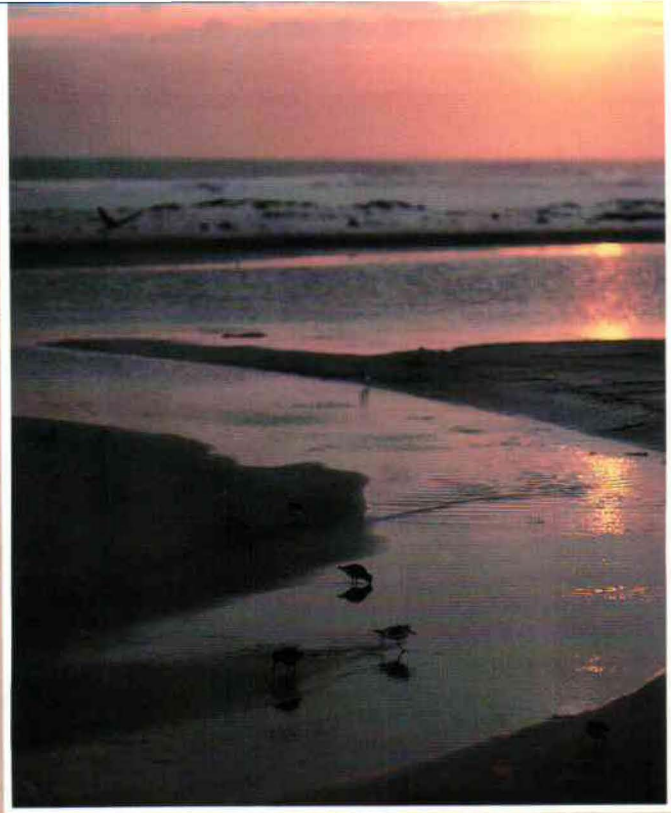

Restless Ribbons of Sand

Atlantic & Gulf Coastal

Barriers

Cover photos © C. C. LOCKWOOD

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Restless Ribbons of Sand

Atlantic & Gulf Coastal

Barriers

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INTRODUCTION

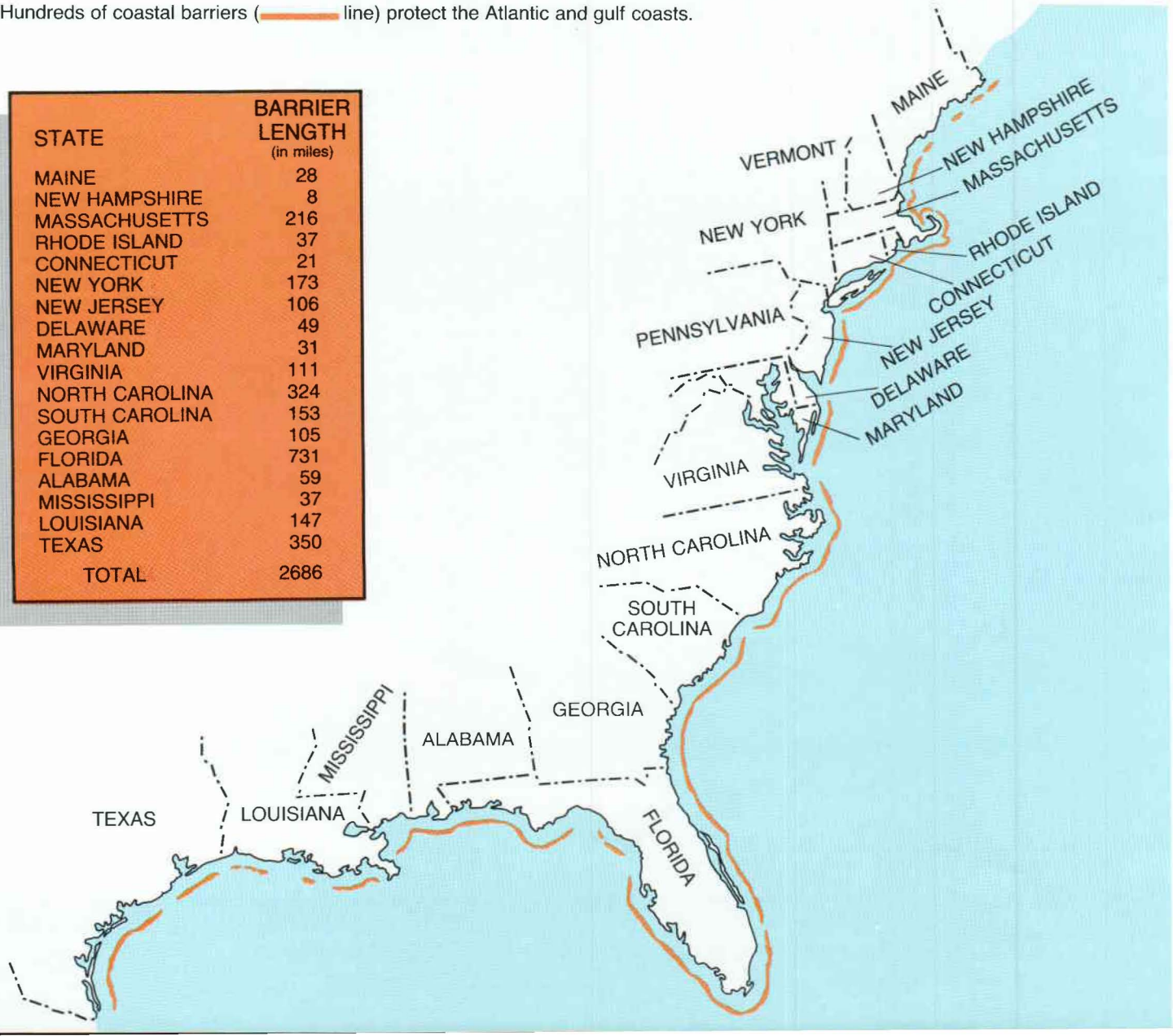
From the rocky headlands of Maine to the arid salt flats of south Texas, coastal barriers form a protective fringe along 2,700 miles of our nation's shoreline.

Although these barriers of sand, shell, and gravel exist on all coastlines of the United States, they are most well developed along the Atlantic and gulf coasts. These barriers are the fragile front lines of defense against wind and tidal energies and especially the ravages of frequent winter storms and occasional hurricanes. As coastal barriers endlessly shift into a variety of shapes and sizes, they absorb ocean energies, buffering the mainland and landward aquatic habitats from the normal scour of waves and currents and the powerful destructive force of hurricanes or northeasters. This brochure discusses the barrier systems of our Atlantic and Gulf of Mexico coasts.

Barriers are locations for lighthouses, fishing communities, Coast Guard stations, ports, and even industrial pipelines; and they are the seaward margins for valuable marshes that form in the sheltered environments along their landward edges. Coastal barriers also serve many aesthetic purposes. The stark contrasts between the sky, the sea, and the land and open spaces of marsh, beach, and water have long inspired poets, writers, and artists to express the pleasures, yearnings, and the almost religious awe that many people experience in visiting or living near coastal barriers. Coastal barriers permit a quiet walk, birdwatching, sunbathing, swimming, boating, picnicking, picture taking, and many

Hundreds of coastal barriers (▬ line) protect the Atlantic and gulf coasts.

STATE	BARRIER LENGTH (in miles)
MAINE	28
NEW HAMPSHIRE	8
MASSACHUSETTS	216
RHODE ISLAND	37
CONNECTICUT	21
NEW YORK	173
NEW JERSEY	106
DELAWARE	49
MARYLAND	31
VIRGINIA	111
NORTH CAROLINA	324
SOUTH CAROLINA	153
GEORGIA	105
FLORIDA	731
ALABAMA	59
MISSISSIPPI	37
LOUISIANA	147
TEXAS	350
TOTAL	2686



other nonconsumptive recreational activities. All nine Atlantic and gulf coastal units of the National Park System contain coastal barriers.

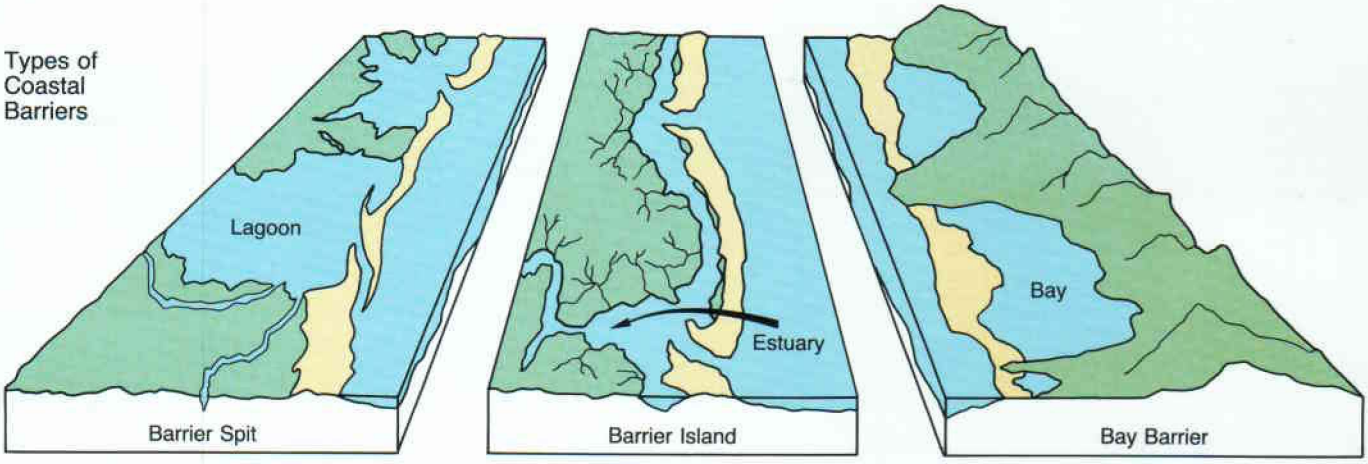
Coastal barriers probably harbor a greater variety of bird species than any other ecosystem in the continental United States. Yet this diversity occurs all within an extremely small area in the narrow zone of contact between the land and sea. It seems curious that the edges between major habitats, the land-sea boundary for instance, are preferred by many birds and other animals as well as by people. Barriers provide valuable habitat for endangered species, mammals, waterfowl, fish, and shellfish. About 50 Fish and Wildlife Service National Wildlife Refuges contain coastal barriers.

Perhaps most of us think of coastal barriers as islands with pristine and extensive sandy beaches, such as those along Cape Cod, Massachusetts, the Outer Banks of North Carolina, or South Padre Island in Texas. The scientist, however, defines coastal barriers as depositional features that consist of sedimentary materials, subject to winds, waves, and tides, and that protect landward aquatic habitats such as adjacent marshes, estuaries, inlets, and nearshore waters. In addition to islands, coastal barriers can be spits and bay barriers.

Eighteen states along the Atlantic and Gulf of Mexico coasts are fronted by nearly 400 coastal barriers. They range from small, isolated shoals of sand, scarcely above the level of the sea, to chains of islands, some more than a mile wide, that stretch for hundreds of miles and are covered with sculptured dunes.

Yet, a casual stroll along the beaches of almost any of our coastal barriers reveals an alarming fact. Our coastal barriers are not faring very well. Most of their beaches are eroding and some have disappeared entirely. We are left with the uneasy feeling that our frail barriers are no longer able to provide the same protective buffer that they offered only 50 years ago. To learn what is happening to these treasures of sand and what can be done to protect them, we must look at how coastal barriers have formed and why their sands are constantly shifting.

Petit Bois Island, a coastal barrier along Mississippi's gulf coast.
© C. C. LOCKWOOD



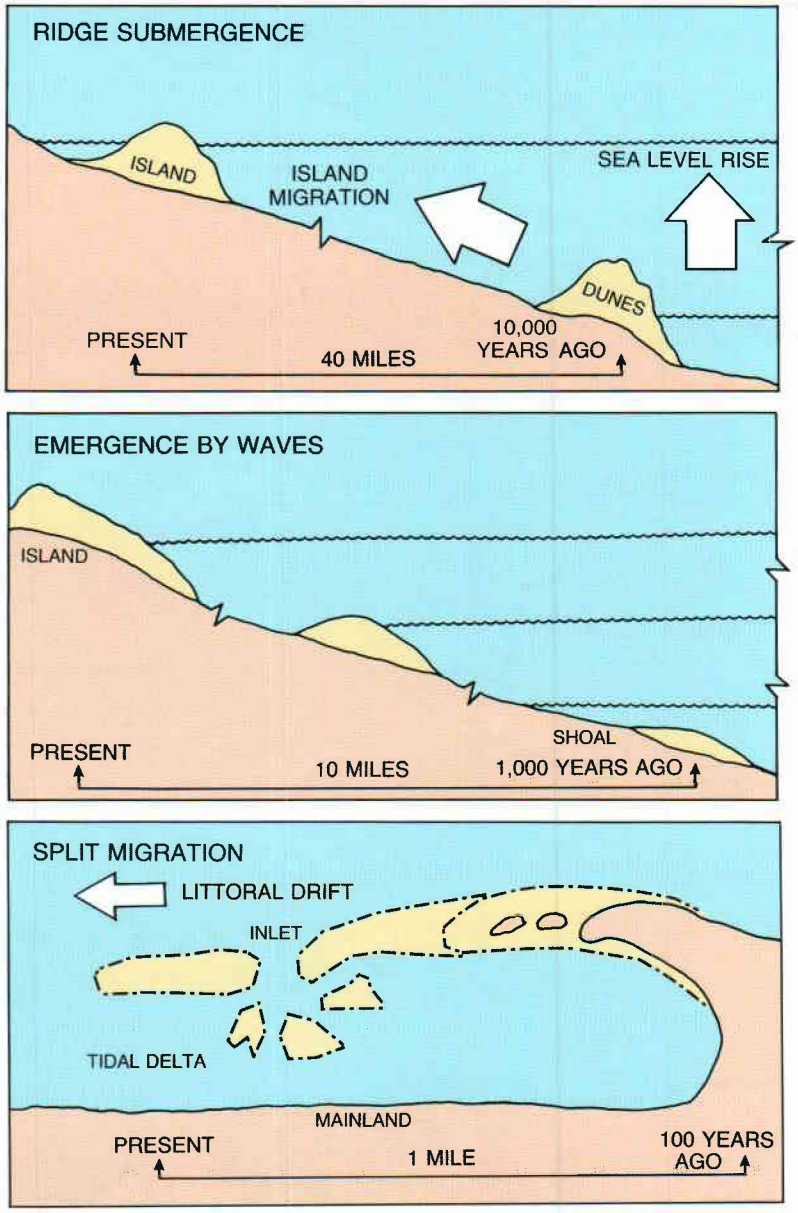
RIBBONS OF SAND: *the formation*

Each coastal barrier is a unique ribbon of sandy sediments. No two barriers are alike and, because of this, their formation has been a subject of controversy for well over a century.

Most of the theories of barrier formation are tied to the changes in sea level caused by the freezing and thawing of great ice sheets during the ice ages. Geologists believe that the latest rise in sea level began about 18,000 years ago as glacial icecaps began melting in Greenland and Antarctica. As the level of the sea rose an amazing 400 feet, the coastlines retreated. Ridges of beach dunes, originally formed by wind-blown sands, were breached by storm waves from rising waters, and the lowlands between these ridges were flooded. These ridges became barrier islands. About 5,000 years ago, after forcing barriers to retreat inland by 40 miles off the Carolinas and perhaps 80 miles

The historical path of migration of coastal barriers across the continental shelf is reflected in the present-day shoals at Cape Lookout, North Carolina.

A. C. HINE



Coastal barrier formation.

An arc shape is typical of many coastal barriers formed from reworked delta deposits.
H. H. ROBERTS

off parts of the Gulf of Mexico coast, sea level rise slowed to about one foot per century. Then, over the next few thousand years, the islands migrated slowly to their present positions.

Another theory maintains that offshore shoals were built upward by waves, eventually emerging above the ocean surface as barrier islands. This probably explains the origin of some small islands along the gulf coast, such as Anclote Key on the west coast of Florida, but cannot explain the origin of long, continuous barrier chains.

Many of the barriers in the northeastern United States, called spits, are attached to the mainland at one end. They form as sediments from the mainland are transported by currents across open water or across the mouth of the bay. Sandy Hook, New Jersey, and the Province Lands of Cape Cod are both spits, curved at their ends by wave action. Spits often become barrier islands after storms separate them from the mainland by forming inlets.

Many coastal barriers in the Gulf of Mexico are remnants of former deltas that were built by old river courses such as those of the Mississippi River. Waves and currents redistributed the sand deposits of these abandoned delta lobes, transforming the eroding headlands into beaches. As the marshy deposits of the abandoned deltas rapidly sank and as sea level continued to rise, the sands became separated from the mainland to form barrier island chains; then, in some cases, the islands themselves subsided and became shoals. The Chandeleur Islands, east of the Mississippi River delta, formed in this way about 3,000 years ago, but in another 300 years will be mere submarine sand bars.

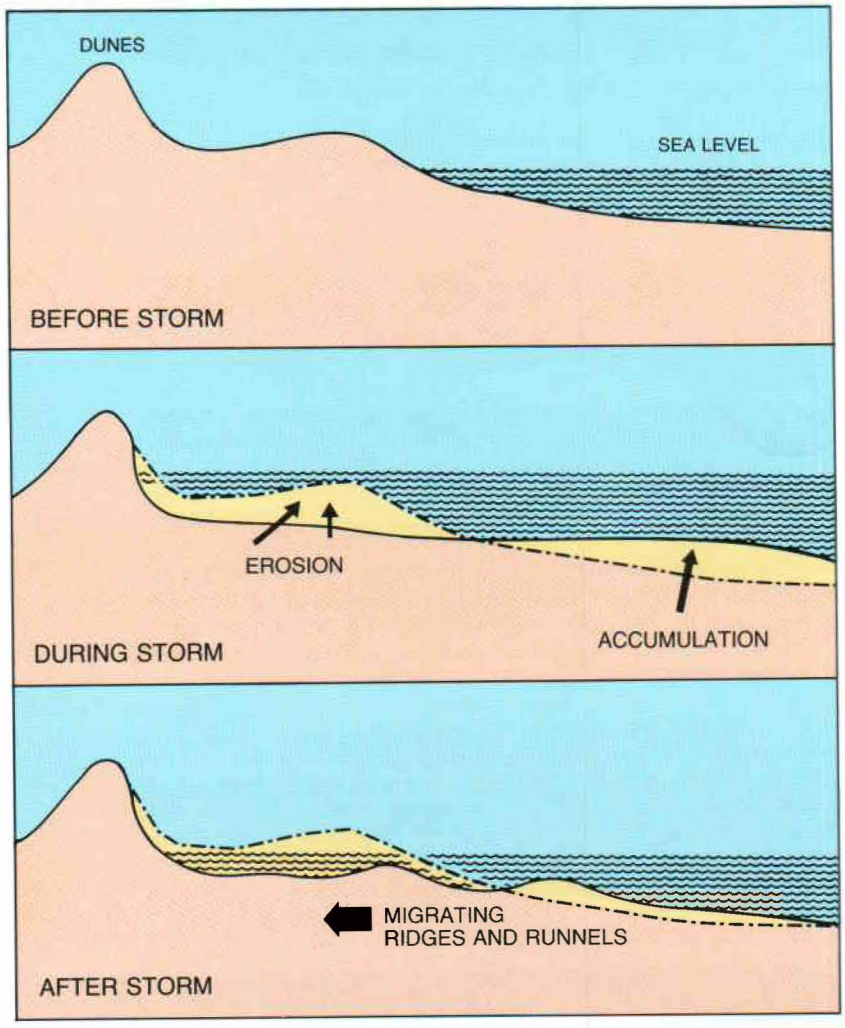
THE "SAND-SHARING" SYSTEM

Barrier islands have not always been where we see them today. In fact, these islands are moving and migration is essential for their survival. As sea level continues to rise, even though more slowly than in the past,

the islands must move inland and up the gentle slope of the coastal plain if they are to remain above sea level. For every one-foot rise in sea level, coastal barriers move 100 to 1,000 feet inland. This migration requires that coastal barriers maintain their mass of sediment intact; to do this they must participate in a sand-sharing system with the continental shelf and with each other.

Offshore to Onshore

Storm waves have always clawed at the beaches of coastal barriers, stripping away precious sand and changing the beach profile.



Storm erosion and natural beach repair.

Following a storm, however, beaches sometimes look surprisingly wide and healthy. This is because the sand removed from the upper beach and dunes is carried to the lower beach and even beyond to the continental shelf. Much of the sand that is removed is simply stored temporarily offshore in storm bars. In a few weeks, fair-weather waves return most of the sand that was borrowed from the beach and gentle sea breezes rebuild the dunes.

Sands are returned to the beach by a system of submerged ridges (storm bars) and their associated troughs, called runnels. As the ridge and runnel system migrates landward, it carries with it most of the sands lost during the storm. Finally, moving ashore, the sands are "welded" back to the beach face from which they were derived. This system of sand sharing maintains a natural balance referred to as dynamic equilibrium. That is, a change in one factor, such as wave energy, leads to adjustment in other factors, such as shape of the beach and location of its sands.

Despite the widespread occurrence of dunes on coastal barriers and their role as primary defense against storm surge, they are by no means impenetrable. Large waves from especially severe storms can push sand through narrow gaps in the dunes or across entire islands. Low areas in the dune ridges serve as passageways for flood waters. As the surge of water flowing through an overwash channel loses its strength, its sediment load is dropped. The result is a fan of fresh sediment called an overwash deposit that is laid down between or behind the dunes or even as far back as the lagoonal marshes. Overwash channels often represent the most likely sites of penetration by ocean waves in the next storm. Coastal barriers differ greatly in elevation, width, and orientation relative to the dominant direction of storm waves and consequently in the degree to which overwash occurs.

Over hundreds of years, coastal barriers are visibly reshaped by these overwash processes. But even

This overwash fan was recently deposited on top of the living saltmarsh.
S. P. LEATHERMAN

Sediment is transported along this barrier beach as waves of sand.
A. C. HINE

This flood-tidal delta was formed by sands diverted from the barrier-to-barrier sand-sharing system and trapped behind the inlet.
A. C. HINE

more importantly, the overwash processes aid the barriers in changing position by allowing them to roll over themselves, continuously sharing sand from the seaward side with the landward side. Although the great quantities of sand deposited as overwash fans will eventually bury the marsh, the landward displacement of the barrier continually recreates the same types of habitats. Oyster shells and tree stumps, both remnants of what once lived on the back side of the barrier but today are found on ocean-facing beaches, provide proof of island migration.

Overwash processes also provide fresh sand for dune development. The combination of sediments from overwash fan deposition and dune formation helps coastal barriers maintain their elevation during migration. Sometimes barriers move landward primarily by dune migration: sea breezes carry sand from the beach to the dunes to the rear of the island, gradually forcing entire dune ridges to shift.

Not all barriers participate in offshore to onshore sand-sharing. Some, such as Fire Island, New York, appear to be drowning in place by eroding on the landward as well as seaward sides. Perhaps such barriers must be reduced in width through erosion before overwash can occur.

Barrier to Barrier

Just as sands can be washed across coastal barriers, they can also be transported along their beaches. Waves that approach the beach at an angle not only suspend sand in the surf zone but also induce longshore currents. As a result, the beaches become virtual flowing "rivers" of sand. Even though the direction of this longshore sediment transport, called littoral drift, may reverse with daily, weekly, or monthly changes in wave direction, the net rates of littoral drift, can reach an incredible one million cubic yards per year along the most dynamic barriers such as Cape Cod and Cape Hatteras.

Just as sands can be transported for many miles along barrier beaches, they can also be transported from one coastal barrier to another. What one island loses, another gains. Chains of coastal barriers operate as a system, receiving sediment at their updrift ends and losing sediment at their downdrift ends. The stubby drumstick-shaped barriers along the coast of South Carolina and Georgia reflect the long-term operation of the barrier to barrier sand-sharing system. Bulbous updrift ends of these islands, which receive sand from an adjacent barrier, give way to thinner central sections and finally to downdrift ends that can be elongated like spits.

Tidal inlets that separate the individual islands of a barrier are conduits for transporting sand into the shallow bays and lagoons behind the islands. These inlets interrupt the littoral drift. Although tidal currents move back and forth through the inlets each day, the sands that are transported into the inlets from the beaches of adjacent coastal barriers are sometimes permanently trapped: the quiet waters of the bays allow the suspended sediments to settle rapidly.

The accumulation of sands behind an inlet creates a flood-tidal delta, complete with meandering channels and lobes of rippled sands only a few feet below the water's surface. The rate at which a flood-tidal delta grows is a measure of the amount of sediment trapped and removed from the littoral drift system. The greater the trapping efficiency, the more rapidly the delta grows. Growing at first only underwater, tidal deltas can gradually achieve elevations high enough for marsh grasses to grow. A tidal delta becomes an especially effective platform for marsh growth once an inlet becomes choked with its own sediments and seals the break between adjacent barriers.

Most inlets, unless modified by people, are inherently unstable. Many form almost overnight: some when impounded storm waters, seeking a direct route to the sea immediately after a hurricane, break through from the bay side of a barrier; others when storm waters scour through an overwash channel. The instability of a quickly formed inlet leads to migration, and as an inlet migrates, so do the sands of its flood-tidal delta. This in turn leads to lateral growth or widening of the barrier. Over several centuries, inlets and their associated sand deposits often migrate 5 to 10 miles. The land created by lateral movement of barriers can be easily located on old nautical charts and topographic sheets by the telltale bulges of luxuriant marsh that extend into the bay.

On coastal barriers subject to high tidal ranges but low rates of littoral drift, and where river flows are large, heavy, and sediment-laden, sediments can also accumulate seaward of the inlets. Under the influence of strong tidal currents, some of the sands carried through the inlets during rising tide are returned during falling tide and deposited offshore in a series of shoals called an ebb-tidal delta. The dynamic equilibrium established by tidal delta shoals allows sand to bypass an inlet, moving underwater, perhaps without notice, from one side of the inlet to the other. An ebb-tidal delta thus functions as a remarkable natural bypass mechanism, thereby preserving from one barrier to another the system of sand sharing.

Unfortunately, overwash deposition and inlet migration on developed barriers are usually associated with loss of property and sometimes personal danger, so people try to prevent these processes from occurring. Yet, ironically, without these sand-sharing processes an immobilized barrier is doomed to become a submerged ribbon of sand where no one can live.

RIBBONS OF SAND: *structure and ecology*

Because of the close interrelations among coastal barriers, adjacent water bodies and the mainland shore, coastal barriers are usually considered in a context that includes five major coastal ecosystems.

These are (1) the coastal marine ecosystem, which includes nearshore ocean and the beach up to the toe of the first dune; (2) the maritime ecosystem, which includes the dune fields, shrub zone, and maritime forest; (3) the estuarine ecosystem, containing saltmarsh or mangroves, sand and mud flats, seagrass beds, oyster rocks, and the open waters of a sound, bay, or lagoon; (4) the freshwater ecosystem, which contains river, lake, or swamp waters and associated forest and marshland; and (5) the upland ecosystem of the mainland adjacent to coastal barriers. These ecosystems are usually considered together because without the coastal barrier to intercept the force of the sea each of these systems would differ greatly.

Coastal Marine Ecosystem: The Ocean Beach

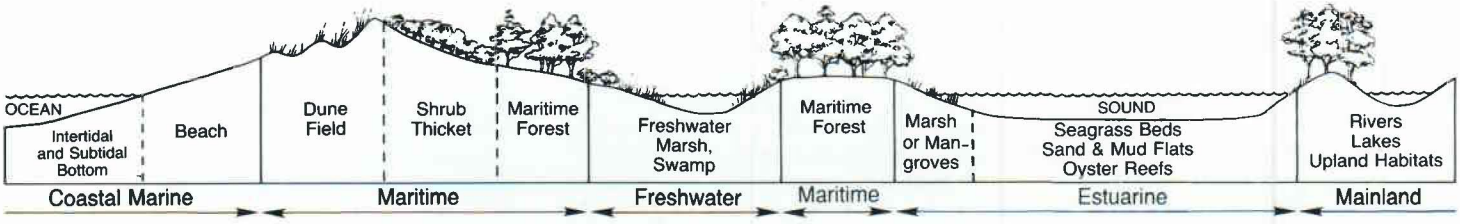
A description of the structure and ecology of coastal barriers begins with the ocean beach because it is the sea that molds the shape of the barrier and simultaneously produces the distinctive vegetational zonation of habitats across the barrier. The mobility of the bottom sediments requires special adaptations among both plants and animals of the beach. No large plants have adapted to life on the subtidal or intertidal portion of sand beaches. Yet this habitat is an extremely productive one for marine invertebrates that burrow into the bottom because the excellent water circulation in the surf brings in large quantities of marine phytoplankton. These microscopic plants support extremely large and productive populations of burrowing marine invertebrates, notably surf clams and sand worms in the northeast, mole crabs from Cape Cod south, and coquina clams from Virginia to Texas. Other marine invertebrates living on barrier beaches are beach hoppers, often around algal debris; ghost crabs, emerging from or diving into burrows; and microscopic flatworms, so small, agile, and highly adapted that they can live in the waters found between sand grains.

Female loggerhead turtles must climb out of the ocean and laboriously make their way up to the dunes to dig a nest and lay their eggs.
P. E. HOSIER

The ghost crab is a common sight on many coastal barrier beaches.
P. E. HOSIER

These marine invertebrates on the barrier beach are so abundant that they directly and indirectly feed valuable surf fishes and shorebirds. Striped bass and bluefish in the north and drum, flounder, and pompano in the south are typical quarry for barrier beach surf fishermen. Sandpipers and numerous deeper-probing shorebirds, especially common during spring and autumn migrations, feed directly on the invertebrates living in the barrier beach.

Fish-eating birds are also characteristic of this environment:



A cross-section of a well developed barrier island and nearby mainland.

The arid climate at Laguna Madre, Texas, is particularly harsh, even for dune vegetation.
© C. C. LOCKWOOD

gulls, terns, cormorants, ospreys, loons, and pelicans. Terns, gulls, skimmers, and cormorants often nest in large colonies on coastal barriers. Few people can forget the image of the elegant skimmer tracing the swash line of the morning and evening beach with its lower jaw extended to skim off animals near the water's surface. The small birds of intertidal barrier beaches are a major food of the peregrine falcon, an endangered species which both excites and awes birdwatchers by its swift aerial dive to attack and capture its prey.

The ocean beach is a valuable nesting site for sea turtles. These magnificent creatures emerge on the high tides of early summer, after unknown odysseys at sea, to climb the beaches of barriers from North Carolina to Texas to lay eggs near the high-tide line. Weeks later the baby turtles that have survived egg predators, like raccoons, hatch and begin their slow march to the sea through a gauntlet of hungry seabirds awaiting their emergence from the nest.

Maritime Ecosystem: Dunes, Shrubs, & Forest

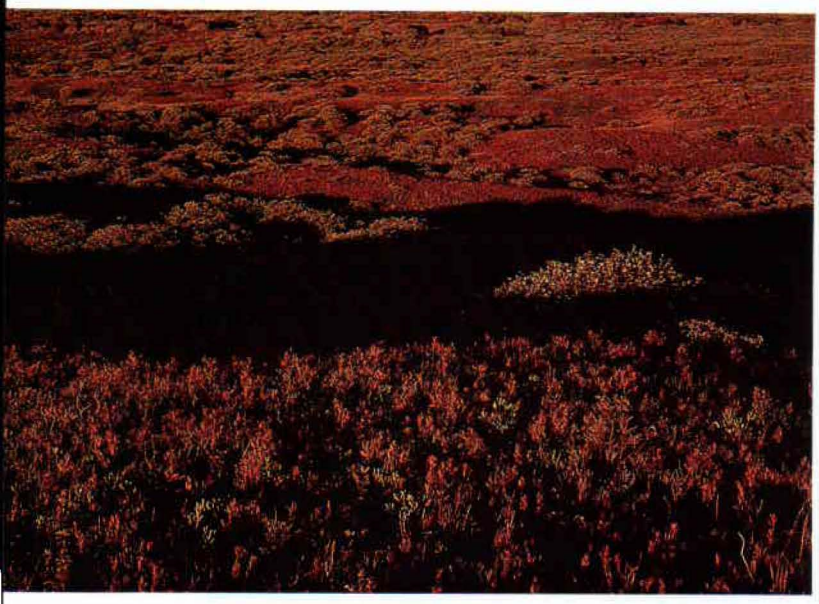
Like the beach itself, the dunes, which make up the next obvious zone on many coastal barriers, are physically rigorous places

This patch of seaside goldenrod traps sand around its base.
© C. C. LOCKWOOD

for life. The winds blow sand around and keep it in constant motion. Fortunately, various grasses tolerate the intense salt spray, damaging winds, and mobile sands. American beach grass north of Cape Hatteras and sea oats to the south form locally dense plains of upright waving grasses. These grasses trap blowing sand and help stabilize and maintain dune fields. By trapping sand, dune grasses actually elevate the dunes, fortifying a major line of physical defense against storm waves and surge and helping to block the inland penetration of salt spray, which is damaging to most vegetation.

Although the waving grasses are the most obvious and functionally important dune plants, other low, salt-tolerant plants also grow there. The purple flowers on the trailing beach pea and later its distinctive seed pods are memorable. In autumn, the bright yellow flowers of the seaside goldenrod, whose nectar feeds millions of migrating bright orange and black monarch butterflies, splash the dune landscape with lively color. Some back dune areas on northeast barriers are carpeted in a nearly pure stand of beach heather, a low-lying gray plant that flowers profusely to form a sea of yellow in early summer. Overwash channels between dunes often have distinctive vegetation like pennywort in the southeast.

© C. C. LOCKWOOD



A thicket of huckleberry and scrub oak covers this section of Nantucket Island, Massachusetts.
© NATIONAL GEOGRAPHIC SOCIETY

Dunes and back beaches are important nesting grounds for several shorebirds, terns, and gulls. Beach mice, rats, and moles are actually residents of this habitat on certain coastal barriers, and large numbers of songbirds feed and rest here, particularly during spring and fall migrations along the coastal flyway.

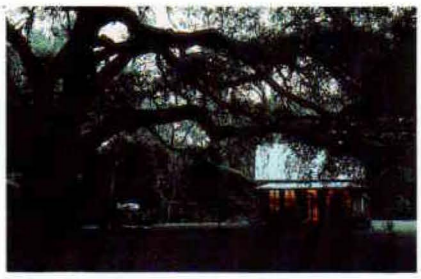
The shrub zone is found landward of the dune field. Often shrubs occur in interdune pockets of low-lying land before a continuous band of shrubs appears. At the landward end of the shrub thicket, the transition into maritime forest is gradual, not abrupt. Though many shrub zone plants, like holly, live oak, and red cedar, are full-grown trees in the maritime forest, they are pruned to smaller sizes in the shrub zone by wind-borne salt spray. The salt spray influence is so strong that it creates a smooth level top to the shrub canopy even when the ground below is uneven. Any branch that attempts to grow up higher than those around it is killed and pruned back by the damaging salt and wind. The shrub zone serves as a wind-break to intercept salt air and protect the maritime forest from its damaging effects.

Although coastal barriers typically receive moderate rainfall, the sunny, windy climate with high evaporation rates, the porous sediments, and the salt spray all interact to produce a physical environment similar to a desert. In response, barrier island shrubs exhibit leaf adaptations usually found in very arid environments: to minimize water loss, their leaves are small, waxy, and rarely lobed. Not surprisingly, prickly pear cacti are common in the shrub zone.

The shrub zone contains only a few species of plants, densely packed with a continuous canopy perhaps 10-13 feet high and almost no understory. Numerous vines such as greenbriars, Virginia creeper, wild grapes, and poison ivy fill in any gaps in the canopy and form what can truly be called a shrub thicket on many coastal barriers. Many shrubs exhibit spectacular displays of white flowers in the spring, especially the shadbush, beach plum, blueberry, and bayberry of the northeast barriers.

Because protection from salt spray is greater in the shrub zone, some reptiles and amphibians can live there. Various songbirds nest under cover of the shrubs and eat the berries of the shrubs and vines. Small predatory birds like the sharp-shinned hawk and short-eared owl occasionally patrol the edge of the shrub zone.

The most well-developed and widely varied plant and animal communities on a coastal barrier are found in the maritime forest. Here, because of the distance from the sea and the salt protection provided by the dunes and shrubs, the damaging influence of salt spray is minimized,



This centuries-old live oak graces the front yard of a simple house in the maritime forest of Daufuskie Island, South Carolina.
© NATIONAL GEOGRAPHIC SOCIETY

The maritime forest of southeastern coastal barriers is the native habitat of the painted bunting. The colorful male pictured here is one of the most beautiful North American birds.
© J. P. PARNELL

and true forest species can survive and grow. Not all barrier islands even possess this special habitat because the necessary protection is not always provided. Coastal barriers are generally narrow strips of land. The most narrow and low-lying barriers possess only the beach habitat, no vegetation and no other zones. With increasing width, elevation, and geographic protection from storm waves, additional zones are added to the barrier island: the dune fields, the shrub thicket, and finally the maritime forest. Maritime forests are most well-developed on the sea islands of South Carolina and Georgia, where wave energy is low and barriers are wider and more stable.

The variety of plants in the maritime forest is great, but its geographic isolation from mainland flora and the continued, although reduced, influence of salt spray keep the diversity lower than in forests on the mainland. The topography of maritime forests is not at all uniform and the moist low swales contain different trees (including red maples, palmettos, and tupelos) from those on the arid ridges (pines, oaks, dogwoods, and hickories).

Because the well-developed forest offers many microenvironments, the variety of bird species living in and utilizing the maritime forest is great. Insect eaters such as flycatchers, warblers, and swallows are the most numerous, but most other bird groups of the mainland forest are also represented.

The maritime forest is also the most favorable zone for skinks, toads, salamanders, frogs, and snakes. Because of the isolation of barrier islands from the mainland forests, some amphibians and reptiles of the coastal barriers have evolved into separate races, clearly recognized by distinctive coloration or size differences. Mammals are most diverse and numerous in this habitat. Herbivores (plant-eaters) such as squirrels, mice, rabbits, and deer forage in this habitat together with predators like foxes, bats, moles, minks, otters, and even bobcats.

Alligators are found on coastal barriers from North Carolina to Texas.
© C. C. LOCKWOOD

Saltmarsh snails find refuge high on marsh grass blades, above the incoming tide.
U.S. FISH & WILDLIFE SERVICE

Estuarine Ecosystem: Soundside Wetlands & Aquatic Habitats

Saltmarshes on the Atlantic and gulf coasts are dominated by tall emergent grasses or, in subtropical environments, by mangroves. The grasses grow on the higher portions of the intertidal shoreline, often in distinct zones. Needlerushes or reeds commonly cover the highest, landward margins, while saltmarsh cordgrasses (*Spartina*) are found closer to the sound or bay. These coastal wetlands are among the most productive of any habitat on earth and provide much of the food that fuels the entire estuarine ecosystem. Very little of the plant is actually consumed in the saltmarsh or mangrove zone. Instead, the plant leaves are shed annually into estuarine waters, where they break up into smaller pieces called detritus. These detrital fragments are heavily colonized by microorganisms which are the base of vast food webs that lead to shrimp, crabs, and numerous fishes.

The saltmarsh is habitat where rails, bitterns, blackbirds, wrens, sparrows, and swallows nest and feed. Many springtime visitors to the saltmarsh have been the objects of aggressive displays by red-winged blackbirds defending their territories. Predatory birds such as hawks and owls forage over saltmarshes. Two furbearing mammals, the muskrat and the nutria, are found in saltmarshes and support a valuable trapping industry and fur trade, especially in Louisiana and Texas.

The soundside marshes on barrier islands do not extend far down into the intertidal zone. Unvegetated mud and sand flats occur at lower elevations on the sound shore. Below these appear other important estuarine habitats, such as seagrass beds and oyster reefs. All of these estuarine habitats are extremely valuable for water birds and serve as nurseries for fish and shellfish. More than 80% of the commercial catch, by both weight and species, of the Atlantic and Gulf of Mexico coasts is dependent upon estuaries at some stage in their life. Two of the most common estuarine species are mullet and menhaden, both of which feed on detritus and microscopic plants. Not only are these species themselves commercially valuable, but they and

The maritime forest gives way to needlerush (tan) and finally to saltmarsh cordgrass (golden) on the backside of this Florida barrier
© C. C. LOCKWOOD

Huge numbers of shorebirds feed on the sandflats and mudflats around coastal barriers.
© C. C. LOCKWOOD

other bait fishes also are in turn prey for other valuable game fishes and commercial species. Estuaries are also the site where virtually all oysters, hard clams, soft-shelled clams, blue crabs, and bay scallops are harvested.

Coastal barriers are necessary for the rich development of the estuaries behind them and protect wetlands from the full force of the sea. These systems are vitally interdependent. Without the coastal barriers, the critical estuarine habitat for ducks, probing shorebirds, waders (herons and egrets), and fisheaters (gulls, terns, and ospreys) would be greatly diminished and even destroyed in most localities along the coast from Maine to Texas. Loss of habitat would also seriously threaten American alligators, manatees, and other endangered and threatened species.

Many coastal barrier plants, like this duck-potato, produce beautiful flowers.
© C. C. LOCKWOOD

Freshwater and Upland Ecosystems

Coastal barriers protect not only the wetland habitats behind them but also freshwater ecosystems on the adjacent mainland. Coastal barriers reduce the influence of tidal and salinity fluctuations in mainland freshwater habitats, indirectly enhancing the diversity of plant and animal life. Freshwater wetlands are valuable habitat for water birds, songbirds, alligators, nutria, muskrat, and numerous fishes including perch, striped bass, and catfish. Although most freshwater wetlands occur on the mainland, some freshwater marshes and swamp forests do occur on the coastal barriers themselves. These wetlands serve a vital function by providing drinkable water to birds and wildlife in a habitat that in ways resembles a desert. Freshwater wetlands also greatly enhance the broad variety of insect and amphibian species on the coastal barrier.

Wild horses on coastal barriers such as Chincoteague, Virginia, add to the mystique of the islands.
P. E. HOSIER

Willets rest on one leg while pondering their next move.
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Values of Coastal Barriers

Protection of the mainland from storm waves and surge

Buffering of wave energy to allow formation of marshes and estuaries

Creation of habitat for:

- Commercial and recreational fishes
- Waterfowl during winter, breeding, and migrations
- Shorebirds, water birds, and migrating songbirds
- Furbearing mammals
- Endangered and threatened species such as the whooping crane and loggerhead sea turtle

Recreation—photography, painting, nature walks, birdwatching, swimming, surfing, boating, fishing, hunting

Vacation and retirement living

Economic benefits of tourism to local coastal communities

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HUMAN IMPACTS ON BARRIERS

Like many locations valued for their natural beauty, coastal barriers are threatened by increased human activity. It is a common irony that by moving to a particularly attractive location, people often end up destroying much of what attracted them there in the first place. Clearly, there is no greater threat to our coastal barriers than extensive urbanization. This development will ultimately need protection by costly engineering projects, many of which will only provide short-term solutions.

One of the most damaging aspects of development is the removal of dunes to build houses, condominiums, hotels, shopping centers, and even roads. In the brief human inheritance of coastal barriers, spectacular and expansive dunes have been routinely leveled for construction at the shoreline, better access to the beach, and an unobstructed view of the water. But without dunes, the beach cannot effectively absorb large waves, nor can it supply the sand needed for the sand-sharing system to adjust the beach profile during storms.

Even where the dunes have been protected by law from bulldozing, other activities in the dunes may substantially damage them. Just walking across the dunes may harm the stabilizing vegetation. Off-road vehicle travel in dunes may be even more damaging. The tires of motorcycles, three-wheelers, and four-wheel-drive vehicles may destroy dune grasses, and linear tire tracks may become wind channels where the dune sands continually erode. The active beach zone is the least damaging place for foot or vehicle traffic because winds and tides will quickly erase the tracks.

As dunes are destroyed and people develop the shore, the normal processes of island migration become problems of erosion. Many engineering solutions have been sought. Protective walls or groins of concrete, steel, or rock, built out into the surf, are designed to trap sand by interrupting the flow of littoral drift. Groins are sometimes an effective means of building new beaches on their updrift sides but a price must be paid: groins cause even faster erosion on their downdrift sides. The sands robbed from the littoral drift system and retained by a groin are no longer available to nourish neighboring beaches. Thus, the problems created by installing one groin can only be "solved" by constructing additional groins.

Extending even farther out into the sand-sharing system and typically on both sides of an inlet, jetties are structures used to prevent sands from accumulating in navigation channels. Jetties can perform several functions: they prevent beach sands

Overdevelopment leads to many problems on coastal barriers like this one in Florida.
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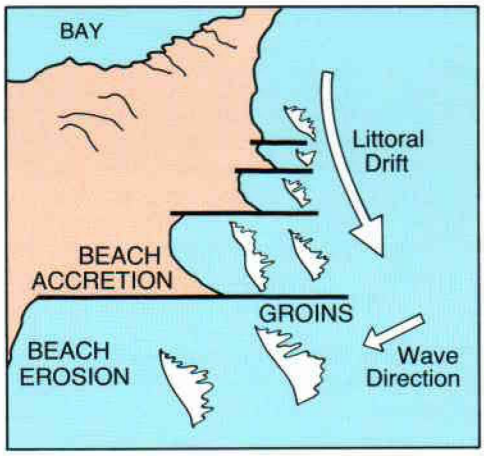

The effects of groins on barrier beaches.

Sandy Hook, New Jersey, has changed repeatedly from spit to island and back again over the last two centuries. Human intervention now competes with natural forces to shape the barrier.

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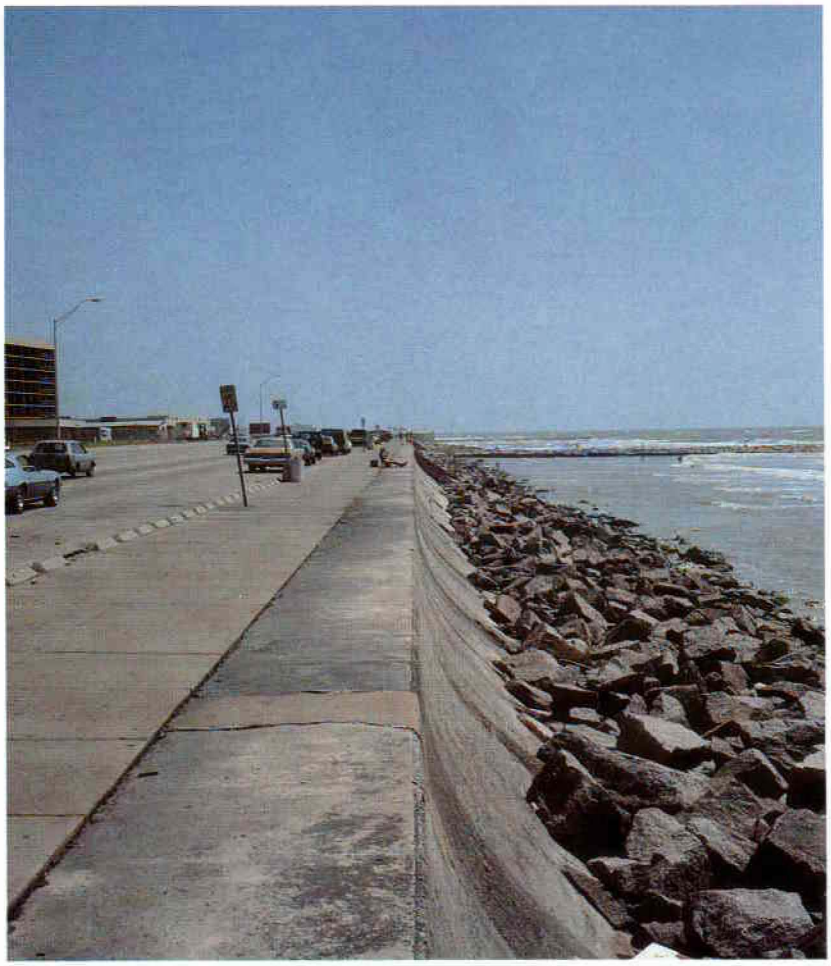
The Galveston seawall was built after a 1900 hurricane submerged Galveston Island and claimed 6,000 lives. Though the city is protected, the sandy beach has been eroded away.

S. M. ROGERS



from being carried into shipping lanes, harbors, and turning basins; they prevent an inlet from migrating along a barrier; and they prevent the inlet from sealing its entrance as many natural inlets have done. Also, like groins, jetties lead to wider beaches on one side of the inlet, while increasing erosion on the other side. Unfortunately, meeting the needs of navigation is not always compatible with minimizing beach erosion.

Fresh sands, pumped onto eroding beaches by the millions of cubic yards and at costs of millions of dollars, can restore beaches temporarily. But over the years, like the sand it replaced, the new sand will disappear. Although often considered the best solution to the erosion problem, beach renourishment has drawbacks. Sources may not be readily available, and the sand, if too fine, will very quickly wash from the beach. Much of the new sand, even if the correct size, will soon be lost because renourishment unnaturally steepens the intertidal and nearshore beach profile. Erosion accelerates as the beach attempts to return to a natural shape.

The most drastic measure to protect property is the construction of seawalls, rigid masses of rock and concrete built parallel to the shoreline to take the impact of waves. Constructing a seawall is usually considered an irreversible act since the beach in front of the wall will almost certainly be swept away. The vital processes of sand sharing, overwash sedimentation, and island migration are brought to an abrupt halt by a seawall and, in time, a seawall will fail or need to be replaced with an even bigger structure.

Perhaps it is instinct that tells us to correct the problems brought on by overdevelopment by "hardening" the beach with seawalls, rip-rap, and other human-made structures, all designed to prevent the beach from moving. Unquestionably, such engineering projects have been able to solve local problems over short periods of time. But most are doomed to failure because coastal barriers, in the long run, respond only to the passage of time. Natural forces cannot be changed. Experience has taught engineers and scientists alike that coastal barriers are dynamic features, always moving, widening at some spots and thinning at others. Thus, we must accept the idea that human-made structures near the shoreline are temporary and that those who choose to live near the sea must be prepared to deal with the consequences.

Beach migration has left these buildings standing in the ocean.
I. A. MENDELSSOHN

These tire tracks on the beach are the result of off-road vehicle traffic.
S. P. LEATHERMAN

Alteration of Natural Habitat

Residents and visitors to coastal barriers can alter and destroy natural habitat. Often these changes are unintentional but they can still have important consequences for wildlife. For example, beaches lighted at night discourage female sea turtles from emerging from the sea to lay their eggs. Some scientists have suggested that newly hatched turtles may not be able to cross vehicle tracks in the dry sands of the upper beach to crawl to the sea. It only takes a few people just walking on the beach or dunes to disrupt the nesting of many birds like skimmers, terns, and gulls.

The conversion of coastal barrier land into human habitations necessarily involves the destruction of some natural habitat, with associated loss of wildlife. Because coastal barriers occupy so little acreage and because the demand for development has been so intense, the high rate of coastal barrier habitat loss is alarming. Often habitat destruction is selective. The rarest of habitats on coastal barriers, freshwater marshes and swamp forests, are often viewed as unsightly nuisances and breeding grounds for mosquitoes so they are destroyed preferentially. Their loss removes unique habitat for those species that require abundant freshwater.

Some development practices encourage destruction of coastal barriers. For example, straight roads leading perpendicularly away from the sea provide overwash channels for storm surge, which can do major damage to structures on the barrier. Such roads can even serve to encourage the evolution of a complete break in the barrier and the development of a new inlet between sea and sound. These roads also funnel damaging salt spray farther back into the interior of the coastal barrier, causing loss of natural vegetation even without major storms.

Because coastal barrier land is scarce, any new development should be considered carefully. For example, coastal barrier land is too valuable both as natural habitat and for housing to be used for all the same purposes as the mainland. Local zoning should probably exclude industrial development and office complexes from coastal barriers and limit commercial development to that necessary to support local residents. With adequate transportation links to the mainland, even shopping centers and other necessary services are probably best located inland on land less dear.

Local town planners should also be concerned with the groundwater supplies on coastal barriers. The thin layer of freshwater that floats on the saltwater bed under a coastal barrier can be easily polluted by improper sewage treatment. Heavy use of shallow wells by barrier residents can deplete the freshwater or allow the saltwater to intrude and spoil the water source. A loss of fresh water would also have dire consequences for the natural vegetation on the coastal barrier and the animals that depend on it. Any development that increases stormwater runoff into the estuary aids the discharge of disease-causing bacteria and other pollutants into valuable shellfish habitat. Proper planning for development is necessary for the wise use of our coastal resources and for the preservation of the tremendous values vested in our coastal barrier systems.

Beach-nesting birds like this least tern can easily lose their young because of human disturbance.
© C. C. LOCKWOOD

COASTAL BARRIER RESOURCES ACT

In 1982 the United States Congress enacted the Coastal Barrier Resources Act, legislation specifically designed to discourage overdevelopment of coastal barriers along the Atlantic Ocean and Gulf of Mexico. The purpose of this legislation is threefold: (1) to minimize loss of human life, (2) to reduce wasteful expenditure of federal revenues, and (3) to reduce damage to fish and wildlife habitat and other valuable natural resources of coastal barriers.

This color infrared photograph shows part of a coastal barrier in North Carolina protected under the Coastal Barrier Resources Act. In color infrared photographs, trees and shrubs appear red.
ENVIRONMENTAL PROTECTION AGENCY

This Act prohibits, within certain specific areas of the undeveloped coastal barrier system, most expenditures of federal funds promoting development and economic growth. The major types of federal funds no longer available for use on the coastal barriers that are protected under this Act are federal flood insurance, Army Corps of Engineers development projects, Veterans' Administration and Federal Housing Administration loans, and federal assistance for the construction of sewer systems, highways, water supply systems, airports, bridges, and jetties.

The provisions of the Coastal Barrier Resources Act apply only to a specified group of largely undeveloped coastal barriers because the intent of the legislation is not to penalize existing communities but instead to remove federal incentive for new development. Those coastal barriers included in this legislation were identified by both geological criteria and the political process at the local, state, and federal levels. Because few coastal barriers are truly pristine, determining which ones were sufficiently undeveloped to be protected by this law was difficult, and review of selected barriers will probably continue.

The coastal barriers that are protected by the Coastal Barrier Resources Act stretch from Maine to Texas. Three coastal states have none of their coastal barriers included in this legislation: New Hampshire, Maryland, and New Jersey. Massachusetts and Florida, with extensive coastlines, have the greatest numbers of separate coastal barrier units covered by this law. Texas has the greatest acreage protected.

The benefits of the Act are evident. Because coastal barriers are so mobile, vulnerable to flooding, and subject to damaging hurricanes and northeasters, the federal government should not pay the costs of rebuilding after storms. People who build on coastal barriers should do so at their own financial risk. The public taxpayer should not have to bear the burden, through subsidized federal flood insurance and emergency relief funds, of maintaining developments on coastal barriers. Furthermore, the federal government should discourage development on coastal barriers to prevent loss of life by those not realizing the very real risk of death in major storms. Most people do not appreciate the probability of storm damage and loss of life until they experience a hurricane firsthand.

The third general benefit of removing federal subsidy for coastal barrier development is also obvious. If development of coastal barriers destroys or degrades extremely valuable public resources, such as fish and wildlife habitat, coastal fisheries, and other natural resources, there is little justification for encouraging that development process.

Storm surges can easily flood structures built too close to the beach.
S. P. LEATHERMAN

OTHER MANAGEMENT EFFORTS

The Coastal Barrier Resources Act is by no means the only protection that our coastal barriers enjoy. Review of various construction projects by federal and state agencies is required by law. Under Section 10 of the Federal Rivers and Harbors Act, the Army Corps of Engineers must review and approve any proposed project affecting U.S. navigable waters, and under Section 404 of the Federal Clean Water Act, the Corps must approve the selection and use of sites for disposal of dredge spoil in U.S. waters and adjacent wetlands. The Environmental Protection Agency may prohibit the use of an area as a disposal site if it would adversely affect municipal water supplies, shellfish beds, fishery areas, wildlife, or recreational areas. The Corps must also consult the Fish and Wildlife Service and the National Marine Fisheries Service to determine the degree of adverse impact of any Section 404 or Section 10 application on fish and wildlife habitat and other natural resources.

The degree to which coastal barrier wetlands receive protection by the review of Section 404 and Section 10 permit applications varies. A narrow interpretation of jurisdictional boundaries, the cumulative effects of many small projects, and loopholes in permit requirements have all contributed to a limited effectiveness of these laws in protecting coastal barrier wetlands and resources.

Many coastal states have active programs to regulate coastal development. The federal Coastal Zone Management Act provides incentives to coastal states to adopt coastal planning legislation consistent with federal goals, including preservation of the natural values of coastal barriers. Most coastal states have strengthened their coastal protection programs under this federal program. Along coastal barriers, development that destroys wetlands frequently requires mitigation: the establishment elsewhere of the same valuable biological resource that has been destroyed. However, mitigation is risky because research has not yet shown that artificially created marshes and seagrass beds can support the same fish and wildlife as the natural habitat or that they can persist in the new locality.

Several other programs help preserve various coastal barriers throughout the United States. The National Park Service, Fish and Wildlife Service, National Oceanic and Atmospheric Administration, and

The U. S. Army Corps of Engineers dredges vast amounts of sediment from the waterways around coastal barriers.
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governments manage a of parks, wildlife refuges, es on coastal barriers. r some protection ies that would degrade fe habitat or other rces. Many individuals coastal barrier land or easements to foundations such as The rvancy or directly to icipalities for their Local zoning in some has recognized the of the natural resources on coastal barriers and l the needs for low- opment and restriction of commercial enterprises rriers. In some towns, deed covenants and laws protect trees and natural dune and marsh vegetation from cutting or trampling. Unfortunately, the federal and state tax laws still promote and underwrite the costs of coastal barrier development with tax credits such as those offered for business investments or casualty losses of property.

Despite the formal protection that exists to perpetuate the values of our coastal barrier resources, the bottom line is public awareness and concern. Without popular support, none of the protection devices would succeed. Public comments are necessary on federal and state laws affecting coastal barrier resources. In every community along our coast, public opinion is frequently sought by regulators administering environmental laws and reacting to permit requests. Individual citizens often achieve more politically by forming or joining local conservation groups.

And the next time your coastal neighbor complains about the mosquitoes or the swamp, take some time to explain a little of what you know about the natural science, the geology, and ecology of coastal barriers, their natural values and benefits, and their susceptibility to development. That level of personal commitment and shared concern is the ultimate protection required to preserve our valuable, yet fragile and changeable, coastal bounty.

Many endangered species, such as brown pelicans, live in coastal barrier habitats.
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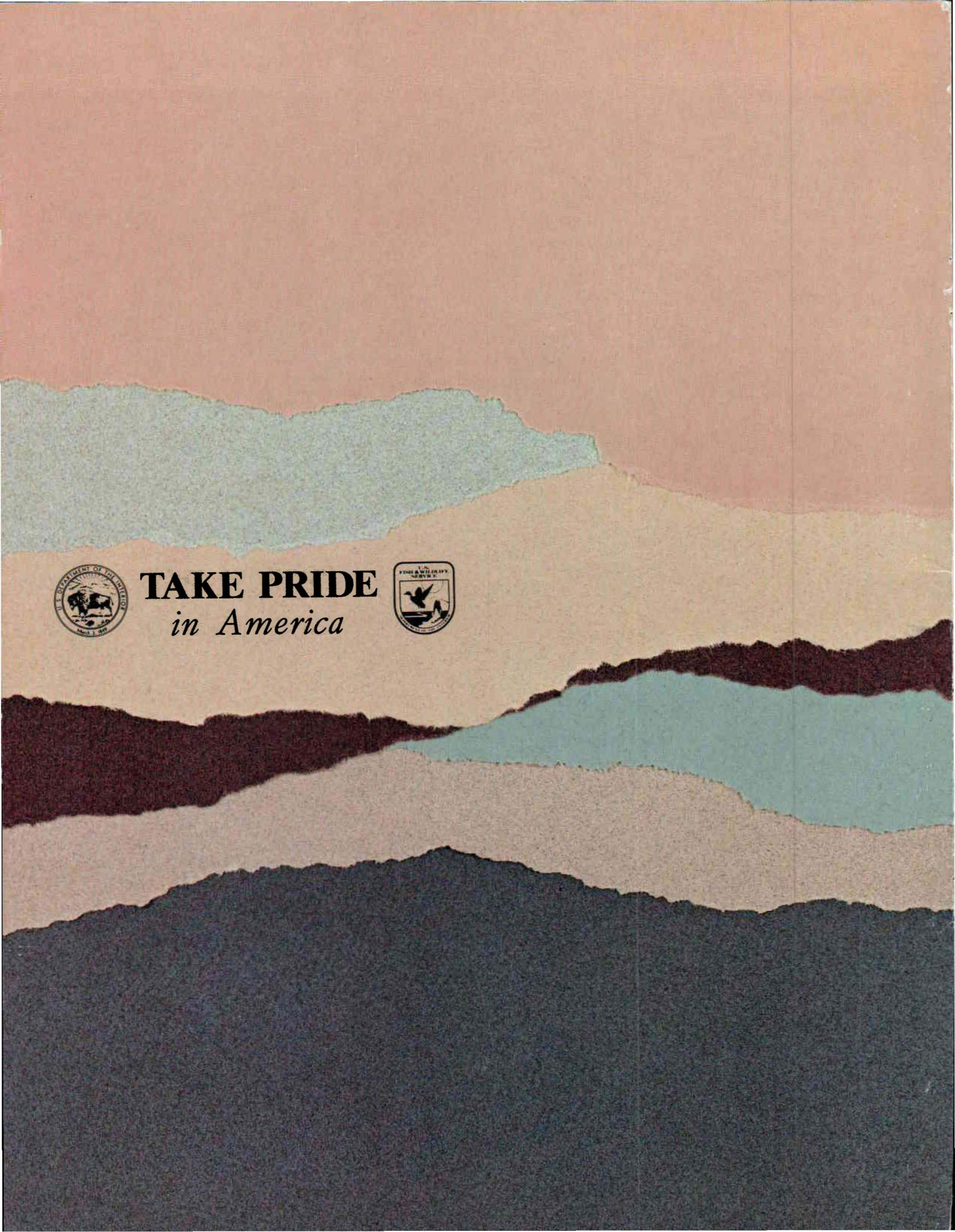
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