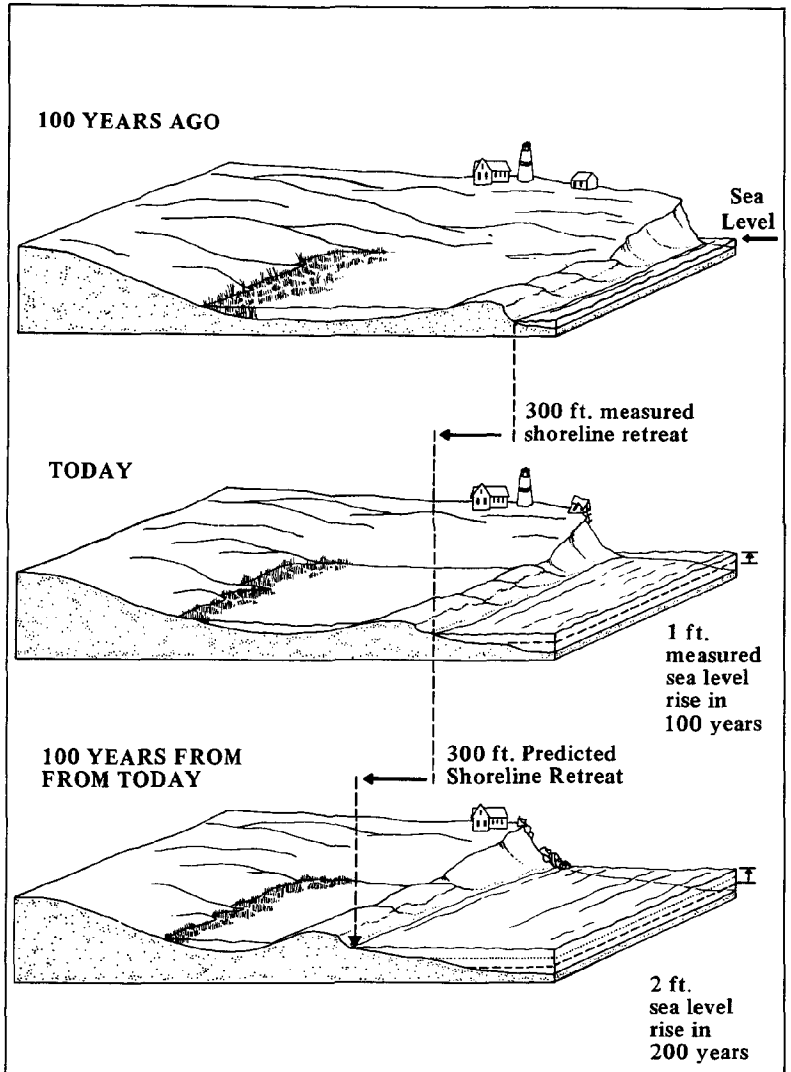


Figure 2.6 Illustration of the effects of sea level rise

Sources of Information

Barrier Island Handbook, Leatherman, 1979.

This handbook provides a good overview of the scientific theories of barrier island (beach) evolution, processes and impacts.

A Geologist's View of Cape Cod, Strahler, 1966.

The geological history of Cape Cod is similar in many respects to several other coastal regions of Massachusetts, such as Buzzards Bay, Martha's Vineyard, and Nantucket. Therefore, this book is a very useful primer on how the Massachusetts coast has evolved.

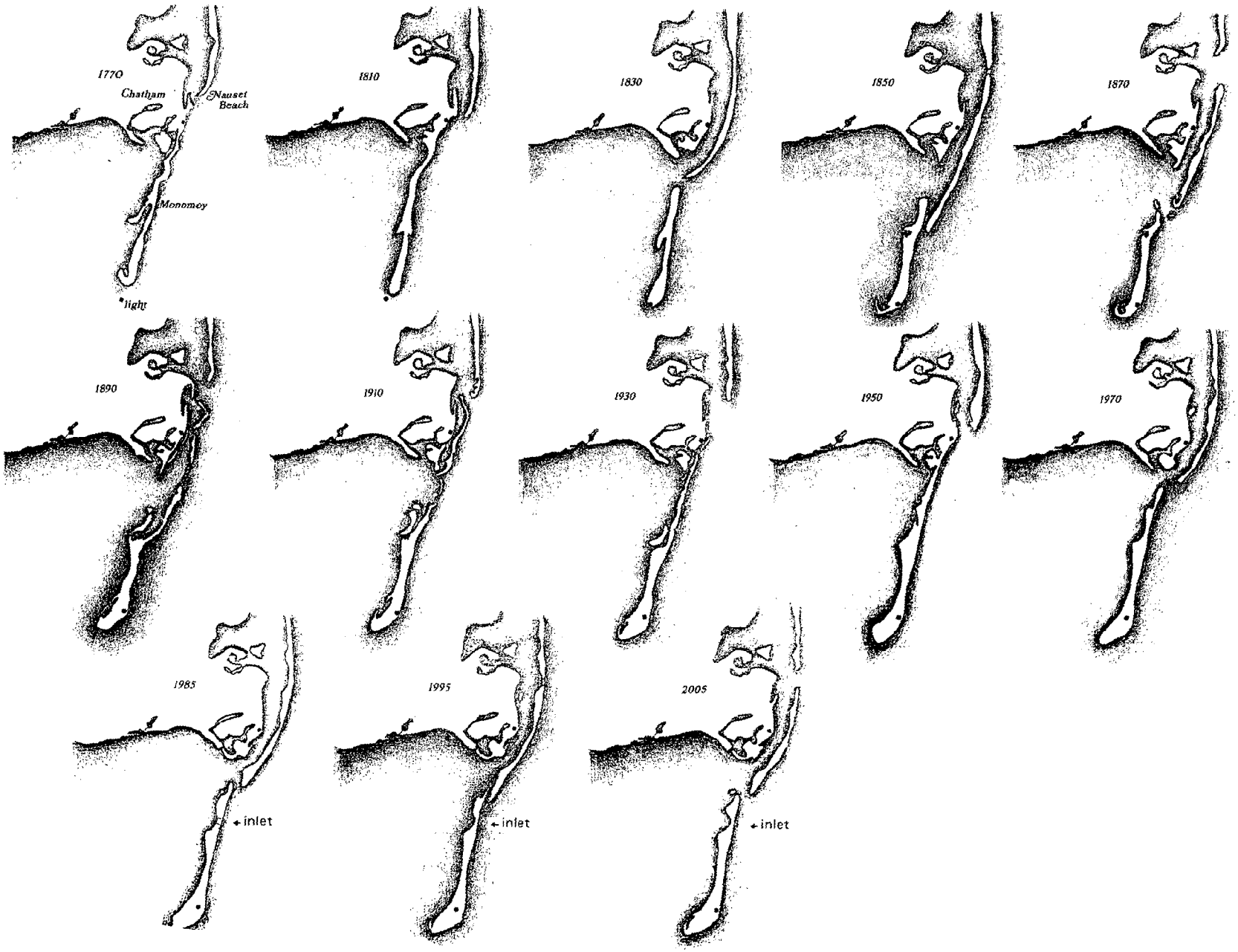
The Beaches are Moving, Kaufman and Pilkey, 1979.

This book describes coastal processes and the problems that have arisen when these processes have been ignored. It offers some useful recommendations on how to choose a safe site for development.

A Manual for Researching Historical Coastal Erosion, Fulton, 1981.

This is a useful handbook on how to compile information on historical shoreline change for a particular coastal area.

Figure 2.7 Illustration of shoreline changes for Nauset Beach and Monomoy Island (after Giese, 1978).



Storms That Affect Massachusetts

Due to its geographic location and orientation, Massachusetts is vulnerable to two major types of coastal storm: *hurricanes* and *northeasters*.

Hurricanes

Hurricanes are intense low pressure systems that form in the tropics during the months of June through October. Typically hurricane paths have crossed the Massachusetts coast in the Buzzards Bay region in August and September (figure 2.8). The erratic behavior of hurricanes indicates that hurricane paths are not predictable and that hurricanes will not always come ashore, as they have in the past in Buzzards Bay and Long Island Sound. Winds of a hurricane, which are over 75 m.p.h., move counter-clockwise about the center or "eye". Therefore, for south-facing coastlines, the highest winds of a hurricane usually do the most damage to the east of a hurricane's eye.

Previous hurricanes have funneled storm tides into south-facing bays such as Buzzards Bay, Narragansett Bay and Mount Hope Bay. For the largest storms the effect was to increase the height of flooding by as much as three feet at the head of the bays from that experienced on the open coast. The last major hurricane affecting coastal areas of Massachusetts occurred in 1960.

Northeasters

Northeasters are similar to hurricanes because they are both generated in a tropical area, follow the trend of the coastline, and generate large storm tides. They differ in frequency, intensity, size and areas affected. Northeasters affect the coast from the fall to the spring, generate wind speeds from 30 to 70 m.p.h., and strike northeast facing coastal areas (figure 2.9).

Northeasters are large, asymmetrical low pressure systems that produce counter-clockwise winds. Northeasters usually do not have winds as strong as those of hurricanes, but they can cause extensive damage especially if they coincide with the highest tides of the month or year and if they remain stalled off the coast for two to three days. The Blizzard of '78 is an example of such a northeaster. In that storm 29 deaths were inflicted and over 250 million dollars worth of damage occurred.

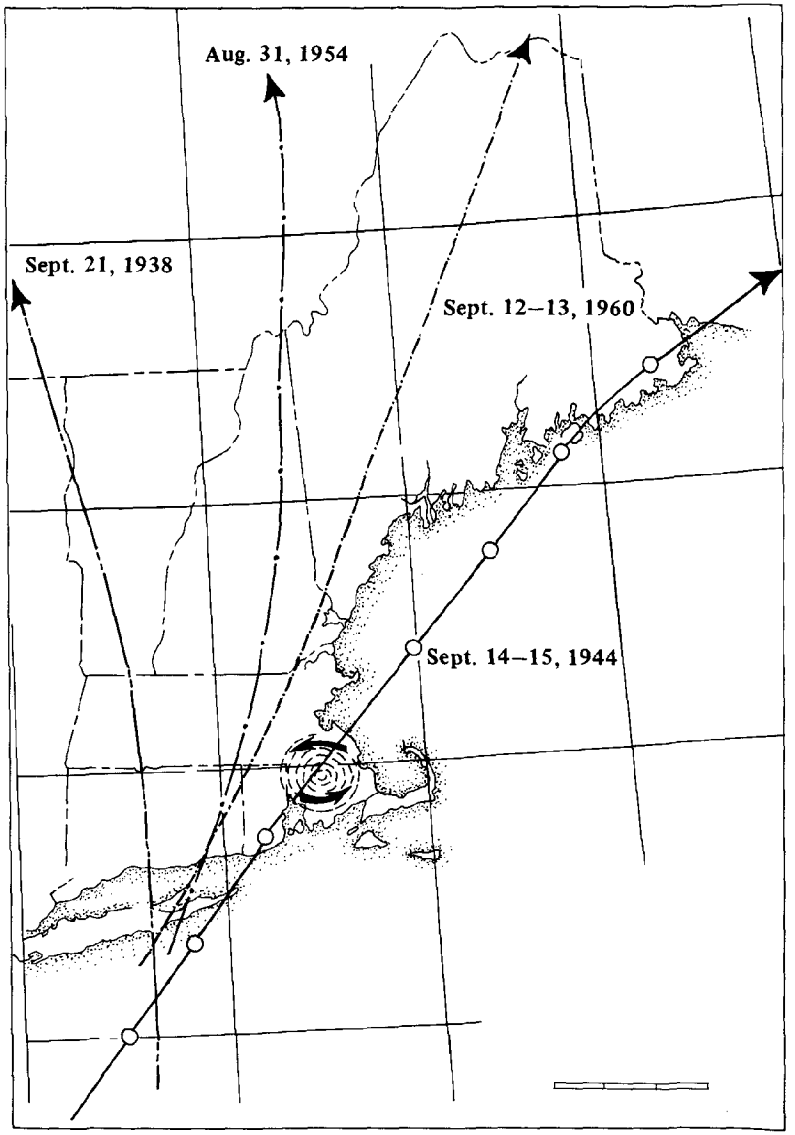


Figure 2.8 Illustration of tracks of selected hurricanes (after U.S. A.C.O.E., 1978)

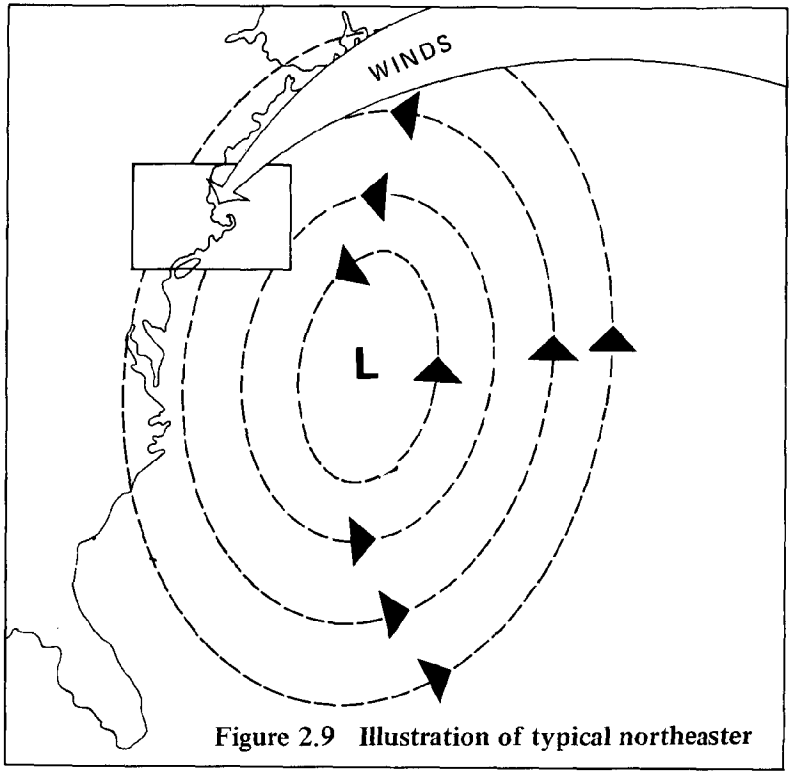


Figure 2.9 Illustration of typical northeaster

Biological Characteristics

Barrier beaches protect landward wetlands, serve as a habitat for many plants and animals and play a vital role in supporting the biological productivity of coastal waters. The following subsection briefly describes marsh formation and wildlife habitats, important biological characteristics of barrier beaches.

Marsh formation

The sediment substrate provided by overwash processes and inlet migration supports the growth and development of wetland plants. Salt marshes, which are some of the most biologically productive areas on Earth, form and prosper behind barrier beaches.

Wildlife habitats

This section describes some of the important habitats for wildlife that are provided by barrier beaches.

Shellfish

Shellfish live in the protected sandy tidal flats behind barriers and in the flats and near shore areas in front of some barriers. Information on shellfish resources in a particular town may be obtained from the town shellfish office.

Seal haul-out sites

Migrant, juvenile seals haul themselves out of the water and onto barrier beaches along the Outer Cape and Islands. The seals haul-out to sun and perhaps rest during low tide. Haul-out sites have deep water close to the shore and have a steep bank where seals can quickly slide off in times of danger. Variations in haul-out behavior occur with the changes in tide level, weather (especially sun and wind), ice, and beach conditions.

Turtle nesting sites

Turtles, such as the Diamondback Terrapin, migrate to the backdune areas of barriers to nest. On Sandy Neck in Barnstable, researchers found that ORVs (off-road vehicles) had killed many of the young turtles before they were able to reach salt marshes and the bay where turtles begin their marine life. As a result of recommendations by these researchers, the ORV trails along the dune-salt marsh border have been closed. See Recreation, Section 3 of Chapter 3 for information on managing pedestrian and off-road vehicle use near these nesting sites.

Migratory bird feeding areas

Migratory shorebirds, such as the Red Knot, use tidal flat areas of Massachusetts barrier beaches to feed in preparation for their long flight south (figure 2.10). With their high productivity of plankton, shell and finfish and aquatic vegetation, these tranquil waters provide migrating shorebirds with crucial resting and feeding areas.

Colonial shorebird nesting sites

Colonial shorebirds, such as Terns and Plovers, nest in the foredune/beach zone of barrier beaches. See Recreation, Section 3 of Chapter 3 for information on managing pedestrian and off-road vehicle use near these nesting sites.

Endangered and threatened species

Numerous endangered and threatened species of fauna and flora are unique to Massachusetts barrier beaches. Information on these species is available from the Natural Heritage Program, Department of Environmental Management, 100 Cambridge St., Boston.

Sources of Information

A Guide to Coastal Wetlands, Massachusetts DEQE, 1978.

This guide describes the role costal wetlands, such as barrier beaches and salt marshes, play in providing storm damage protection, flood control, and fisheries productivity. The types of activities regulated by the Wetlands Protection Act are described and recommendations are presented on how these activities can be designed to avoid damage to the barrier beach.

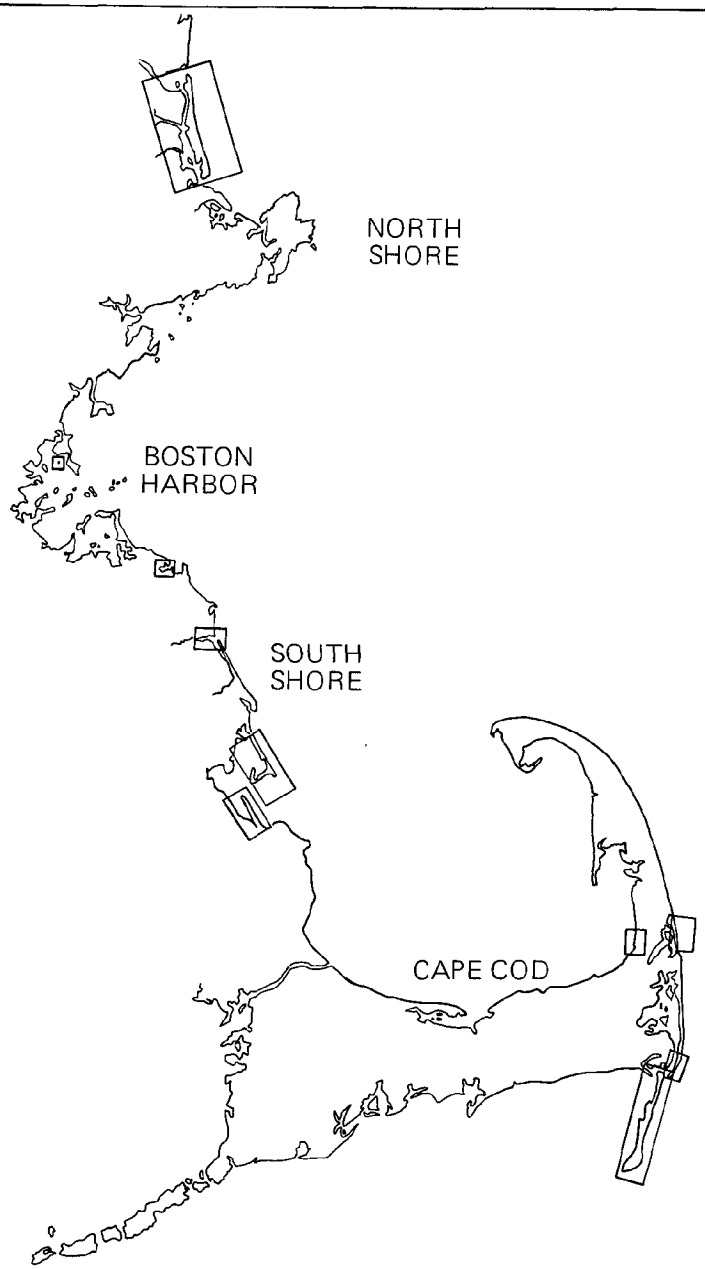


Figure 2.10 Illustration of shorebird stopover sites

Land Use Characteristics

Human Alterations

Many land uses of barrier beaches cause alterations of the natural characteristics. At one extreme alterations may be quite extensive as in the case of urbanized barrier beaches in the vicinity of metropolitan areas. Human alterations to these barriers include residential and commercial construction, roads, sewers, and coastal engineering structures.

Once year-round houses are constructed on a barrier beach, the scenario that often occurs is for the construction of infrastructure (sewers, water supply, paved roads, bridges, etc.) then the construction of coastal engineering structures to "protect" this development. Rather than protecting the development, these engineering structures reduce the protection provided by the natural characteristics of the barrier landform. Consequently, storms do more damage to development on the barrier and to the engineering structures themselves. Once coastal engineering structures are built, it is very difficult to reverse the cycle to restore the natural characteristics.

Storm damaged engineering structures are usually replaced with larger, more expensive engineering structures which in turn encourage more development and investment in the hazard prone location. Chapter 3, Section 1 (Human Alteration) presents alternatives to this cycle of increasing storm damage by offering techniques to correct human alterations. Chapter 3, Section 4 (Storm Preparation) presents methods to reduce storm damage in developed areas.

In contrast to extensively developed barriers are relatively unaltered barrier beaches that are used entirely for recreational purposes. Many of these barriers are owned and managed by natural resource management agencies, such as the National Park Service, the state Department of Environmental Management and local conservation commissions.

However, even these undeveloped barriers have some land use alterations. For instance, recreational use by pedestrians and off-road vehicles can seriously damage the natural characteristics of barrier beaches unless management controls are employed. Chapter 3, Section 3 (Recreation) discusses these and other potential recreational impacts to barrier beaches and presents techniques to manage these impacts. Chapter 3, Section 2 (Acquisition) describes government and private programs which may be used to acquire barrier beach property for recreation as an alternative to development.

Human alteration on all barrier beaches is managed through regulatory programs. Chapter 3, Section 5 (Regulation) lists the federal and state regulatory programs for barrier beaches. Numerous options for local regulation of barrier beaches are also

included in that section.

Hazards

Coastal storms cause flooding and erosion to residential and commercial development on barrier beaches. These hazards can threaten the safety and health of residents. For example, in the year 1900, 6,000 residents died on Galveston Island when a hurricane overwashed this Texas barrier beach.

On barrier beaches in Massachusetts there is a long history of life loss and property damage. Table 2.1 lists these storm statistics for Massachusetts during this century.

Table 2.1 Coastal storms of the 20th century

DATE	DEATHS	DAMAGE*	TYPE
February 6, 1978	29	$250 M	NE
February 19, 1972	–	$9,166,000	NE
January 1961	–	$10,000,000	NE
September 1960	3	$1,222,000	H
December 29, 1959	–	$1,352,000	NE
September 19, 1954	60	$454 M	H
November 1953	–	–	NE
September 1950	–	$400,000	NE
November 1947	–	–	NE
November 28, 1945	–	–	NE
August 1944	40	$2,635,000	H
April 20, 1940	–	–	NE
December 26, 1909	–	–	NE

**All damage estimates are corrected to 1977 cost levels.*

Flood information is available from Flood Insurance Rate Maps and Flood Hazard Boundary Maps, both of which are available from FEMA (Federal Emergency Management Agency). These maps delineate areas of a 100-year storm, which is a storm with a one percent chance of happening in any given year. There are two principal types of flood hazard delineated on these maps, the areas that would be flooded by still water (A-zone) and those areas that would experience flooding with velocity (V-zone). The effects of erosion during such a storm are not indicated on these maps. Since erosion produces shoreline change during these catastrophic storms, these hazards should be considered with flood hazards when management techniques are considered (Chapter 2, Physical Characteristics and Appendix B – Technical and Educational Assistance).

Sources of Information

Proceedings of "The Blizzard of '78": its effects on the coastal environment of southeastern New England.

This booklet is the proceedings volume of a conference sponsored by Boston State College on the Blizzard of '78. Accounts of Massachusetts barrier beach damage, particularly in the Winthrop and Scituate areas is described. Other topics covered include washover identification, sand movement during storms, erosion, and storm models.

Coastal Flooding in Barnstable County, Cape Cod, Mass.
Crane, Donald A., Commonwealth of Massachusetts, Water Resources Commission, Boston, 1962.

A general overview of storm damage due to coastal flooding in Barnstable County is provided with tabulated information on storms occurring from 1635 to 1909. Specific information on storm damage to Cape barrier beaches is provided, including flood hazard maps.

Massachusetts Coastal Study, ACOE NE Division, 1978

This study provides storm information for hurricanes from 1938 to 1960, and northeasters from 1909 to 1972. A commentary on the storms provides information on dates, storm type, maximum tide, wind, precipitation, and death and damage estimates. Information on specific types of damage such as residential, commercial, and transportation is provided for some of Massachusetts' more recent coastal storms.

Chapter 3: Management of Barrier Beaches

Introduction:

Management practices for Massachusetts barrier beaches vary depending on such factors as historic land use, flooding and erosion hazards, natural resource values, economics, and ownership. At one extreme, some barrier beaches are extensively developed, for example Revere Beach (figure 3.1). On the other hand, some barriers are pristine and virtually free from any alterations. Such unaltered barrier beaches are rare in Massachusetts since most uses of a barrier beach will cause an alteration to one of its characteristics. The key to sound management is to accommodate uses that neither cause deterioration of the natural characteristics, nor increase hazards.

This chapter assumes that the reader has identified the barrier beach (Chapter 1), and is familiar with the natural and land use characteristics of the barrier beach (Chapter 2). Five major management sections are included in this chapter: Section 1, human alteration; Section 2, acquisition; Section 3, recreation; Section 4, storm preparation; and Section 5, regulation. Each section has information which is applicable to all barrier beaches except Section 4, storm preparation, which is concerned only with developed barrier beaches.

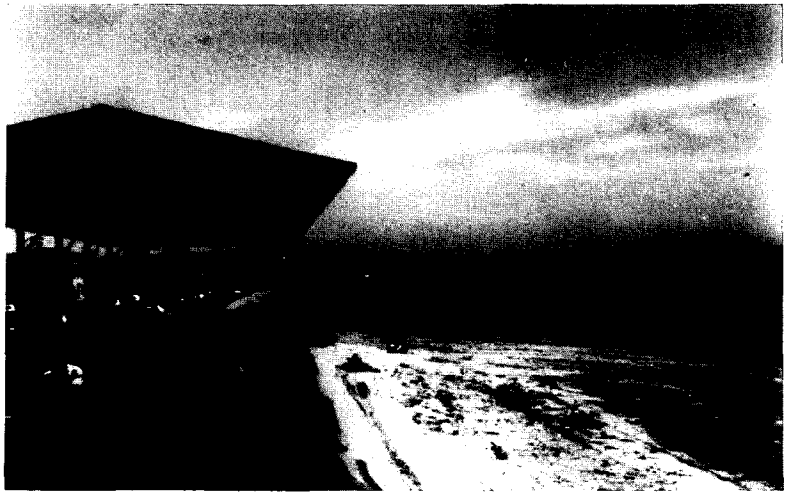


Figure 3.1 Photo of Revere Beach

Section 1 Human Alteration

Introduction

This section describes common human alterations to barrier beaches and proposes methods for correcting the adverse effects of these alterations. The types of human alterations are divided into the same general categories as appear in the state Guide to Coastal Wetlands: coastal engineering structures; dredging; filling and removal; houses, roads, and utilities; and trails and paths. For each type of alteration, techniques are presented that will help reduce storm damage losses and restore characteristics of the barrier beach that provide storm protection and biological values. Following the discussion of human alterations, techniques for rebuilding altered dune and beach areas of barrier beaches are discussed.

Coastal engineering structures

Coastal engineering structures are devices of rock, steel, timber or concrete designed and constructed to prevent or minimize flooding and erosion of specific sites along the coast. They may also be constructed to maintain navigation channels and harbors. Coastal engineering structures often interrupt the natural processes of the shoreline. While the purpose of these structures is to trap

sediment in front of one person's property, they usually increase erosion of adjacent or down-beach properties. These structures are grouped according to their location and design: groins and jetties, seawalls and revetments, and offshore breakwaters.

groins and jetties

These structures are located on the beach perpendicular to the shoreline. As is true of most other coastal engineering structures, groins and jetties may be constructed of such varied materials as rock, steel, timber or concrete. The most important and obvious effect of these structures is to interrupt the movement of sediment along the beach. This brings about an increase in beach width and elevation on the *updrift* side of the groin or jetty with accompanying loss of beach width and height or erosion on the *downdrift* side (figure 3.2). The erosion or decrease in volume of the downdrift beach diminishes the storm protection capability of the beach. Resultant changes in sediment size, beach elevations, and changes in circulation that may accompany groin- and jetty-related erosion may also damage shellfish and finfish resources by removing their habitat.

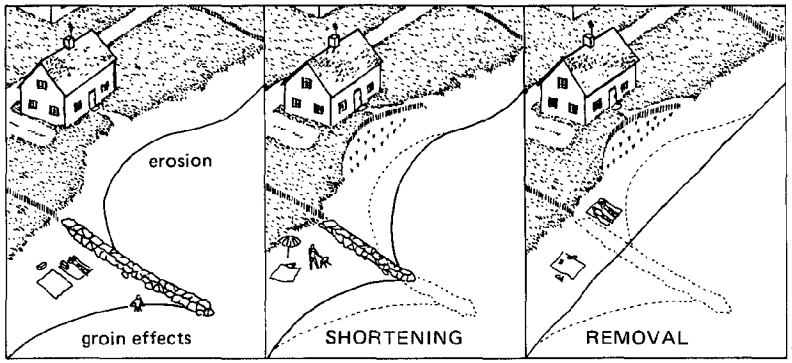


Figure 3.2 Illustration of groin alternatives

Groin-corrective techniques

Several techniques are suggested to restore beaches affected by groins. Generally it is desirable to make modifications such that sand movement along the beach will be renewed and downdrift areas will refill with sand again. Alternatives are presented as follows.

1. Remove groin

If it is economically and physically feasible to remove the groin this may be the best alternative. Removing the groin leads to a straightening of the shoreline: up-beach of the removed structure, sand will be lost, and down-beach the sand volume will increase. When storms destroy or damage a groin, this is the critical time to consider whether it must be rebuilt or if modifications 2–4 below are feasible.

2. Shorten groin

By removing the seaward end of a groin to its *entrapment capacity* sand can begin to move around the end of the structure to restore the down-beach area.

3. Lower height of groin

Removal of the top of a groin can allow sand to move over the structure, and thus build up the down-beach area.

4. Increase porosity of groin

"Porosity" of a groin refers to the number and size of holes between the rocks of a groin. By removing rocks from within the groin, sand can begin to be moved through the groin to the down-beach area.

5. Nourish beach

"Nourishment" refers to the placement of sand on a beach or barrier beach to increase its volume. The feasibility of nourishment should be evaluated in combination with modifications to the groin structure (described in 1–4 above). Sand used for nourishment should be similar in size to that of the natural beach. Sometimes sand of a larger size is necessary for nourishment if all natural sources of sand have been depleted. To determine if sand is "compatible" with the nourishment site, scientific assistance should be sought (see appendix B).

Nourishment sand may be obtained from several different sources and by different methods. Sand may be moved from updrift of a groin to the downdrift beach with an earthmoving machine such as a front-end loader. Sand dredged from navigation channels may be pumped onto the eroded beach with hydraulic machinery. Typically, sand nourishment must be performed periodically if the source of natural sand no longer exists for a given beach area. Beach erosion rates should be determined (as discussed in Chapter 2, Shoreline Change); the sources of sand and the mechanisms of beach nourishment must be investigated, and the frequency and volume of sand necessary to maintain the beach must be identified. Storm frequency and magnitude can greatly affect how much and how often sand nourishment may be required.

Jetty-corrective techniques

Jetties are constructed to maintain a navigation inlet in a fixed position. Often the corrective techniques used for groins are unworkable for jetties because of the need to insure safe navigation. As with groins, the alternatives should be reviewed in a step by step fashion to determine which approach is most feasible and desirable.

1. By-pass sand across inlet

To restore the movement of sand along the beach, sand must

be moved from the updrift side of the inlet to the downdrift as shown in figure 3.3. Sand "by-passing" is a mechanical way of moving sand along the beach. By-passing may be done continuously with a permanent pumping station set up for inlet systems with a large volume of sediment movement along the beach. In Massachusetts, by-passing may be necessary only periodically. Sand is dredged as often as is needed to keep the navigation channel from filling, to maintain the size of the downdrift barrier beach, and to insure that erosion and overwashing of the downdrift barrier beach is not accelerated.

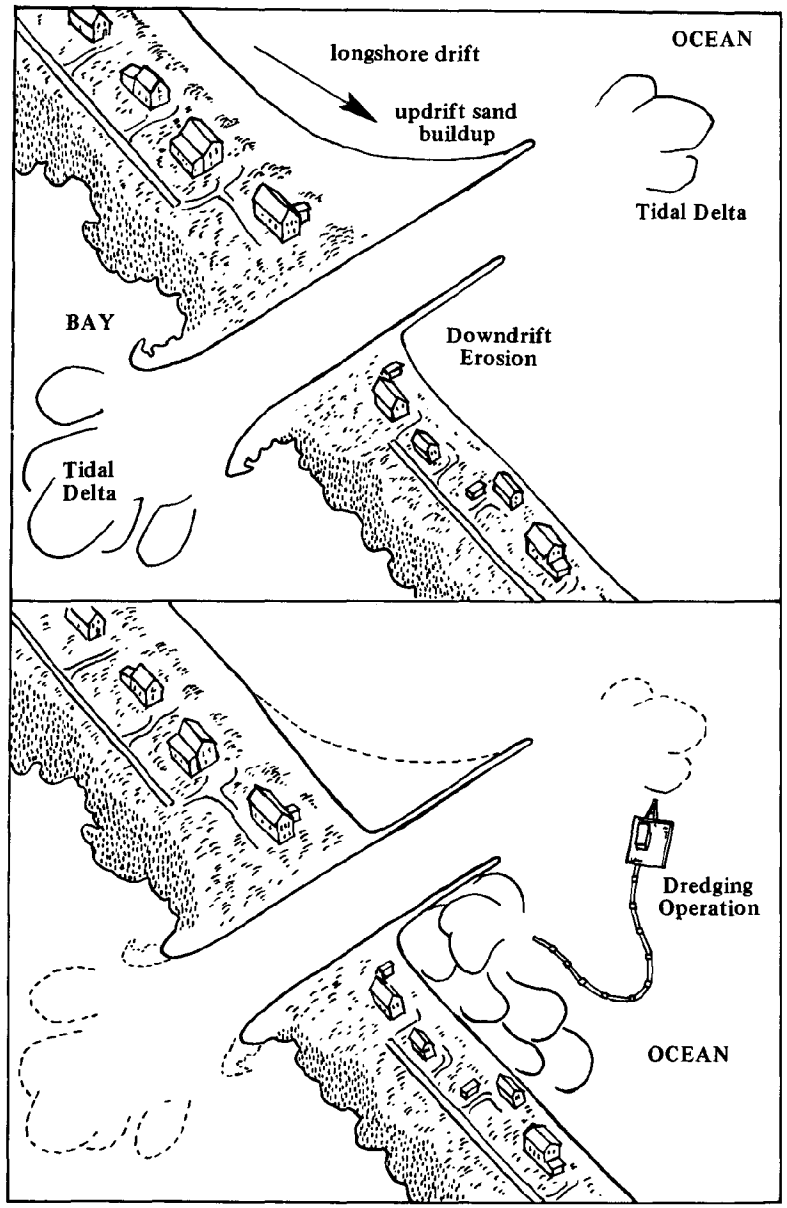


Figure 3.3 Illustration of jetty alternatives

2. *Use dredge material to nourish downdrift beaches*
   (See dredging-corrective techniques).

seawalls and revetments

Seawalls and revetments are structures placed parallel to the orientation of the shoreline. They are usually located on the landward side of the beach in front of coastal dunes, if dunes are present. They may be constructed of steel, rock, timber, or concrete. Seawalls are typically massive structures designed to keep landward areas from flooding and eroding (figure 3.4).

Figure 3.4 Photo of seawall

Revetments are usually aprons of rock or concrete which are placed as a covering over the seaward face of a coastal dune or placed seaward of a seawall to reduce wave scour at the seawall base.

Seawalls and revetments trap the source of dune sand that is required to naturally resupply the beach. Seawalls can also cause erosion in front of them due to the reflection of storm waves. Over the longer term the most serious adverse effect of seawalls and revetments is their interference with the landward shifting of the barrier beach. As discussed in Chapter 2, barrier beaches must be able to move landward to keep up with rising sea level.

If the barriers do not shift landward, storm damage will intensify as the size of the barrier is diminished. Likewise, the costs of maintaining a seawall will accelerate, and adjacent non-seawalled barrier areas will experience severe erosion.

Seawalls and revetments-corrective techniques

It is usually difficult to correct the problems associated with seawalls. As with groins, the critical time to consider corrective approaches for these structures is immediately after they have been damaged or destroyed by a storm. Instead of automatically rebuilding the seawall, an effort should be made to determine the feasibility of one or a combination of the following alternatives.

1. *After the storm, evaluate if seawall must be rebuilt.*

Alternatives to rebuilding the seawall may be non-structural efforts such as dune construction and beach nourishment. These measures may be combined with the relocation or modification of houses or other buildings behind the seawall. If landward structures are substantially damaged, they may qualify for relocation financial assistance from FEMA (see Acquisition, Section 2).

2. *If seawall must be rebuilt, modify seawall design and nourish beach.*

Seawalls must be rebuilt in certain situations. For example, there may be insufficient room to allow artificial dune construction; sources of compatible sediment may not be available; or the expense of any one or a combination of these techniques may be prohibitive. In these situations techniques to modify the seawall should be used including: moving the seawall landward, placing a more gradual face on the seawall, placing a sloped revetment in front of the seawall, and nourishing the beach in front of the seawall.

offshore breakwaters

An offshore breakwater is usually constructed in shallow water seaward of and parallel to the barrier beach. It is a massive structure built to provide a harbor of refuge in the lee of the structure (e.g. the Provincetown Harbor Breakwater) or in an attempt to reduce severe storm damage to beachfront property (e.g. the Five Sisters Breakwater of Winthrop). Breakwaters interrupt longshore sediment transport by changing the direction and energy of waves. Beaches on the downdrift side are eroded because sand is trapped between the breakwater and the shore.

Offshore Breakwaters-corrective techniques

Dredge behind breakwater and nourish eroding beaches

Beach areas adjacent to the offshore breakwater which experience erosion may be nourished periodically with dredged material from areas that build up behind the breakwater (see dredging-corrective techniques).

Dredging

Dredging is the mechanical removal of sediment from intertidal or subtidal areas. It is typically performed to allow safe navigation through inlet channels and shallow bays behind barrier beaches. Dredging seaward of a barrier beach can adversely affect a barrier beach by removing a portion of the offshore bar which is part of the barrier beach sand system. It can also change the coastal processes such as wave direction and height which determine the shape and volume of the landform. Consequently, dredging should be done far enough seaward of a barrier beach and should avoid causing deep holes which change the direction and height of waves. Dredging should not remove portions of tidal flats or subtidal bottom areas behind a barrier beach because the substrate necessary for marsh growth and for the landward shifting of the barrier is eliminated.

Dredging-corrective techniques

1. *Use dredge material to nourish downdrift beaches.*

To maintain the size of downdrift beaches, clean dredged material of similar grain size should be used for nourishment. The tidal deltas on the seaward (ebb) side and bay (flood) side of an inlet are often good sources of compatible beach sediment. Frequently such deltas are dredged because they are shallow sand bodies that interfere with navigation. Scientific assistance should be obtained to aid in the evaluation of proposals for dredging and beach nourishment.

2. *Navigation channels immediately behind barrier beach should be moved.*

When dredging is required to maintain a navigation channel immediately behind a barrier beach, the channel should be relocated slightly landward to keep up with the rate of barrier beach landward shifting. (See Chapter 2, Shoreline Change, to obtain information on shoreline change rate). Dredged material of appropriate grain size that is removed from the channel should be placed on the barrier beach.

Filling and Removal

Filling refers to the artificial placement of material on a barrier beach; removal is the artificial extraction of sediment from a portion of a barrier beach. Removal reduces the volume of the beach or dunes and diminishes their effectiveness as storm buffers. Filling and removal changes the natural contours

and processes that shape a barrier beach. Filling with sediment of compatible composition and grain size is called "nourishment" (see dredging). Filling with incompatible sediment can change the way the barrier beach and dunes respond to coastal forces. This alteration can result in increased erosion, interference with landward movement of the barrier, and disturbance of natural vegetation.

Filling and removal-corrective techniques

It is very difficult to correct damage caused when inappropriate fill has been placed on a barrier beach. Where sediment removal has occurred, restoration can be achieved by replacement with appropriate grain sized sediment and revegetation with beachgrass. A geomorphologist should be consulted to determine the appropriate grain size and volume of sediment to restore the barrier beach area.

Artificial dune building is one effective method of restoring the barrier beach in areas where dunelines have been removed. The design and construction of an artificial dune requires analysis of specific beach and dune characteristics, erosion rates, and vegetation needs. Sand from the beach should not be used to build dunes, because the volume of the protective beach is reduced. Therefore off-site sources of sand, such as sand and gravel pits, must be considered. Artificial dune building is environmentally preferable to structural approaches, such as groins or jetties. However, it is expensive and is usually used only when valuable property and resources are particularly vulnerable to storm damage.

Houses, Roads, and Utilities

Houses, roads, and utilities are types of development existing on some barrier beaches in Massachusetts. Some of these land-uses have greatly altered the physical and biological characteristics of barrier beaches and created flood and erosion hazards. Housing development on barrier beaches has led to other types of alterations such as coastal engineering structures, roads, and utilities. Since the signing of Executive Order No. 181 on barrier beaches in 1980, Massachusetts policy regarding such construction projects on barrier beaches is that state and federal funds "shall not be used to encourage growth and development in hazard-prone barrier beach areas" (see Appendix A – Executive Order for Barrier Beaches). Typical projects which encourage growth and development of barrier beaches are: new water, sewer, and natural gas lines for residential, commercial, or industrial purposes; new septic systems; and new or expanded roads and bridges.

To completely eliminate the adverse affects and hazards caused by development on barrier beaches, all structures would have to be removed. This is not a reasonable alternative in most circumstances. However, if a coastal storm does major damage to structures on a barrier beach, relocation should be seriously investigated before rebuilding is considered.

Financial incentives are available to owners of storm-damaged dwellings for relocation out of coastal flood areas. Two acquisition programs, administered by the Federal Emergency Management Agency (FEMA), are described in the acquisition section.

The following additional steps should be taken to minimize disturbance caused by houses, roads, and utilities to the natural resources of the barrier beach and reduce hazards associated with these alterations.

1. *Acquire barrier beach property.*

Acquisition is one of the most effective ways to manage a barrier beach. Numerous federal, state, local, and private programs are available for barrier beach acquisition (see Acquisition, Section 2).

2. *Prohibit new construction on the barrier beach.*

All new construction should be prohibited on most barrier beaches. Several recent judicial and regulatory decisions have concluded that houses, utilities, and septic systems adversely affect the resources of barrier beaches and pose health and safety problems. Implementation of prohibitions on new construction may be accomplished through local by-laws, (Wetlands, Board of Health, Building Code) and state coastal wetland regulations.

3. *Prohibit construction in the velocity zone or foredune (primary dune) of the barrier beach.*

It may not be feasible to prohibit all new construction on some extensively altered barriers. However, at a minimum construction should be prohibited in the *velocity zone* or on the first large dune landward of the beach. (This dune is sometimes called the foredune or the primary dune).

4. *Move buildings*

As buildings are increasingly threatened by coastal storm damage, they should be moved to a more landward location preferably off the barrier beach. A Coast Guard life-saving station, threatened with destruction by storm overwash, was recently moved from the Nauset barrier beach in Chatham. If it is feasible to move the building off the barrier beach, it should be relocated landward as far as possible. A geomorphologist should be consulted to help determine the setback distance based on the predicted shoreline change rate (see Chapter 2, Shoreline Change).

5. *Elevate or floodproof existing dwellings and develop a storm preparedness plan for developed areas.*

For those areas where moving a threatened dwelling is not feasible due to lack of land or financial considerations, dwellings should be elevated or floodproofed to the maximum extent possible. This should be done after consultation with the local building inspectors (see Storm Preparation-Section 4).

6. *Restore open-space areas with natural landforms and vegetation.*

Most barrier beaches, even developed barriers, have areas of open space. These areas may be prime sites for restoring dune landforms by planting beachgrass or replenishing dune sand. Open space areas closest to the beach should receive priority for restoration because they are the first line of buffer against coastal storms.

7. *Use open pile and temporary walkways over dune areas.*

Foot traffic can kill beachgrass vegetation which stabilizes the dunes. Loss of the stabilizing vegetation can cause loss of dune sand by wind erosion. These impacts can be dramatically reduced by building walkways on piles or by placing temporary walkways over foredunes for beach access (figure 3.5).

Figure 3.5 Photo of dune walkover

Trails and Paths

The restoration of barrier beach areas modified by trails and paths is discussed in the Recreation Section.

Dune Building

Human alterations to barrier dunes can decrease the volume of these landforms, thereby reducing the storm protection provided for landward property and wetlands. The purpose of this subsection is to describe techniques to rebuild altered dunes or create new dunes where they have been completely destroyed.

Natural dunes are formed when wind- blown sand forms a hill with the help of stabilizing vegetation. The essential elements for the formation of a natural dune are:

1. sand
2. wind
3. vegetation

Altered dune areas may be restored by using techniques which help provide natural ingredients for dune building. These are presented as follows with the easiest techniques first.

Vegetation

If beachgrass or other dune plants have been destroyed by human alteration, disease, or other causes, planting may be required. American Beachgrass *(Ammophila breviligulata)* is the best plant to use for this purpose in Massachusetts. Two options are available for obtaining beachgrass: harvesting the plants from adjacent, healthy areas, or purchasing plants from commercial nurseries. Towns and private organizations may wish to develop a local nursery stock.

Where disease in beachgrass occurs, bitter panicum may be planted between the beachgrass to control disease and help build the dune. Proper *foredune* slope may be achieved by decreasing the distance between rows as the dune crest or proposed dune crest is approached from the beach. Planting in staggered rows parallel to the duneline and beach is the most effective method. If large, flat areas exceeding an acre are to be planted, mechanical planters may be an efficient planting method, however, a large well-organized group can easily perform the same task.

Wind

In coastal areas strong winds that blow in off the water pick up sand from the beach and carry it landward to the dune. Dune volume depends in part on the frequency of these strong sea breezes. Sand is deposited on the dunes because the wind velocity is reduced here and vegetation traps the blowing sand. Fences can be used to build dunes because they reduce wind velocity and help trap sand.

In highly exposed areas, sets of sand fence installed parallel to the beach and dune face build a dune more quickly than beachgrass plantings (Knutson, 1977). The most effective technique, however, is to plant beachgrass in conjunction with fence use.

The best fence material to use is snow fence with a 50%

porosity, held in place by posts at 10 to 15 foot intervals. Snow fence is widely available, catches sand better than brush fence, is less expensive than fabric fence, requires less labor to install than fabric or brush fence, and is less subject to vandalism than fabric fence (Woodhouse, 1978).

Sand

The source of sand for natural dune building is the adjacent beach. Where beach volume has been reduced by human alterations (such as coastal engineering structures) another sand source may be required. Sand which is artificially or mechanically brought in to build a dune should be compatible with the sand in adjacent natural dunes (see "nourishment" in the filling and removal subsection). Vegetative plantings should be done in conjunction with this artificial dune construction.

The dimensions of an artificial dune should be similar to adjacent unaltered natural dunes, if the latter are available for comparison. If not, a coastal geomorphologist should be consulted to determine the optimum dune dimensions and locations (see Appendix B).

Where buildings have replaced dunes, buildings should be moved if possible, to provide sufficient room for construction of an artificial dune.

Beach Building

When the volume of a beach is reduced by human alterations, less storm protection is afforded. When this situation exists on a densely developed barrier beach, beach building or beach nourishment may be economically justified. Because beach nourishment is usually very expensive, this technique should be considered only if all other efforts such as acquisition, housing set-backs, etc. have failed (see houses, roads, and utilities subsection). An economic assessment of nourishment should be performed to evaluate the feasibility of this type of protection.

Nourishment sand, such as the dredged material that is taken from inlets, should be used for beach nourishment (see dredging subsection).

Sources of Information

Beach and Dune Nourishment Guidelines, *Shore Protection Manual,* U.S. Army Corps of Engineers, C.E.R.C, 1977.

This manual contains several useful sections concerning beach and dune building. Guidelines for beach nourishment are discussed including a technical review for determining the compatibility of sediment.

Dune Building and Stabilization with Vegetation, W.W. Woodhouse Jr., 1978 C.E.R.C.

This report discusses the use of fences and vegetation for dune creation and gives practical information on fencing and planting techniques.

Planting Guidelines for Dune Creation and Stabilization, P.L. Knutson, 1977 C.E.R.C.

This report provides guidelines for selecting plants, planting methods, storing and maintaining plants, and estimating labor requirements for planting projects.

How to Build and Save Beaches and Dunes, J.A. Jagschitz and R.C. Wakefield, 1971, U.R.I. Marine Pamphlet no. 4.

This leaflet explains how the individual owner can use snow fences and vegetation to build and save dunes.

Landscaping the Seashore Cottage, R.A. Goodno, 1978, Coop. Ext. Service USDA.

This leaflet is for homeowners living on the seashore. It offers suggestions for location and types of landscaping features and dune protective planting.

Section 2 Acquisition

Introduction

Public acquisition of barrier beaches is one of the best techniques for protecting the beach's natural characteristics and eliminating storm damage, and at the same time increasing coastal recreation opportunities. This section describes public and private programs in Massachusetts for the acquisition of barrier beach property.

Federal

The federal government acquires barrier beach property through its land management agencies, the National Park Service and the Fish and Wildlife Service. The National Park Service

owns most of the barrier beaches of the Outer Cape in the Cape Cod National Seashore. On the Massachusetts North Shore, the Fish and Wildlife Service manages the southern three quarters of Plum Island as a wildlife refuge and on Cape Cod, Monomoy Island as a wilderness area. In addition, federal Land and Water Conservation Funds are provided to the state which disburses them to local municipalities for land acquisition.

State

The Department of Environmental Management (DEM), the Commonwealth's principal land management agency, is responsible for acquiring, conserving, and managing most state-owned barrier beach properties.

Through the Statewide Comprehensive Outdoor Recreation Plan (SCORP), DEM defines its annual program of state acquisition and local funding for acquisition. SCORP recently recommended an aggressive program of barrier beach acquisition through the following programs: DEM capital budget outlay, federal Land and Water Conservation Funds, state Self-Help and Urban Self-Help funds, and Federal Emergency Management Agency (FEMA) funds. The 1981 capital outlay proposal requested and received legislative approval of a one million dollar bonding authorization for the acquisition of coastal properties by DEM.

The Barrier Beach Executive Order also directed DEM to acquire or assist towns in acquiring remaining undeveloped barrier beach properties. In response to the Barrier Beach Executive Order which establishes a high priority for barrier beach acquisition, DEM targeted more than 30 sites for acquisition and management and more than 20 properties for coastal towns to consider. DEM technical assistance is available to towns interested in the acquisition of these coastal sites.

Examples of DEM initiatives since the Executive Order was issued include:

1. Merrimack Life Saving Station. A 54-acre surplus property at the northern tip of Plum Island barrier beach was obtained from the Coast Guard.

2. Scituate. Using FEMA 1362 funds (see 1362 Program Section 4), 6 acres of undeveloped barrier beach on Egypt and Peggotty beaches were acquired from ten willing sellers, and leased to the Town of Scituate for passive recreation use by the public. Hull is also a priority area for this type of acquisition.

3. South Cape Beach. The Department received legislative approval for the acquisition of a 131-acre parcel in Mashpee which contains a large barrier beach system. This area is included in the Waquoit Bay ACEC (Area of Critical Environmental Concern).

4. South Beach. Federal Land and Water Conservation Funds were used to acquire this 68-acre site on Martha's Vineyard which includes a barrier beach. The town of Edgartown has assumed responsibility for managing this area.

Previously acquired barrier beach properties, such as Salisbury Beach State Reservation and Horseneck Beach State Reservation, are the subject of new master planning efforts to improve public recreational amenities while restoring and preserving the natural values of the coastal landforms.

The Metropolitan District Commission (MDC) is the other major state land management agency with barrier beach holdings. MDC operates twenty beach areas comprising approximately 1,000 acres on the shoreline from Lynn to Hull; many of these areas are barrier beaches including Revere Beach and Nantasket Beach. While no major properties are currently available for acquisition along Boston Harbor's heavily developed shoreline, new acquisition opportunities may arise after future coastal storm damage.

Local

Community acquisition of barrier beaches can serve a variety of local objectives including prevention of development in hazardous areas, protection of natural buffer areas, enhancement of recreational opportunities, and protection of wildlife habitat. Though highly vulnerable to severe damage, coastal property is typically very expensive and therefore often considered beyond the financial reach of community acquisition. However, through federal and state funding programs, private foundations, local land trusts, and individual donations, communities can reduce the costs of acquiring and managing barrier beach property.

In addition to high cost, loss of tax revenue is sometimes perceived as another drawback to local acquisition. Anticipated tax losses, however, may be offset by increased tourism and attendant commercial benefits which result from enhanced recreational open space. Additionally, land used for open space rather than for development saves tax money in the long run as this use places fewer demands on tax-raised revenues. Finally, future storm damage costs which are shouldered by the general public are avoided in these hazard-prone areas.

Examples of Massachusetts barrier beaches in part or full community ownership include: Wingaersheek Beach, Gloucester; Peggotty Beach, Scituate; Rexhame Beach, Marshfield; Saquish Beach and Long Beach, Plymouth; Sandy Neck, Barnstable; Nauset Beach, Orleans and Chatham; Red River Beach, Harwich; Sea Gull Beach and Grays Beach, Yarmouth; Davis Beach and Chapin Beach, Dennis; First Encounter Beach, Eastham; Ballston Beach and Gull Island (Pamet North Spit), Truro;

Bournes Pond, Falmouth; Esther Island and Muskeget Island, Nantucket; and Norton Point Beach, Dukes County. The Westport Conservation Commission owns 50 acres on the west end of Horseneck Beach.

The Division of Conservation Services in the Executive Office of Environmental Affairs administers three programs which assist Massachusetts municipalities in acquiring and/or developing recreation and conservation areas and facilities:

1. The federal *Land and Water Conservation Fund*. Established by Congress in 1965, this fund provides up to 50% reimbursement to states and their political subdivisions for acquisition and development of public outdoor recreation areas and facilities. Funds are not available for operation or maintenance. One of the requisites for obtaining monies through this fund is consistency with the Statewide Comprehensive Outdoor Recreation Plan (SCORP).
2. The *Massachusetts Self-Help Program.* Established in 1961, this fund provides up to 80% reimbursement for the acquisition of conservation lands to communities with established conservation commissions. Since the intent of this program is to preserve lands and waters in their natural state, its funds may be used only for acquisition of land for conservation or passive recreation purposes.
3. The *Massachusetts Urban Self-Help Program.* Established in 1977, this fund provides up to 80% reimbursement for the acquisition of park or recreation lands. To qualify, a city or town must have a population of at least 35,000 and a park or recreation commission and conservation commission.

To apply for any of these programs, a municipality must submit to the Division of Conservation Services, or have on file, an approved open space/recreation plan that has been developed or updated within the past five years. Each project considered for funding is reviewed for consistency with its conservation/recreation plan and the SCORP. Requirements for planning documents and technical assistance are available from the Division of Conservation Services, 100 Cambridge Street, Boston, MA 02202, (617) 727-1552.

Private

Twenty-two percent of the Massachusetts coastline is protected from future development through ownership by public and private conservation agencies. Private organizations which acquire barrier beach property by purchase or gift can provide permanent stewardship and transfer or re-sale to public resource management agencies. Private agencies also occasionally negotiate acquisitions to avoid the sometimes time-consuming procedures of obtaining public acquisition authority and funding. A gift of land can provide the donor with attractive tax reductions.

The Trustees of Reservations is a privately-administered, charitable corporation in Massachusetts whose purpose is to acquire and preserve places of significant natural and historical interest for public use. Trustees holdings include the 1352-acre Crane's Reservation encompassing Castle Neck, Ipswich; the 810-acre Coatue Wildlife Refuge, Nantucket; the 484-acre Cape Poge Wildlife Refuge and the 200-acre Wasque Reservation, Chappaquiddick; and the Long Point Wildlife Refuge, West Tisbury. Additionally, the Trustees operate the largest conservation restriction (1900 acres) in the Commonwealth on Nashawena Island (Elizabeth Islands); a 175 acre parcel on the eastern end is a barrier beach.

A conservation restriction is a legal means of protecting an area's natural and scenic qualities. It prevents fundamental changes in the present land patterns and limits development while according the owner full title to and exclusive use of the property.

The Nature Conservancy is a national conservation organization which acquires areas of outstanding natural or ecological value through donations or purchase. Some areas are retained and managed by the Conservancy, while others are transferred or sold to other appropriate agencies that are prepared to protect them. Although the Nature Conservancy currently owns no barrier beach properties in Massachusetts, it has purchased an important chain of barrier beaches known as the Virginia Coast Reserve. These thirteen islands, ten of which are owned entirely by the Conservancy, are held and managed in their undeveloped state for research, education, and recreation.

Smaller private groups also play an essential role in preserving barrier beach property in Massachusetts. The Essex County Greenbelt Association, a non-profit conservation organization, owns a 65-acre reservation and has a 60-acre conservation restriction on the Wingaersheek barrier beach. Five miles of Duxbury Beach owned by the Duxbury Beach Reservation are leased to the town of Duxbury on an annual basis. The Nantucket Conservation Foundation owns 323.9 acres in assorted parcels known as the Coatue Wildlife Refuge.

Sources of Information

State

Commonwealth of Massachusetts
Division of Conservation Services
100 Cambridge Street
Boston, MA 02202

Commonwealth of Massachusetts
Department of Environmental Management
100 Cambridge Street
Boston, MA 02202

Private

The Trustees of Reservation
224 Adams Street
Milton, MA 02186 (617) 698-2066

The Nature Conservancy
Eastern Regional Office
294 Washington Street, Room 850
Boston, MA 20108

Barrier Island Newsletter
Published by the National Wildlife Federation
1412 Sixteenth Street, N.W.
Washington, D. C. 20036 (202) 797-6050

Directory of Massachusetts Land Conservation Trusts
Massachusetts Audubon Society
Lincoln, MA 01773

Section 3 Recreation

Introduction

Of the various uses of a barrier beach, recreation is most compatible with conserving natural resources and minimizing hazards. The large numbers of people who are attracted to the natural and scenic qualities of barrier beaches, however, can present problems of user access and impact. The diversity of recreational use–swimming, sunbathing, fishing, boating, camping, hiking, and off-road vehicle travel--may also cause user conflicts and resource alterations. For example, careless recreational use may adversely affect the form and volume of coastal beaches and dunes which are necessary for the protection of landward areas against storm damage and flooding. Wildlife populations dependent upon barrier beach systems for nesting and/or feeding may be disrupted by human visitors. Management policies therefore must balance the recreational needs with other uses and resource values of barrier beaches.

Parking

One of the major management concerns of barrier beach recreational use is to provide parking areas for user access without damaging the physical and biological resources. Since barrier beaches shift landward over time, if at all possible, parking areas and other facilities should be located on adjacent upland areas off the barrier beach (figure 3.7). This will avoid damages to barrier resources and eliminate the need for costly storm damage expenditures.

If a parking lot is already located on the barrier beach, moving the parking lot to a more landward area of the barrier beach would permit the maintenance of a foredune ridge which would reduce future storm damage.

Facilities

The number of people attracted to a particular area is influenced by the availability of beach facilities including bathrooms, changing rooms, showers, picnic areas, food concessions, and educational displays. Motorized shuttle service between parking areas off the barrier beach and access points on the beach is encouraged for public use during the summer season.

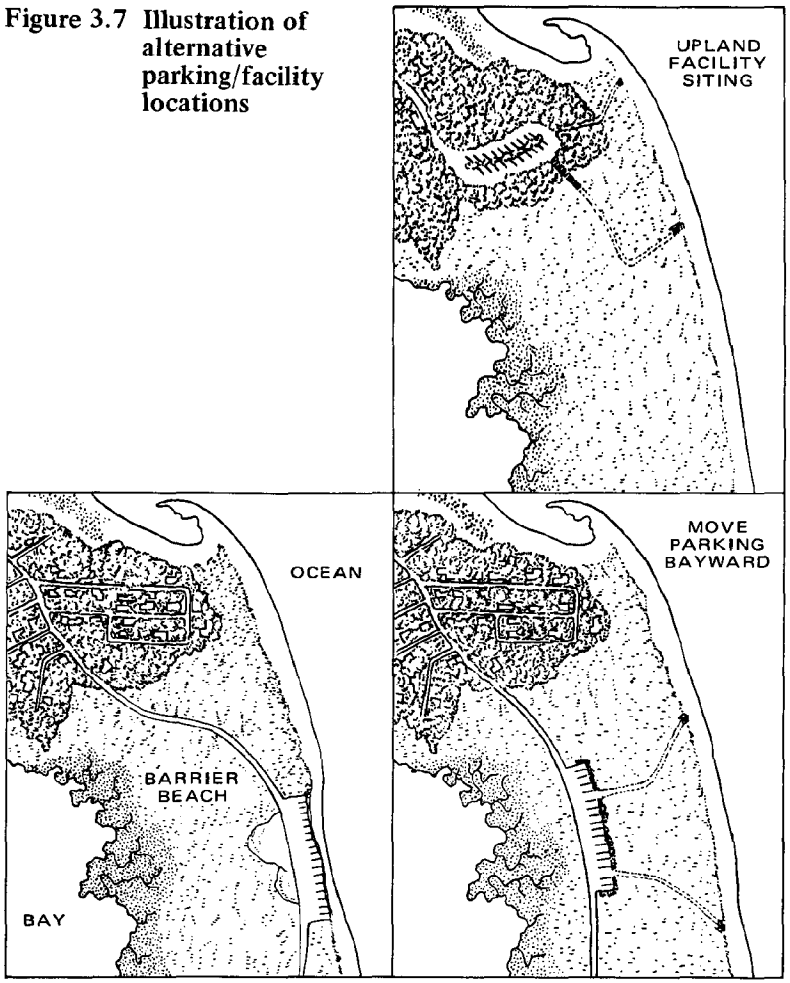
Pedestrian Traffic

When many people use a barrier beach, the vegetation and wildlife may be damaged by excessive foot traffic. Scientific studies performed at Cape Cod National Seashore and elsewhere indicate that heavy pedestrian traffic can cause damage to stabilizing vegetation. Based on these and other studies, the following guidelines and educational suggestions are provided.

Guidelines for pedestrian use on dunes

1. Designate and maintain trails across the dunes.
2. Limit the number of designated access points and trails.
3. Confine pedestrian traffic to designated trails and restrict traffic from the driftline zone and developing dune edge by using fencing and shrub borders. Rugosa rose, bayberry, and beach plum provide effective barriers.
4. For heavy use areas, build walkways over dunes. Re-

Figure 3.7 Illustration of alternative parking/facility locations



movable wooden walkways that can be taken up during the winter storm season may be the most effective and economically desirable. Such walkways help reduce damage to dune vegetation. Elevated wooden platforms from which users may view surrounding terrains help confine people and minimize adverse impact.

Educational Suggestions

1. Provide public educational programs, displays, and signs that:
   a) describe the values of the beach, dune, salt marsh, and tidal flat environments, and
   b) describe damage that pedestrians can cause to beach, dune, salt marsh, and tidal flat environments.
2. Signs should be used to:
   a) mark designated pedestrian trails and closed dune areas, and
   b) mark sensitive areas including:
   - sites of nesting birds, including terns, gulls, herons, and shorebirds, and nesting turtles during nesting season;
   -driftline zone or expanding dune edge; and
   - sites of endangered and threatened plants and animals.

Off-road Vehicles

According to the 1979 report of the President's Council on Environmental Quality, *Off-Road Vehicles on Public Lands,* "the off-road vehicle (ORV) problem is one of the most serious land use issues we face." Prior to World War II, few vehicles were seen on coastal beaches, but since 1960, ORV registrations nationwide have grown nearly 2,000 percent.

Five years of scientific studies on ORV impacts on coastal environments in Cape Cod National Seashore concluded that "there is no 'carrying capacity' for vehicular impact on coastal ecosystems. Even low-level impacts can result in severe environmental degradation. The most naturally unstable areas, such as the intertidal ocean beach, tend to be the least susceptible to damage. (However, this does not imply that there are no negative effects from ORV impact in this zone.) Dunes can be quickly devegetated by vehicular passage, resulting in blowouts and sand migration. Of all the (coastal) ecosystems evaluated, the salt marshes and intertidal sandflats are the least tolerant of ORV impacts."

Based on these studies and others performed on the East Coast, the following restrictions, guidelines, and educational suggestions are provided.

Beach

ORV use should be prohibited on:

1. driftline zones or expanding dune edges,
2. developing dunes, and
3. nesting areas of Least Terns and other shorebirds.

Guidelines for ORV use on beaches

1. Trails for ORV use should be located such that:
   a. drivers follow previously made tracks and
   b. the number of access points to the beach is minimized.
2. Beach trails should be closed during high or exceptionally high tides so that drivers will not damage the seaward edge of

the dunes. (The times of the prohibition will vary due to the width of the beach and the height of the high tide.)

Dunes

ORV use should be prohibited on:

1. driftline zones or expanding dune edges,
2. developing dunes,
3. border zone between dunes and saltmarshes/tidal flats or freshwater wetlands,
4. nesting bird areas (including terns, gulls, herons, and shorebirds) and nesting turtle areas during nesting season, and
5. sites of endangered and threatened plants and animals.

Guidelines for ORV use on dunes

1. Trails should be located such that:
   a. prevailing winds do not create blowouts;
   b. dune routes do not include sharp turns and steep grades;
   c. trails do not cross unstable dunes; and
   d. trails avoid sensitive areas such as nesting areas, blowouts, and sites of endangered and threatened plants and animals.
2. To keep ORV use on the designated trail, rutted trails should be repaired.
3. Traffic should be confined to designated routes by use of fences (especially strong fences made of cable) and dense impenetrable shrubs.
4. Efforts should be made to protect the foredune.
   a. Access points should be minimized.
   b. Ramps should be built and maintained.
   c. Parking and use of blowout areas should be prohibited and controlled by fencing.
5. When an ORV trail creates an unstable dune area such as a blowout, a reduction in foredune height, or a migrating dune, then the trail should be closed and this area restored. (See dune building, Section 1, Human Alteration.)

Educational Suggestions

1. Provide public educational programs, displays, and signs that:
   a. describe the values of beach, dune, salt marsh, and tidal flat environments; and
   b. describe the damage that ORV use can cause to beach, dune, salt marsh, and tidal flat environments.
2. Signs should be used to:
   a. mark designated ORV trails and access points across foredunes.
   b. mark restricted areas, when appropriate, such as shorebird and turtle nesting areas during nesting seasons, and
   c. prohibit ORV use during high or exceptionally high tides.

(The times of the prohibition will vary due to the width of the beach and the height of the high tide.)

Massachusetts became the first state in the nation to limit ORV use on state owned beaches with the issuance of Executive Order 190. This order directs the Department of Environmental Management and the Department of Fisheries, Wildlife, and Recreational Vehicles to develop guidelines for ORV use on its properties (see Appendix A – State Executive Orders and Section 5, Regulation.)

Sources of Information

The Impact of Off-Road Vehicles on Coastal Ecosystems in Cape Cod National Seashore: "An Overview," S.P. Leatherman and P.J. Godfrey, 1979.

This report summarizes the results of extensive research on ORV impacts on coastal ecosystems. It offers recommendations to minimize the adverse impacts of ORVs on coastal ecosystems.

Proc. Barrier Id. Forum and Workshop, "Provincetown, Mass.; May 1980", Mayo, B. and L. Smith, Eds. 1982. Boston, U.S. National Park Service. 207 pp.

This is a proceedings volume which provides a record of the 1980 Barrier Island Forum and Workshop. One section includes a workshop on human impacts which reports the results of studies on ORV and pedestrian impacts.

"Management guidelines for parks on barrier beaches." in *Parks: international journal of national parks, historic sites and other protected areas.*, Godfrey, Paul J., Jan.–Mar. 1978.

This article gives a good explanation of barrier beach processes. It then goes on to list guidelines for management of park systems on barrier beaches and guidelines for the prevention of beach erosion caused by ORV use and pedestrian impacts.

Section 4 Storm Preparation

Introduction

The first step in preparing for a coastal storm is to assess potential landform changes and flooding hazards of the barrier beach (see Chapter 2, Natural Characteristics). This coastal hazard information should be used to develop a storm preparedness program which should also include warning, evacuation, and recovery plans. The warning and evacuation plans for most barrier beach areas should already be available from local civil defense or disaster preparedness officials. Unfortunately, many people do not respond to storm warnings until it is too late. For this reason, a storm awareness educational program is often an essential part of the storm preparedness program

Storm Awareness

Education concerning hazards associated with a storm increases the responsiveness of barrier beach residents to emergency actions during the actual storm event. Studies by Texas A&M University–Sea Grant concluded that making the public aware of the following information helps increase positive response during a storm:

1. Tell what should be done during a storm watch and warning.
2. Describe what type and magnitude storm can affect specific areas.
3. Describe what tidal height is required to block evacuation of specific areas.
4. Tell how long it takes to evacuate specific areas.

When a storm warning news release is given, the following techniques should be employed:

1. Use a respected authority figure to issue the news release (for example, an official from the National Weather Service).
2. Emphasize surrounding associated events such as factory closings, etc.
3. Use a combination of information, testimony, and alarm in the presentation.
4. Use film coverage of destruction wrought by previous storms.
5. Give the location of the storm in distance from specific coastal areas.
6. Use bilingual presentations when appropriate.

Recovery Plan

Immediately after a damaging storm, opportunities exist to reduce future hazards through a combination of acquisition, house relocation or rebuilding to safer standards, and modification or elimination of coastal engineering structures. A recovery plan should consist of an acquisition plan for storm-damaged property and a rebuilding policy for houses and coastal engineering structures.

Acqusition of Storm-Damaged Property

Purchasing storm-damaged property poses a practical alternative to the usual cycle of destruction-reconstruction-destruction again. The Federal Emergency Management Agency (FEMA) offers two programs for acquiring flood-damaged structures.

1. *1362 Program*

This program allows FEMA to purchase property from willing sellers where insured buildings have been damaged more than 50% in a single storm or at least 25% in three storms over a five year period. The local or state government is then given the land to manage for open-space purposes.

One of the first applications of this program in the nation occured for storm-damaged property on Peggotty and Egypt Beaches in Scituate, Massachusetts. After houses on these barrier beaches were destroyed in the 1978 Blizzard, ten properties were acquired by FEMA and given to the state for leasing to the town of Scituate.

2. *Constructive Total Loss (CTL) Program*

For structures covered by a standard flood insurance policy where local regulations do not permit rebuilding, and when the structure is in an extremely hazardous location (such as a coastal high hazard area), FEMA is authorized to pay up to the full face value of the policy in force. This program has not been used yet in coastal Massachusetts but it may be a useful acquisition

tool in some communities. For other forms of purchase, the reader should refer to the Acquisition Section.

Rebuilding policy: houses

When it is not possible to acquire storm-damaged property, and rebuilding is planned, the new house or reconstructed house should be sited and designed to minimize future storm damage. The house should be sited as far landward as possible. A protective dune should be restored if there is sufficient area (see Human Alteration, Section 1). The design of a proposed new house should follow the guidelines recommended in *"Design and Construction Manual for Residential Buildings in Coastal High Hazard Areas"* (FEMA, 1981). This manual is also useful in designing improvements for substantially storm-damaged houses.

Floodproofing

For houses that have not received major structural damage in a storm or for houses out of the V-zone (high velocity zone), floodproofing measures should be investigated. For example, these measures can include floodproofing or elevating the heating, plumbing, and electric systems of the house. A new handbook entitled *"A Coastal Homeowner's Guide to Floodproofing"* is available from the Bookstore, Secretary of State, the Commonwealth of Massachusetts. This guide helps the homeowner evaluate flood risk and outlines key steps to follow in floodproofing an existing dwelling.

Rebuilding policy: coastal engineering structures

After a coastal storm occurs, a difficult decision facing land managers and owners is whether or not to rebuild destroyed coastal engineering structures. When few structures have existed, non-structural measures should be pursued in lieu of rebuilding engineering structures. Acquisition of the storm-damaged property (see Acquisition, Section 2) should also be pursued in conjunction with such non-structural measures. When coastal engineering structures have been used extensively, however, replacement of these structures with a non-structural alternative such as dune or beach building is less feasible. In these cases, coastal engineering structure-corrective techniques should be used to minimize the adverse effects on the resources of a barrier beach (see Human Alteration, Section1).

Sources of Information

A Coastal Homeowner's Guide to Floodproofing, Commonwealth of Massachusetts, (undated).

This guide is designed to help coastal homeowners evaluate flood risk and decide on measures for floodproofing their homes. It should be used for homes located in areas subject to flooding, but not flooding accompanied by waves or tidal action.

Design and Construction Manual for Residential Buildings in Coastal High Hazard Areas, FEMA, 1981.

This manual offers methods of design and construction for homes located in hazardous coastal areas. Because it is not advisable to build new homes in hazardous coastal areas, this manual should be used as a guide to minimize flood, wind, and erosion damage to homes already built in these areas.

Section 5 Regulation

Introduction

This section describes the federal, state and local regulatory programs affecting barrier beaches in Massachusetts. Certain programs require permits for human alterations on barrier beaches or adjacent areas. Other programs described may be used by local governments to further protect the natural values and reduce storm damage associated with barrier beaches.

Federal

The regulation of activities on barrier beaches and in adjacent coastal waters is shared by several federal agencies. The principal regulatory activities are administered by the Army Corps of Engineers, Federal Emergency Management Agency, Environmental Protection Agency, and Office of Coastal Zone Management as described in Table 3.1. In addition, all federal agencies are required to comply with Federal Executive Order 11988, Flood Plain Management, and Executive Order 11980, Protection of Wetlands.

These executive orders direct federal agencies to avoid adverse impacts associated with activities in flood plains or wetlands and avoid the direct or indirect support of development in those areas. Each agency must evaluate the possible effects of

actions, planning programs, and budget requests to ensure that adequate consideration is given to flood hazards, flood plain management, and wetland protection. An agency undertaking or supporting an activity affecting a floodplain or wetland must show that it is the only practicable alternative and must be designed to minimize harm to the floodplain or wetland. A public notice must be circulated explaining why this activity must be located in the floodplain or wetland.

Regional Policy Statement on Flood Plain Management

The Regional Policy Statement on Flood Plain Management was adopted through the New England River Basins Commission (NERBC) by representatives of the governors of New England and New York and the heads of NERBC member federal agencies including the U.S. Department of the Interior and the U.S. Army Corps of Engineers. This policy statement was applied to coastal flooding problems in the NERBC publication *"Dealing with Coastal Hazards: Implementing the Regional Policy Statement of Flood Plain Management."* This report recommends ten ways to reduce the region's vulnerability to coastal storm damage; these are quoted directly from the report as follows:

1. Implement programs to acquire previously developed high hazard properties in lieu of reconstruction.
2. Strengthen the requirement that heavily storm-damaged homes and businesses be rebuilt according to floodproofing standards.
3. Keep development away from high hazard areas that are still undeveloped.
4. Improve construction standards for floodproofing.
5. Take account of natural coastal processes in cleanup, construction, and repair of protective measures.
6. Refocus data collection and analysis activities.
7. Improve coordination in storm and disaster planning and recovery operations, as well as in flood plain management programs.
8. Improve and utilize educational programs to support the programs, plans, and policies of flood plain management programs.
9. Shift the cost of protection to those who create the risk and enjoy the benefits of location in coastal hazard areas.
10. Utilize Executive Order 11988 (Flood Plain Management) and Executive Order 11990 (Wetlands), as well as federal consistency provisions for approved coastal zone management plans, to strengthen disaster and flood plain management planning.

Table 3.1 Federal Regulatory Programs

Agency:
Army Corps of Engineers (ACOE)

Authorizing Legislation:
Rivers and Harbor Act of 1899
Federal Water Pollution Control Act Amendments (1972)

Regulatory Program:
Section 10 Permit Procedure
Section 404 Permit Procedure
(administered jointly with the EPA)

Areas Regulated:
Section 10: Requires a permit for structures in navigable waters.
Section 404: Requires permits for discharge, dredge or fill activities in all waters including fresh water and tidal wetlands.

Agency:
Federal Emergency Management Agency

Authorizing Legislation:
Flood Control Act (1936)
National Flood Insurance (1968, amended 1973)
Flood Disaster Protection Act of 1973
Housing and Community Development Act (1977)

Regulatory Program:
National Flood Insurance Program (NFIP) including Flood Insurance Study and Flood Insurance Rate Maps (FIRM). Participating communities must draft, implement and enforce a flood plain management plan that meets minimum FIA standards, (24 CFR 1909).

NFIP Regular Program: After community enters the program and the FIRM becomes effective, the first insurance protection is government subsidized for existing structures. The second insurance protection and insurance for new structures is obtained at actuarial rates.

Areas Regulated:
Flood plain areas of all communities that wish to participate in the program.

Table 3.1 Federal Regulatory Programs (continued)

Agency:
Office of Coastal Zone Management (CZM)

Authorizing Legislation:
Coastal Zone Management Act (1972)

Regulatory Program:
Administration and approval of state coastal zone management plans.

Areas Regulated:
State CZM plans subject to approval based on national CZM criteria. For approved states, such as Massachusetts, federal actions must be consistent with the state plan.

Sources of Information

Massachusetts Coastal Zone Management Program and Final Environmental Impact Statement, 1978.

This book describes the Massachusetts Coastal Zone Management Plan which was approved by NOAA (National Oceanic and Atmospheric Administration), Washington, D.C.

U.S. Army Corps of Engineers Guide for Applicants, U.S. Army Corps of Engineers, 1977.

This pamphlet is designed to assist applicants who are applying for a Corps of Engineers permit.

New England Wetlands: Plant Identification and Protective Laws, Environmental Protection Agency, 1981.

This manual summarizes New England wetlands laws at the federal and state level. It also contains color photographs and identification information for the lay person on common wetland plants.

Dealing with Coastal Hazards: Implementing the Regional Policy Statement on Flood Plain Management, NERBC, 1980.

This report provides a summary of storm damage and disaster assistance response for the Blizzard of '78. It discusses problems with that response and recommends actions which should be taken to improve New England's ability to deal with future storms.

State

Coastal Zone Management--Federal Consistency

Federal activities such as federally assisted actions, direct federal actions and issuance of licenses and permits must be consistent to the "maximum extent practicable" with the state's approved Coastal Zone Management Program. For barrier beaches, this means that these projects "do not promote growth and development on barrier beaches, do not damage natural barriers (coastal dunes and beaches) and are safe from flood and erosion related damage."

Massachusetts Wetlands Protection Act (G.L. 131, S. 40)

Through the Wetlands Protection Act, local conservation commissions review applications for construction activities in coastal wetlands such as barrier beaches. Coastal Wetlands Regulations provide performance standards that proposed activities must follow to protect the public interests of the particular coastal wetland area. "A Guide to the Coastal Wetlands Regulations" is available to assist in the application of these regulations to specific sites and projects.

Barrier beaches are protected by the Wetland Protection Act, because they provide storm damage prevention and flood control. Additionally, barrier beaches provide protection for shellfish and fisheries resources located behind the landform.

Coastal Wetlands Restriction Act (G.L. 130, S. 105)

The Department of Environmental Management places deed restrictions on barrier beach, beach, dune, salt marsh, shellfish bed, and salt pond property. These restrictions define permitted and prohibited uses that can occur in these coastal wetland areas to protect vital natural resources. The principal difference between the Restriction Program and the Wetlands Protection Act is that the Restriction Program defines what is allowed and not allowed on specific parcels through deed restrictions, whereas the Protection Act regulates activities which may be permitted on a case-by-case basis.

Waterways Act (G.L. 91, 21A, S. 14)

The Division of Waterways within the Department of Environmental Quality Engineering regulates work in navigable waters and Great Ponds and acts as trustee over public lands below mean low water. Licenses and permits are issued by Waterways for structures in these areas.

Waterways Projects

The Division of Waterways is also the state funding agency for dredging and coastal engineering projects. State policy for barrier beaches encourages the use of dredged material for barrier beach nourishment. Non-structural measures, such as

nourishment and dune rebuilding, are encouraged to provide protection from flooding and erosion.

Massachusetts Environmental Policy Act (MEPA) (G.L. 30, SS. 61-62 H)

MEPA is a state office which helps determine the environmental suitability of all state projects. MEPA requires the preparation of an environmental evaluation for projects undertaken, funded or regulated by a state agency. A short Environmental Assessment Form is required for projects which have no significant impact on the environment, whereas an Environmental Impact Report is required for projects deemed by a state agency to have a significant environmental impact. Both types of projects are listed in the bi-weekly *Environmental Monitor* issued by the MEPA Office of the Executive Office of Environmental Affairs. Citizens are encouraged to comment to the MEPA office on projects listed in the *Monitor.*

A-95 Review

This program provides a mechanism for the review of federally funded projects by regional planning agencies, state agencies, and interested citizens. Projects proposed for barrier beaches must be consistent with Executive Order No. 181. Therefore, interested parties should ask the local regional planning agency to notify them about projects proposed for local barrier beach areas so that they may provide comments. See Appendix A for the Executive Order.

Sources of Information

A Guide to Understanding and Administering the Massachusetts Wetlands Protection Act, Colman and Kline, 1977, Massachusetts Audubon Society.

This guide takes the reader through the procedural aspects of the Wetlands Protection Act.

Environmental Handbook for Massachusetts Conservation Commissions, Dawson and Nickerson, 1978, Association of Conservation Commissions.

This is a comprehensive book on laws, regulations, programs, and techniques concerning the protection of Massachusetts Wetlands compiled over a fifteen-year period by the Massachusetts Association of Conservation Commissions (MACC).

A Guide to the Coastal Wetlands Regulations, Department of Environmental Quality Engineering and Coastal Zone Management Office, 1978.

This guide describes the processes and significance of coastal wetlands. Alterations frequently proposed for coastal wetlands are reviewed and their acceptability is discussed.

Q & A: Questions and Answers on the Massachusetts Wetlands Protection Act (G.L. 131, S. 40), Department of Environmental Quality Engineering, 1979.

Local

State regulations and restrictions are applicable to all barrier beaches of the Massachusetts coast. However, each barrier beach is a unique system with specific characteristics and processes, and each municipality values its barrier beaches according to local interests. For these reasons, barrier beach management at the local level is essential.

Towns should develop management plans that maintain the natural protection provided by the beach and dunes of the barrier beach and preserve the productive wetlands behind the barrier. Uses of the barrier beach must accomodate the continual changes that occur in this dynamic environment. On developed barrier beaches, management must include techniques to reduce future storm damage to buildings and the subsequent need for public expenditures for disaster relief.

Ordinances and by-laws for proper barrier beach management are implemented by local officials such as the mayor or board of selectmen. The local conservation commission is appointed by the board of selectmen to preserve and protect the natural resources of the community. It protects local coastal wetlands by using the state Wetlands Protection Act and in some circumstances local wetland by-laws. The conservation commission may assist the planning board, selectmen, and other town boards in developing new local zoning by-laws and ordinances.

Some barrier beaches in Massachusetts are important recreational assets for the communities. In these cases it may be useful to establish a special purpose commission which represents varied land use interests. The Sandy Neck Commission of the town of Barnstable is an example of such a commission.

Examples of types of local laws and regulations are as follows:

Conservation or wetlands zoning

This type of zoning controls development in order to protect the natural characteristics of specific areas.

Cluster zoning

This type of zoning allows certain areas to be more densely developed as long as surrounding areas are preserved. This zoning technique prevents the destruction of all or most natural characteristics of the barrier beach and provides an opportunity for locating development on the least hazardous sites of the landform.

Zoning of building density

This type of regulation controls the numbers of structures allowed per given area, and can consequently reduce storm damage, dune destruction and stress on local water supply.

Coastal high hazard area zoning

This type of zoning establishes areas where no further building is allowed or where building standards are more stringent. Scientific studies should be conducted to define the coastal high hazard areas of a particular barrier beach.

Dune management districts

Since one natural characteristic of the barrier beach is the tendency to shift landward (see Chapter 2), communities must realize that attempts to "stabilize" the barrier beach in a fixed position actually causes narrowed beaches, necessitates expensive erosion control measures, and increases beach erosion rates. However, certain local management strategies, such as an ordinance which designates dune management districts, are compatible with the natural processes of the barrier beach.

A *dune district* encompasses both the dune and the zone behind it into which the dune will move, and precludes building or other development in this area. (Dune district boundaries must be precise, however, so that the ordinance will be defensible in court.) Detailed scientific studies of dune height, width, rate of landward shifting, and length of planning period are required to establish the dune district dimensions.

Shoreline set-back requirements

To protect against storm damage, especially in areas where the protective dune has been removed or altered, ordinances can be adopted that require the placement of buildings a specified distance from the shoreline. The distance may be determined by referring to the history of shoreline change for the area (see Shoreline Changes, Chapter 2), and the width of the dune, if present.

Coastal Hazards Disclosure Ordinance

Local government may pass an ordinance which would require sellers of property to provide a written statement concerning flood and erosion hazards to potential buyers. This type of ordinance is being carried out in a county in California where associations of realtors provide educational material to real estate agents on how to follow the local disclosure ordinances.

Building codes

Development is already prevalent on many barrier beaches of Massachusetts. Ordinances setting forth specific barrier beach building code requirements are therefore necessary. Building codes insure that:

1. builders place floor, pilings, and access roads a minimum height above flood level.
2. buildings do not cause erosion.
3. the soil under the structure will provide for waste disposal and structural support, and
4. the building is able to resist wind, wave, and erosion damage.

Building ordinances do not regulate the siting of structures on barrier beaches. Set-back ordinances can specify site requirements.

Board of Health Ordinance

Erosion associated with coastal high hazard areas of barriers can damage or destroy septic systems causing pollution of adjacent waters and wetlands. Local government can minimize storm damage to septic systems by requiring strict Board of Health design and siting standards. Systems should be prohibited in sites most vulnerable to damage, such as the foredune ridge.

Ordinances related to dune traffic

Pedestrian and ORV traffic are especially prevalent on public lands. Towns can minimize the damage to recreational dune and beach areas by adopting ordinances that limit access trails to beaches, and prohibit or restrict ORV and pedestrian traffic. Revenues received from parking and recreational use permits can be used to pay salaries needed for enforcement of these regulations.

Effective barrier beach management can be achieved by using a town's regulatory power to protect public health, safety, and the environment. The support of an informed public can do much to help a town achieve a thoughtful barrier beach management program (also see Appendix B).

Conservation commissions and town planners can receive assistance in designing and implementing by-laws and ordinances from organizations, which are listed in Appendix B.

Sources of Information

Coastal Dunes: Their Function, Delineation and Management, Gares, Nordstrom and Psuty, 1979.

This book describes the coastal dune district program that was developed for the state of New Jersey. Similar programs can be developed for towns in Massachusetts by incorporating techniques presented in this book. (Also see State – Sources of Information p. 3.17).

Appendix A
Executive Orders

COMMONWEALTH OF MASSACHUSETTS

By His Excellency

EDWARD J. KING
Governor

EXECUTIVE ORDER NO. 181

BARRIER BEACHES

Preamble

A barrier beach is a narrow low-lying strip of land generally consisting of coastal beaches and coastal dunes extending roughly parallel to the trend of the coast. It is separated from the mainland by a narrow body of fresh brackish or saline water or marsh system. It is a fragile buffer that protects landward areas from coastal storm damage and flooding.

The strength of the barrier beach system lies in its dynamic character; its ability to respond to storms by changing to a more stable form. Frequently man induced changes to barrier beaches have decreased the ability of landform to provide storm damage prevention and flood control. Inappropriate development on barrier beaches has resulted in the loss of lives and great economic losses to residents and to local, state and federal governments. The taxpayer, who often cannot gain access to barrier beach areas, must subsidize disaster relief and flood insurance for these high hazard areas.

Since barrier beaches are presently migrating landward in response to rising sea level, future storm damage to development located on the barriers is inevitable.

WHEREAS, the Commonwealth seeks to mitigate future storm damage to its barrier beach areas;

NOW, THEREFORE, I, Edward J. King, Governor of the Commonwealth of Massachusetts, by virtue of the authority vested in me by the Constitution and laws of the Commonwealth, do hereby order and direct all relevant state agencies to adopt the following policies:

1. Barrier beaches shall be given priority status for self-help and other state and federal acquisition programs and this priority status shall be incorporated into the Statewide Outdoor Comprehensive Recreation Plan. The highest priority for disaster assistance funds shall go towards relocating willing sellers from storm damaged barrier beach areas.

2. State funds and federal grants for construction projects shall not be used to encourage growth and development in hazard prone barrier beach areas.

3. For state-owned barrier beach property, management plans shall be prepared which are consistent with state wetland policy and shall be submitted to the Secretary of Environmental Affairs for public review under the provisions of the Massachusetts Environmental Policy Act.

4. At a minimum, no development shall be permitted in the velocity zones or primary dune areas of barrier beaches identified by the Department of Environmental Quality Engineering.

5. Coastal engineering structures shall only be used on barrier beaches to maintain navigation channels at inlets and then only if mechanisms are employed to ensure that downdrift beaches are adequately supplied with sediment.

6. Dredge material of a compatible grain size shall be used for barrier beach nourishment, if economically feasible.

7. The Coastal Zone Management Office shall coordinate state agency management policy for barrier beach areas.

Given at the Executive Chamber in Boston this 8th day of August, in the year of Our Lord one thousand nine hundred and eighty and of the independence of America, two-hundred and five.

Edward J. King
EDWARD J. KING
GOVERNOR
Commonwealth of Massachusetts

Michael Joseph Connolly
Secretary of the Commonwealth

GOD SAVE THE COMMONWEALTH OF MASSACHUSETTS

COMMONWEALTH OF MASSACHUSETTS

By His Excellency
EDWARD J. KING
GOVERNOR

EXECUTIVE ORDER NO. 190

REGULATION OF OFF-ROAD VEHICLE USE ON PUBLIC LANDS CONTAINING COASTAL WETLAND RESOURCES

WHEREAS, while off-road vehicles (ORV's) provide enjoyment and recreation for many, their indiscriminate use threatens our public lands. Uncontrolled, they have severely damaged coastal wetland resources; including dunes, beaches, barrier beaches, salt marshes and tidal flats; disturbed wildlife; and conflicted with other recreational uses.

Scientific studies conducted for over five years at the Cape Cod National Seashore have concluded that even low-level vehicular use can result in severe environmental degradation of coastal ecosystems.

With the substantial increase in the number of ORV's, and the concomitant increase in the use of our public lands for other recreational purposes, major conflicts have arisen and will continue to develop.

NOW, THEREFORE, I, Edward J. King, Governor of the Commonwealth of Massachusetts, by virtue of the authority vested in me by the Constitution and laws of the Commonwealth, do hereby order and direct that all state agencies shall balance the competing uses of the Commonwealth's public lands and minimize the degradation of its public coastal wetland resources:

1. For the purposes of this Executive Order, "Off-road vehicle" (ORV) shall mean any motorized vehicle designed for or capable of cross-country travel on or immediately over land, water, sand, snow, ice, wetland or other natural terrain, except that such term excludes; (a) any registered powerboat, (b) any military, fire, emergency, or law enforcement vehicle, and (c) any vehicle expressly authorized for official state agency use.

2. For the purposes of this Executive Order, "public lands" shall mean: (a) all lands under the custody and control of a state agency, which contain coastal wetland resources; and (b) all lands purchased in whole or in part with state funds, or federal funds administered by the state, which contain coastal wetland resources.

3. All state agencies shall be responsible for establishing scientifically supported guidelines and monitoring procedures for ORV use on public lands. Such guidelines, which are to be submitted to the Secretary of Environmental Affairs for public review under the provisions of the Massachusetts Environmental Policy Act within one year of the effective date of this Executive Order, shall:

(a) balance ORV use with other recreational uses of the public lands;

(b) assure that ORV use is consistent with the state coastal wetland policy, as defined under the state Coastal Wetland Protection Act and regulations;

(c) exclude ORV use in sensitive environmental areas, specifically, dunes, salt marshes, and tidal flats, which provide significant public interests; and

(d) assure that soil erosion and damage to vegetation are minimal; and

(e) assure that harassment of wildlife and significant disruption of wildlife habitats are minimized; and

(f) ORV's will not be excluded from public lands but will be channeled into environmentally acceptable areas.

4. The Secretary of Environmental Affairs, in conjunction with the Commissioners of the Department of Environmental Management and Fisheries, Wildlife and Recreational Vehicles shall review all guidelines and monitoring procedures to ensure compliance with this Executive Order, and shall coordinate and assist when necessary in the development of these guidelines and procedures.

Given at the Executive Chamber in Boston this 24th day of December, in the year of Our Lord one thousand nine hundred and eighty and of the independence of the United States of America two hundred and four.

Edward J. King

EDWARD J. KING
GOVERNOR
Commonwealth of Massachusetts

Secretary of the Commonwealth

GOD SAVE THE COMMONWEALTH OF MASSACHUSETTS

Appendix B
Technical and Educational Assistance

FEDERAL ASSISTANCE

Soil Conservation Service (SCS)
21 Cottage St.
Amherst, MA 01002
(413) 549-0650

Resource Conservation and Development Program (RC & D)
Designed to speed up resource programs as a base for economic development and environmental protection. Soil and water resource information is available.

Flood Plain Management Assistance Program
Assistance in carrying out flood hazard evaluations, inventories of natural and beneficial values. Technical data available in flood plains to aid planning and regulating of flood plains.

Rural Clean Water Program (RCWP)
Financial/technical assistance available to help control water pollution, particularly non-point sources of pollution resulting from poor soil conservation practices. Supplements local initiative.

National Oceanic and Atmospheric Administration (NOAA)
Whitehaven Building
Rockville, MD
(301) 443-8780

Office of Coastal Zone Management

Coastal Zone Management Program
Assistance varies with each state. CZM useful in identifying other state/federal assistance programs, providing legal aid/consultation, technical data, regulatory information and interpretation.

Estuarine Sanctuary Program
Financial assistance for the purpose of acquiring, developing, or operating estuarine areas set aside to serve as National field laboratories.

Coastal Energy Impact Program (CEIP)
Financial assistance available to help local communities cope with burden of development of large energy facilities in their locality through grants and loans.

National Ocean Survey

Coastal Hazards Initiative (CZM Coastal Hazards Assistance Program)
To achieve the Initiative's goal of reducing loss (of life and property) in coastal areas, NOAA has available a variety of technical data and information relevant to risk assessment, evacuation planning, coastal mapping, storm surge modelling. Financial assistance is available through CZM and the Sea Grant Program.

U.S. Army Corps of Engineers (COE)
New England Division
424 Trapelo Road
Waltham, MA 02154
(617) 894-2400

Flood Plain Management Services Program (FPMS)
Technical information, planning assistance, and guidance is available to state, local, and private citizens to help identify flood hazards and implement wise floodplain management plans.

Flood and Erosion Control Programs
Activities undertaken by the ACOE* in coastal areas include:
- –aquatic plant control
- –small beach erosion control projects
- –(small) flood control, coastal protection works for Public shores rehabilitation
- –emergency coastal protective works
- –protection of essential public works
- –snagging and cleaning for flood control
- –(small) navigation projects including stream channelization

*initiated through the District Engineer

Other
Technical data/assistance concerning the mapping and/or restoration and/or management of wetlands is available.

U.S. Fish and Wildlife Service
1 Gateway Ctr.
Newton Corner, MA
(617) 965-5100

Biological Services Program
Scientific data available on fish and wildlife resources and their supporting ecosystems.

Wetlands Inventory
Assistance and information available on identifying, mapping, maintaining, or restoring wetland areas.

Land and Water Resource Development Planning Program (LWRDP)
Consultation, field evaluation and planning assistance available for proposed water and related land projects. Recommendations on conservation measures may also be supplied.

E.P.A.
Regional Office
JFK Federal Building
Boston, MA
(617) 223-7223

Regional Water Quality Planning (Section 208)
Funds available to states and designated regional areas for preparation of water quality plans aimed at control of non-point pollution.

Other Assistance
Technical assistance with implementation of floodplain management plans and wetlands restoration.

F.E.M.A.
Division of Insurance and Mitigation
J.W. McCormack Post Office and Courthouse Building
Rm. 462

Boston, MA 02109
(617) 223-2616

National Flood Insurance Program
Up-to-date floodplain mapping and consultation is available.

F.E.M.A. Services
Floodplain management planning, assistance, and engineering assistance concerning siting of structures in flood hazard areas is available.

STATE AND REGIONAL AGENCY ASSISTANCE

Coastal Zone Management Office
100 Cambridge St.
Boston, MA 02202
(617) 727-9530

Scientific assistance on barrier beach identification, evaluation of characteristics, and all phases of management; planning and legal assistance; educational assistance includes coastal hazard guidebooks, pamphlets, films, and slide shows.

Conservation Services
100 Cambridge St.
Boston, MA 02202
(617) 727-1552

Planning and funding assistance for acquisition of barrier beach properties.

Department of Environmental Quality Engineering
Division of Wetlands Protection
1 Winter St.
Boston, MA
(617) 727-9706

Coastal wetland regualtory assistance through the northeast and southeast regional offices. Coastal Wetland legal assistance through the DEQE legal office.

Department of Environmental Management
100 Cambridge St.
Boston, MA 02202
(617) 727-3151

State Assistance Program
Planning assistance for coastal hazard assessment and storm preparation.

Natural Heritage Program
Information is available on rare plants and animal species and significant plant communities and aquatic habitits. This information can be used for planning, conservation, and environmental impact assessment.

Wetland Restriction Program
Orthophoto maps are available of most state barrier beach areas.

Department of Fisheries, Wildlife, and Recreational Vehicles
100 Cambridge St.
Boston, MA 02202
(617) 727-3151

Assistance on colonial shorebird nesting sites.

ASSISTANCE FROM NON-PROFIT ORGANIZATIONS

Provincetown Center for Coastal Studies
Box 826
Provincetown, MA 02657
(617) 487-3622

Technical Assistance:
Geological and biological assistance on barrier beach identification, assessment of characteristics and all phases of management.

Educational Assistance:
Weekly seminars for the public often covering barrier beach management; pamphlets, reports and audio-visual material on barrier beaches.

Massachusetts Audubon Society
South Great Road
Lincoln, MA 01773
(617) 259-9500

Technical Assistance:
Biological assistance on barrier beach characteristics.

Educational Assistance:
Publications on environmental issues which include barrier beach management.

Conservation Law Foundation
3 Joy Street
Boston, MA 02108
(617) 742-2540

Technical Assistance:
Legal assistance on regulatory aspects of management.

Educational Assistance:
Pamphlets published through the Massachusetts Association of Conservation Commissions on regualtory issues.

Sea Grant
Woods Hole Oceanographic Institution
Woods Hole, MA
(617) 548-1400

Technical Assistance:
Scientific assistance on identification, characteristics and management of coastal areas.

Educational Assistance:
Reports on barrier beach scientific studies.

Resources for Cape Ann
(Massachusetts Audubon Society)
159 Main Street
Gloucester, MA 01930
(617) 283-0598

Technical Assistance:
Biological assistance characteristics and management for the North Shore region.

Educational Assistance:
Pamphlets on barrier beach management techniques for the North Shore region.

Massachusetts Association of Conservation Commissions
Lincoln Filene Center
Tufts University
Medford, MA
(617) 628-5000, x 352

Educational Assistance:
Two meetings each year for Conservation Commissions with sessions on barrier beach management.

Massachusetts Marine Educators
Biology Department
8 Ashburton Place
Boston, MA 02108
(617) 723-4700, x 246

Educational Assistance:
Clearinghouse for barrier beach related curriculum material.

Cape Cod Museum of Natural History
Route 6A
Brewster, MA 02631
(617) 896-3867

Educational Assistance:
Curriculum material on Cape Cod barrier beaches; talks, displays and library include barrier beach information.

Association for the Preservation Of Cape Cod
Orleans, MA 02653
(617) 255-4142

Educational Assistance:
Several pamphlets related to barrier beaches; audio-visual material on barrier beaches.

Massachusetts Wildlife Federation
12 School Street
S. Hamilton, MA 01982

Educational Assistance:
Curriculum material on barrier beaches through the national organization, National Wildlife Federation.

Appendix C
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Appendix D
Glossary

A-Zone: flood zone subject to still water flooding during a storm with a 100 year recurrence interval.

barrier beach: a narrow low-lying strip of land consisting of beach and dunes extending parallel to the trend of the coast and separated from the mainland by a fresh, brackish or salt water body or marsh.

barrier island: a barrier beach that is unconnected to the mainland.

barrier spit: a barrier beach that is connected at one end to upland and unconnected at the other end.

bay barrier: a barrier beach that is connected at both ends to upland.

beach: unconsolidated sediment subject to wave, tidal and coastal storm action which forms the gently sloping shore of a body of salt water and extends from the mean low waterline (including tidal flats) landward to the duneline, coastal bankline or the seaward edge of coastal engineering structures.

bedrock: a general term for the rock, usually solid, that underlies soil or other unconsolidated surficial sediment.

boulder: a detached rock with a diameter of 256 mm (10 in.) or greater.

breakwater: a linear mound-like coastal engineering structure constructed offshore parallel to the shoreline; designed to protect landward property, a harbor or anchorage from storm waves.

coastal bank: the seaward face or side of an elevated landform, other than a coastal dune, which lies on the landward side of a coastal beach, land subject to tidal action or other wetland. Some coastal banks are unconsolidated and erode to supply sediment to beaches, dunes and barrier beaches.

conservation restriction: a legal agreement, either voluntary or involuntary, designed to restrict use of privately owned land for conservation purposes.

downdrift: in the direction of the predominant movement of sediment along the shore.

dredging: the removal of sediment or excavation of tidal or subtidal bottom to provide sufficient depths for navigation or anchorage.

dune: any natural hill, mound, or ridge of sediment landward of a coastal beach deposited by the wind or storm overwash; sediment deposited by artificial means and serving the purpose of storm damage prevention and flood control.

entrapment capacity: when the updrift side of a groin or jetty is filled completely with beach sediment.

foredune: the first dune or dune ridge landward of the beach.

gravel: rounded rock particles with diameters from 2 to 75 mm (1/6 to 3 in.)

groin: a narrow elongate coastal engineering structure constructed on the beach perpendicular to the trend of the beach; its intended purpose is to trap longshore drift to build up a section of beach.

hurricane: an intense tropical cyclone with winds which move counterclockwise around a low pressure system; maximum winds exceed 75 mph.

jetty: a narrow elongate coastal engineering structure constructed perpendicular to the shoreline at inlets; designed to prevent longshore drift from filling the inlet and to provide protection for navigation.

mean high water (mhw): the average height of all of the high waters recorded at a given place over a 19 year period.

mean low water (mlw): the average height of all of the low waters recorded at a given place over a 19 year period.

mean sea level (msl): the average height of the surface of the sea at a given place for all stages of the tide over a 19 year period.

northeaster: a large asymmetrical low pressure system that produces counterclockwise winds from 30 to 70 mph which strike northeast facing coastal areas.

nourishment: the placement of sediment on a beach or dunes by mechanical means.

overwash: the uprush and overtopping of a coastal dune by storm waters. Sediment is usually carried with the overwashing water and deposited as a washover fan on the landward side of the dune or barrier.

revetment: an apron-like sloped coastal engineering structure constructed on a dune face or fronting a seawall; designed to dissipate the force of storm waves and prevent undermining of a seawall.

seawall: a vertical wall-like coastal engineering structure constructed parallel to the beach or duneline and usually located at the back of the beach or the seaward edge of the dune.

sediment: solid fragmental material that originates from weathering of rocks and is transported or deposited by air, water, or ice. Essentially all unconsolidated materials.

storm ridge: a low ridge of coarse gravel, cobbles and/or boulders piled up by storm waves; located at the inner margin of the beach and not reached by average waves or spring tides.

tombolo: a barrier beach that connects an island to the mainland or to another island.

updrift: the direction opposite that of the predominant movement of sediment along the shore.

upland: a general term for high land or ground that is elevated above the floodplain.

velocity zone (V-zone): flood zone subject to velocity water flooding during a storm with a 100 year recurrence interval.