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BEACH EROSION in SOUTH CAROLINA

by Timothy W. Kana, PhD

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PREFACE

Debates about coastal erosion in South Carolina often assume that our shoreline is one lengthy, overdeveloped beach. This is not the case. Of course, unwise development has taken its toll on beachfront resources and structures in areas which are most accessible to the public. But our coast is made up of many beaches, some bounded by tidal inlets and barrier islands, some eroding severely and others not at all.

In looking for solutions to the erosion problem, then, we must first understand the characteristics of each beachfront area. Not until we accept the uniqueness and variety of our coast can we understand the processes that have shaped it for centuries.

It is this perspective that Dr. Timothy Kana explores in the following essay, "Beach Erosion in South Carolina." In it he explains the evolution of South Carolina's coast, discusses the causes and effects of erosion in given areas, and offers guidelines for managing our beaches based on his expertise as a geologist and coastal erosion consultant.

We hope you find this information helpful. For more information, please contact us here at the Consortium, or phone your marine extension agent.

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SYNOPSIS

Although beach erosion is a problem in South Carolina, its nature varies greatly from one area to the next. Fully 40 percent of our coast is held in trust as parks and wildlife preserves where the causes and impacts of erosion differ from the 50 percent of our shoreline that is developed close to the oceanfront. A third of the developed coast is eroding at more than one foot per year; 60 miles of developed oceanfront are stable or eroding at less than one foot per year.

South Carolina's compartmented coast offers the opportunity to isolate erosion problems from one beach to another. How we develop and manage Kiawah Island may be very different from our approach to Folly Beach, one inlet away, given the dramatically different shoreline histories in these two areas.

South Carolina's compartmented coast offers the opportunity to isolate erosion problems from one beach to another. The tidal inlets separating our shorelines essentially control the stability of all our beaches. Inlets can provide a natural source of sand, or they can withhold it from a beach. Inlets partially isolate one beach from another, acting as natural boundaries and allowing for both diversity of natural processes and diversity of development. Thus, how we develop and manage Kiawah Island may be very different from our approach to Folly Beach, one inlet away, given the dramatically different shoreline histories in these two areas. At the same time, adjacent beaches may interact; loss of sand from Dewees Island contributes significantly to beach growth at Isle of Palms and Sullivans Island.

Ultimately, the beach erosion problem is strongly linked to coastal development, exacerbated by such human activities as the damming of rivers and construction of harbor jetties. But our problem is manageable if we adopt a common framework to address the problem. Misunderstandings or misrepresentations of beach erosion originate from many quarters, and popular articles on erosion reflect the diversity of perspectives on the problem. Developer or regulator, scientist or citizen, we must consider the problem within a common framework if we are to form a consensus on solutions.

Beach erosion is essentially a sand budget problem. Any solution first requires the definition of a set of boundaries within which an accounting of sand losses or gains can be made on a routine basis. Then we must select a common time frame for planning purposes. Given our present understanding of the coast and of planning requirements, a time frame of 50 years is appropriate.

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Future demands on our beaches can only increase, given rising population and migration into the coastal zone. But the shoreline 50 years from now does not have to look like New Jersey's with its massive seawalls and numerous groins.

- **Areas that are already protected** should pose little problem, provided their supplies of sand are also managed.

- **Areas that are undeveloped** but subject to possible future development should implement building setbacks based on careful review and analysis of historical erosion rates.

- **Developed areas that have been accreting** should lock-in existing setbacks and enjoy their relatively wide margin of safety.

- **Areas eroding at fairly low rates** should favor soft engineering solutions such as beach nourishment in order to keep pace with erosion and conserve recreational beaches.

A relatively small portion of the developed coast, about 26 miles, appears to be eroding at moderate to high rates. These areas offer the greatest challenge for future management. Some may be able to afford nourishment at a cost commensurate with returns from development. In others it may be necessary to implement shore protection involving some combination of sand retaining structures with beach nourishment where the costs of such measures are balanced by expected benefits.

Regardless of the area or degree of the problem, solutions to erosion are possible. The larger problems often are achieving consensus for a solution within a community and finding the funds to pay for it. Clearly, funding should be linked to users; and public benefit should be a requisite of public funding of solutions.

While controversy is bound to persist in the beach erosion debate, the degree of South Carolina's erosion problem and the existing patterns of development and preservation offer considerable cause for optimism. Stronger coastal zone management is needed to ensure the continued balance of preservation and public access with revenue-generating development. As we gain more experience, we may be able to extend our vision beyond 50 years and discover innovative ways to deal with erosion, working with nature, rather than against it.

INTRODUCTION

The renewed public interest in beach erosion prompted by last year's storms is heartening to those who make a profession of studying the problem. Yet, though eroding beaches are common in South Carolina, as they are around the world, the severity of the problem is often misunderstood or misrepresented. Many widely circulated conceptions about erosion are simplistic, erroneous, or both.

For example, a recent sampling of popular articles and letters to the editor might lead one to believe that sea level will rise ten feet in the next century, or that sand washed away during storms is lost from the beach forever, or that seawalls are the principal cause of erosion, or that all beach nourishment projects are expensive.

There is a tendency to interpret the beach erosion problem in simple terms: as a result, we look for scapegoats.

At worst, such statements are factually incorrect, with no data to support them; at best, they are oversimplifications. The natural processes that mold and shape the coast are very complex, a varying combination of winds, waves, and tides acting on the sediments that make up our beaches and wetlands. An added factor is human activity. Coastal development, harbor construction and the damming of rivers can alter the sand supply or change local current patterns, thus, interrupting the natural system. There is a natural human tendency to interpret the beach erosion problem in simple black and white terms, such as "erosion is inevitable" or "you cannot fight nature." As a result, we look for scapegoats--the imprudent developer who built too close to the dunes or the government agency that constructed those jetties. On few issues are the lines more clearly drawn -- powerful development and commerce at odds with preservationists. While this may make for drama in the media, it does little to educate people about the true extent of the problem. Reality is much different. We obviously should not allow people to build too close to vulnerable beaches, but we cannot preserve every mile of our shoreline from development given the enormous demand on the

The purpose of this paper is to provide a framework for considering the beach erosion problem as it applies to South Carolina.

resource. There are people who want to develop the coast in a sensitive way, just as there are people who want to conserve our beaches. What, then, is a responsible approach?

The first requirement is a better definition of the problem. Our coast is continually evolving in response to variations in physical forces and sediment supply. Though many factors (Table 1) are known to influence beach erosion, it is difficult to determine how and where specific factors, singly or in combination, will affect a given beach adversely.

Although our limited knowledge in this area indicates a need for further research, the purpose of this paper is to provide a rational perspective on beach erosion, a general framework for considering the problem as it applies to South Carolina, based on what we have learned from some 30 years of studies (see bibliography). Further, we will propose a common frame of reference with which to assess the current problem of beach erosion. But before we can develop a vision of how the coast might be managed in the future, we need to review its past.

Table 1

Factors affecting shoreline erosion

Natural	Man-Made
Breaking waves	Dams on rivers
Winds	Shorefront development
Currents	Seawalls
Rains	Groins, breakwaters
Sediment supply	Harbor jetties
Tidal cycle	Offshore dredging
Storm frequency	Beach sand mining
Sea-level rise	Boat wakes
Nearshore bathymetry	Farm practice
Sediment type	Surface water runoff
Regional geology	
Biogenic processes (e.g. reef building, burrowing by organisms)	

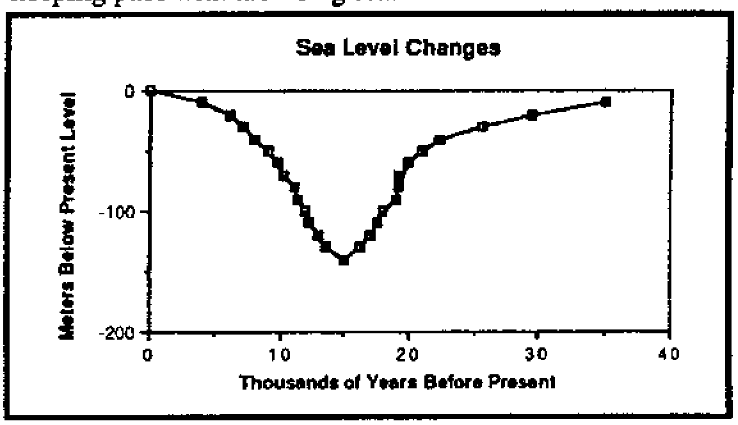
Viewed in geologic time--South Carolina's coast has not eroded at all. What have been eroding are the Appalachian Mountains, providing the sediments that form today's coastal plain.

EVOLUTION OF SOUTH CAROLINA'S COAST

Viewed in geologic time--that is, millions of years--South Carolina's coast has not eroded at all but has instead built into the ocean by many miles. What have been eroding are the Appalachian Mountains, providing the sediments that form the matrix of today's coastal plain.

In geologic time all the sedimentary coasts of the world--the narrow strips of land that interact with the sea--are ephemeral. The barrier islands and beaches at the edge of our coast are very young in a geologic sense, having been formed within the past 4,000 years or so.

From 20,000 until about 4,000 years ago, the glaciers of North America and Eurasia were melting rapidly, causing the sea level to rise two to three feet per century (over 350 feet in all). The edge of the continent retreated many miles as rising seas rapidly inundated the land. Along most coastlines, flooding of the land exceeded the supply of sediments carried from the mountains by rivers. Beaches existed, but without adequate sediment supplies they shifted inland, keeping pace with the rising sea.



We can see the same process occurring today, in a much abbreviated time span, with Utah's Great Salt Lake. Over the past decade rising waters have doubled the area of the lake, flooded surrounding land, and caused millions of dollars of damage to roads, houses, and businesses along the lake shore. Lake levels are now 10 feet higher than 20 years ago; and the shoreline is adjusting to this dramatic change.

South Carolina's present barrier islands began to grow, and the wetlands behind the outer beaches to evolve, around 4,000 years ago, when the rise in sea level stopped or at least slowed to such a rate that the sediment supply from rivers and tidal deltas could keep pace with subsequent changes. Here, thanks to the mountains in the upstate, the sediment supply to the coast has been plentiful. (Damming of rivers has, of course, affected this supply in recent years.) A mixture of sands, silts, and clays, these sediments tend to be sorted very efficiently by waves and currents. Where the wave energy is greatest, the fine silts and clays wash away, leaving the coarser sand to form the beaches. The finer sediments flow with the tides to quieter areas where they settle to form marshes or offshore deposits.

Because the sediments that make up our coast are discrete particles, they are subject to continual movement by winds, waves, or currents. However, fortunately for the stability of most of our coast, large areas of land that formed over the past few millenia are now well removed from the action of tides: Kiawah Island, Isle of Palms, and even Edisto Beach, to cite several examples, are more than a mile wide in places. All these islands were created from the loose, sandy sediment originally sorted by waves along the beach. Then as more sand was supplied over time, new shorelines formed seaward of the original beach, leaving behind parallel rows of dune ridges that reflect the shape and position of earlier shorelines. Only the most seaward of these beach and dune lines are directly exposed to the action of waves and tides, thus protecting previously formed shorelines.

While the popular notion holds that all barrier islands are fragile and quite vulnerable to storms, this simplification breaks down in South Carolina.

While the popular notion holds that all barrier islands are fragile and quite vulnerable to storms, this simplification breaks down in South Carolina. Our barrier islands are much different from the classical barriers on North Carolina's Outer Banks. Primarily, South Carolina barriers

Most of South Carolina's barriers gain extra protection from their width, the lack of open lagoons , and the presence of tidal inlets which channel floods efficiently.

tend to be shorter and wider, bounded by larger tidal inlets. They are also backed by mature tidal marshes. In contrast to the Outer Banks, most of South Carolina's barriers gain an extra measure of protection by virtue of their width, the lack of open lagoons that contribute to erosion along the landward shoreline and the tidal inlets which channel floods efficiently. While average elevations are relatively low along our barriers, they are little different from the adjacent mainland. Geologic studies, in fact, have shown much of the South Carolina coastal plain to be formed from ancient barrier-beach deposits.

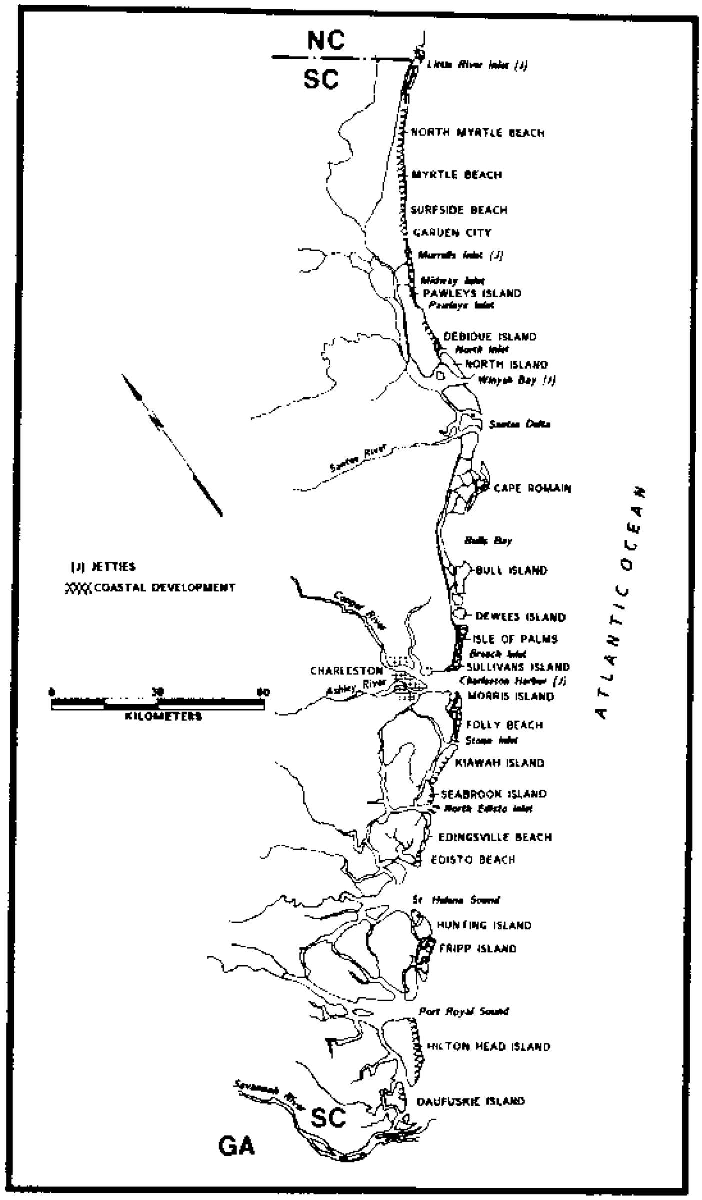
Coast Morphology and Erosion Processes

The most dramatic instances of beach erosion are those brought about by storms which may in one day wipe out a row of dunes or destroy homes or other structures adjacent to the beach. But subtler changes occur between the storms, influenced by numerous other factors (Table 1) and a sand supply free to shift during and after storms: these changes are perhaps more fundamental to the stability of South Carolina's beaches.

It is worth noting at this point that South Carolina's coast is complex: it tends to be irregular and broken up by numerous tidal inlets (Figure A); one beach may face southeast, while another, nearby, faces north. This is significantly different from the relatively straight shorelines of North Carolina's Outer Banks and Florida's east coast, and conclusions of erosion studies in these areas may not apply to South Carolina.

South Carolina's relatively high tidal range and low wave energy allow more inlets to form and remain stable along our coast.

South Carolina's shoreline is controlled by the hydrographic regime for this area--the range of tides and the relative energy of ocean waves. Because the continental shelf is wider off South Carolina and Georgia, the tidal range is at least twice as great as North Carolina's or Florida's: 6- to 7-foot tides each month, compared to 3-foot tides at Cape Hatteras and 1- to 2-foot tides along the Gulf coast. On the other hand, wave energy in South Carolina is significantly lower. More tidal energy or lower wave energy allows more inlets to form and remain stable along our coast; while inlets



South Carolina's Coast

South Carolina's tidal range and closely spaced inlets become important when we consider the probable effects of a temporary rise in sea level caused by strong winds blowing toward shore.

With numerous tidal inlets to channel the water and wider barrier islands to absorb the flood, there is less tendency for breaches to occur across our coastal islands.

are often 40 to 50 miles apart along the Outer Banks, they are usually 5 to 10 miles apart in South Carolina. These processes account for our relatively short barrier islands.

Storm Tides

South Carolina's tidal range and closely spaced inlets become important when we consider the probable effects of a "storm surge"--in effect, a temporary rise in the sea level caused by strong storm winds blowing toward shore. The peak storm surge expected to occur in a 100-year period[1] ranges from 10 feet in some East Coast localities to more than 20 feet along the Mississippi coast. In South Carolina a typical 100-year storm surge is from 13 to 15 feet. However, the effects of the predicted surge would differ from one coast to another.

For example, Hurricane Camille struck Biloxi, Mississippi, in 1969 with a surge of 20 to 22 feet, raising tides more than 10 times the normal height. The effects on the beach were dramatic: flooding and waves destroyed almost every house within a quarter-mile of the beach; new tidal inlets were cut through barrier islands; sand was shifted toward shore by waves washing over the dunes or later transported back out to sea through new channels cut by the receding waters.

But the effects in South Carolina of the predicted 100-year surge should be much less devastating. A 14-foot surge would represent a doubling of our normal tidal range, not the 10-fold increase experienced in Biloxi. With numerous tidal inlets to channel the water and wider barrier islands to absorb the flood, there is less tendency for breaches to occur across our coastal islands. Certainly where sand spits are narrow (e.g., Pawley's Island, where there is land enough for only one row of houses), there is a good chance new inlets would form. But this is much less likely to occur on the wider islands like Isle of Palms, Kiawah or Hilton Head.

[1] The maximum predicted storm tide over a 100 year period is used by Federal Emergency Management Agency (FEMA) as a basis for coastal flood insurance.

Typically storm surges last only a few hours; afterward the coast will readjust to the normal hydrographic regime, the rate of adjustment being dependent upon the severity of the surge. On the basis of their usual tidal ranges and the 100-year peaks predicted, one would expect the readjustment to take much longer at Biloxi than along the South Carolina coast.

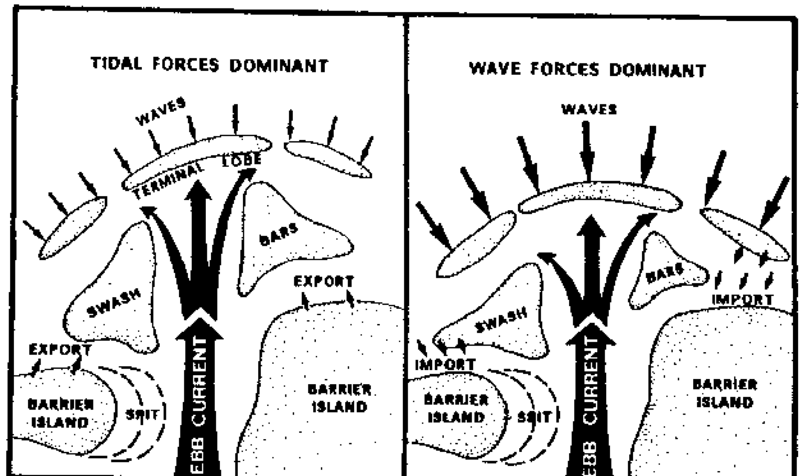
Review of storm histories also indicates that the peak surge during our most powerful storms--hurricanes--will generally be focused on a relatively small section of coast to the right of the storm track. Areas away from this section will experience a diminished surge level. Consequently, the degree of erosion varies along the shoreline. Lower intensity storms, on the other hand, such as the northeaster of January 1, 1987, do not produce tides as high as landfall hurricanes do, but the surge is more commonly uniform along the entire coast. This accounts for the fairly consistent rate of dune erosion observed from Edisto to Myrtle Beach in January 1987.

The Role of Tidal Inlets

In addition to their function in mitigating the effects of a storm surge, tidal inlets and the deltas associated with them are an important part of the more subtle, day-to-day dynamics of our beaches and dunes. Like river deltas, tidal deltas are simply deposits of sediment that, in this case, have been flushed into or out of an inlet. Most important in South Carolina are the seaward deltas, referred to as "ebb-tidal deltas" because they are formed of sand generally derived from adjacent beaches or rivers and deposited on the ebb (outgoing) tide.

The size of an ebb-tidal delta is related to the size of the tidal inlet itself. Pawleys Inlet, for example, has an ebb-tidal delta extending offshore only a quarter mile or so, while North Edisto Inlet (south of Seabrook Island), is more than 100 times larger with an ebb delta extending more than two miles out to sea; Port Royal Sound (the inlet north of Hilton Head Island) is larger still.

The delta's size is determined by the balance between tidal currents flowing out through the inlet and the energy of the waves breaking in shallow water as they move toward shore. Tidal currents flush sand offshore, while breaking waves tend to push it back toward the land. This natural balance at any inlet determines the amount of sand trapped in the shoals of its delta and thus affects the future of the shoreline in its vicinity.



EBB TIDAL DELTAS

Inlets affect beach erosion in a number of ways. The seaward shoals of inlets act as natural breakwaters, but can focus wave energy on a given section of beach, producing rapid erosion while allowing sand to build up in another spot nearby

Inlets affect beach erosion in a number of ways. Their seaward shoals act as natural breakwaters, causing ocean waves to break and expend energy before reaching shore. Thus, they usually shelter beaches in the lee of the shoals, creating calmer zones where erosion diminishes. However, through a process called "refraction," irregularities in offshore shoals can change the direction of incoming waves and focus wave energy on a given section of beach, producing rapid erosion there, while wave energy is lessened in another spot nearby, allowing sand to build up.

For the most part, South Carolina's inlets and tidal deltas are neither growing nor decaying but are remaining essentially constant in channel size, depth, and delta area (there are exceptions at such artifically altered inlets as Charleston Harbor, Murrells Inlet, and Little River Inlet, which have been jettied and dredged for navigation). However, though their various dimensions may be constant, we say the inlets are in "dynamic equilibrium" because the position of the channel may be changing (as at Captain Sam's Inlet, which migrates along the shore between Kiawah and Seabrook Islands) or sand may be shifting from one part of the delta to another, or back and forth between shoals and the beach.

New Inlet at Captain Sam's/Seabrook Island (foreground)

Note shoals trapped in abandoned ebb-tidal delta (Seabrook, 1983)

Sand Bypassing

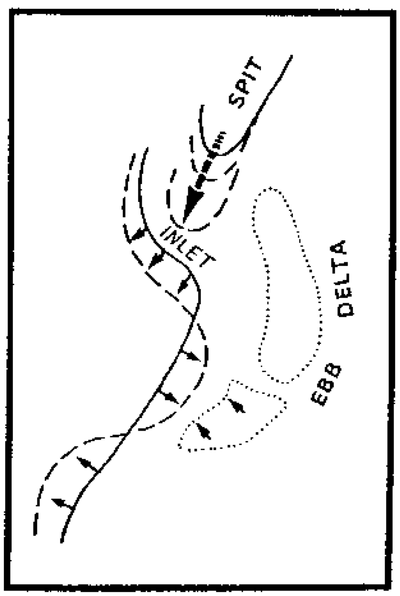
The better we can understand patterns and rates of sand movement at every inlet in the state, the more accurately we can predict changes in our shorelines.

The complex pathway for movement of sand around tidal inlets is perhaps the most difficult to understand of the erosion-related processes. Researchers at the University of South Carolina and elsewhere have been studying this process for the past two decades; the better we can understand patterns and rates of sand movement at every inlet in the state, the more accurately we can predict changes in our shorelines. At present our best documented examples are Price Inlet, between Bulls Island and Capers Island, Dewees Inlet at Isle of Palms, Stono Inlet at Kiawah, and Captain Sams Inlet at Seabrook. The large sounds at Hilton Head are least known because of their size.

We know that most of our inlets depend on a continual supply of sand from beaches to the north .

We know that most of our inlets depend on a continual supply of sand from beaches to the north to feed the inlet system. Averaged over several years there is a tendency for sand to shift southward under the influence of winds and waves from the northeast in South Carolina. The route each sand grain takes is circuitous: breaking waves strike the beach at an angle, pick up sand, and carry it southward. When the sand reaches the inlet, ebb currents flush it offshore, where it may remain for many years, trapped in a shoal. Or it may soon shift to a remote area free from tidal currents, where it will again be subject to the influence of waves.

Periodically, and sporadically, an entire sand bar measuring from hundreds to thousands of feet in length will "detach" from the offshore delta and begin moving toward shore in



Migrating tidal inlet and shoal bypassing

Sometimes sand actually bypasses the inlet as it shifts from the northern to the southern beach.

Together the many tidal inlets, their offshore shoals, and the process of sand bypassing control the shape and orientation of all South Carolina's beaches.

the same direction as the waves are moving. In South Carolina this most commonly occurs south of the inlet from a few hundred yards to several miles down the beach. The distance, predictably, is related to the size of the inlet. The movement continues until the sand bar literally attaches to the beach, burying the old beach and forming a new outer beach. The process is referred to as "inlet sand bypassing" because sand actually bypasses the inlet as it shifts from the northern to the southern beach.

Together the many tidal inlets, their offshore shoals, and the process of sand bypassing control the shape and orientation of all South Carolina's beaches. A glance at a map of our coast reveals that the northern ends of our barrier islands are commonly bulbous or wider than the southern ends. This phenomenon results from sand bars that have bypassed the inlet and attached to the beach, as well as the effects of the inlet's ebb tidal delta that shelters this part of the island from the full force of breaking waves. Typically, the "bulge" near the northern end of each island is close to the southern terminus of the ebb-tidal delta, its position related to the size of the inlet. At Pawleys Island the bulge is only a quarter mile south of Midway Inlet, one of the smaller inlets on our coast. At Isle of Palms the bulge is about one mile south of Dewees Inlet. And at Hilton Head the bulge lies close to the mid-point of the beach, about five miles south of Port Royal Sound, one of our largest inlets.

Any beach lying between the bulge and an inlet is controlled directly by the inlet and is subject to greater change than beaches that are farther removed, and erosion or accretion tends to be controlled by processes more complex than the simple, steadier trend of southerly sand movement. Furthermore, at inlets the usual southerly movement is often interrupted by periods or zones of sand movement to the north. In such an area, predicting future shorelines depends upon predicting the behavior of the inlet. In some places, as at Seabrook or Isle of Palms, long-term studies have given us the ability to do this fairly well. But in most areas we have little information to go by and must find other ways to predict the shoreline's behavior.

Based on the data available to us, we can be reasonably sure that because of regular sand bypassing the following areas have healthy beaches near inlets:

--Cherry Grove up to one-half mile from Hog Inlet
--The northern half-mile of Pawleys Island;
--The northern mile of Debidue Island;
--Most of Isle of Palms and Sullivans Island;
--Most of Kiawah Island.

Considered over a 50-year perspective, exceptions to the general trends in sand movement will probably be short-lived and localized. A recent situation at the northeast end of the Isle of Palms provides a case in point: a major sand-bypassing event there has produced a half-mile bulge into the ocean, while the beach to either side is eroding because of wave refraction. Until the new sand spreads up and down the beach over the next few years, shoreline trends will be irregular. But over the next several decades the beach is likely to build out to sea, as it has in this area for the last 1,500 years.

New beach accreting seaward of old shoreline marked by prominent dune.
(Photo courtesy SC Coastal Council)

Inlet Stability

Sand movement from north to south not only keeps an inlet in a dynamic condition, but also affects erosion on north-lying beaches.

While inlet bypassing is basic to the sand supply of every barrier island in South Carolina, beaches lying to the north of inlets may respond differently to the process. Sand movement from north to south not only keeps an inlet in a dynamic condition, but also affects erosion on north-lying beaches. For example, if more sand than needed reaches an inlet that is dynamically stable--one that remains in essentially the same location over many years--some will settle and the beach will build. On the other hand, if the sand supply is insufficient, tidal currents at the margins of the inlet will sweep away part of the beach--in effect cannibalizing the dunes to feed the system. At first the resulting erosion is worst near the inlet. But as the trend persists, the beach and dunes to the north will increasingly experience the same effects.
For example, consider inlets that are dynamically stable. Over a 50-year period, the shorelines to the north of Price Inlet and Calibogue Sound (Bulls Island and southern Hilton Head Island, respectively) are experiencing accretion. By contrast, the islands north of Capers, Dewees, Stono, and North Edisto Inlets (Capers and Dewees Island, Folly Beach, and Seabrook Island, in that order) are eroding.

Inlets with a history of southerly migration cause erosion, shortening any beach to the south of it.

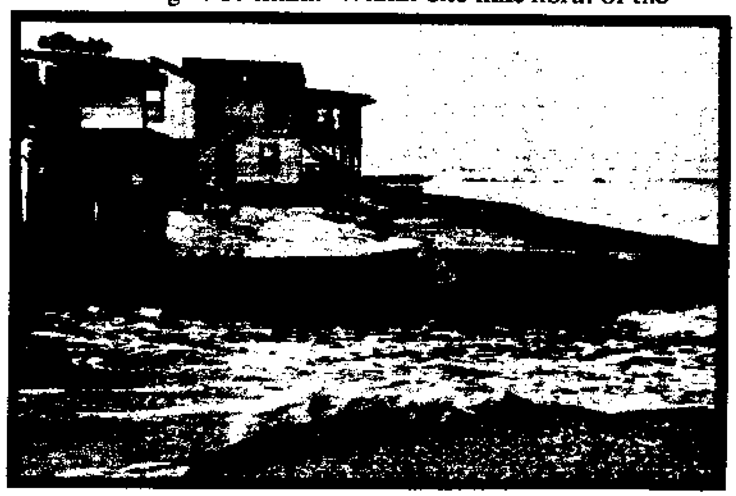
Some South Carolina inlets have a history of southerly migration because their channels are shallow and easily shifted by the growth of sand spits extending from the northern beach. Among these are Murrells Inlet, Midway Inlet, Pawleys Inlet, Breach Inlet, and Captain Sam's Inlet. Obviously, such a migrating inlet causes erosion, shortening any beach to the south of it. But its effects on the shoreline to its north are more subtle.

For example, 50 years ago Murrells Inlet, south of Garden City, lay about two miles north of its present position. Shoals deposited offshore in its ebb-tidal delta produced a bulge in the alignment of the coast. As the inlet shifted to the south over a period of years, sand from the northernmost shoals of the delta either moved with the

The combination of accelerated erosion and imprudent development along parts of Garden City set the stage for major erosion damages during the storm on New Year's Day, 1987.

inlet or migrated ashore and attached to Garden City's beach. The beach became longer; it also realigned with the new inlet position. Gradually the original bulge in the northern shoreline eroded, becoming a principal sand supply for the growing spit to the south. Garden City's shoreline is no longer "anchored" at the south by the earlier bulge. As a result, erosion to the north has increased. This natural process is largely responsible for erosion along much of Garden City. Because the process (erosion of the bulge) lagged behind inlet migration, it did not become a problem until recently. The combination of accelerated erosion and imprudent development along parts of Garden City set the stage for major erosion damages during the storm on New Year's Day, 1987.

In examining this site specific trend more closely, it should be remembered that in Garden City, the area which drew the most media attention after the New Years Day storm, most of the property damage was confined to a one-mile reach. Unlike the rest of Garden City, the damaged section was particularly vulnerable to storm tides. Its beach was narrower and its development was positioned much closer to the normal high tide mark. Within one mile north of the

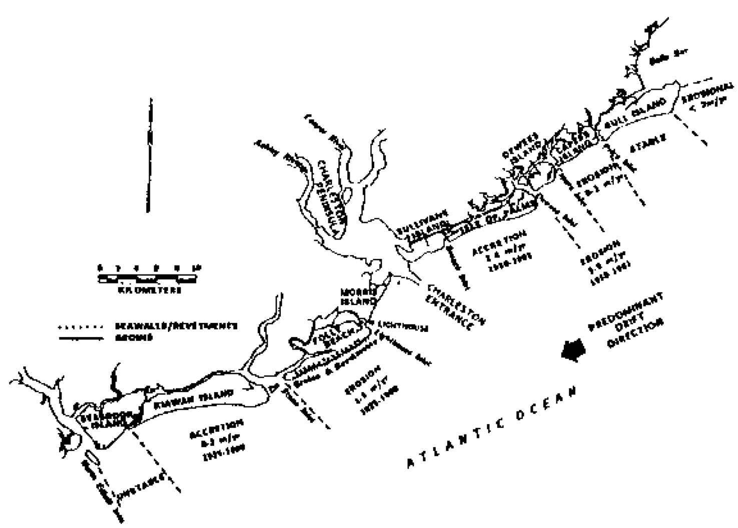


Not the ultimate solution -- even though seawall is intact, sand has washed away from behind the wall.
(Photo courtesy SC Coastal Council)

Kingfisher Pier, for example, there were almost no building setbacks before the storm. High tide reached the seawall in front of many buildings almost every day; without the seawall the natural shoreline would be at least 50 feet inland. Thus, it was not surprising that properties such as these sustained damage, when virtually the entire coast of South Carolina temporarily retreated about 40 feet during the storm. Unless a structure was at least that far behind the foredune, had a minimum healthy beach in front, or had the protection of a very substantial seawall, it sustained damage.

Some of our inlets have been stabilized by jetties which have altered the flow of sand, and for the most part eliminated the natural process of sand bypassing

Some of our inlets have been stabilized by jetties which have altered the flow of sand, and for the most part eliminated the natural process of sand bypassing. The earliest jetties at Charleston Harbor were completed in 1898. Since then, a large supply of sand arriving from the north has built up Sullivans Island by hundreds of feet and now appears to be affecting Isle of Palms in the same positive way. South of Charleston Harbor, Morris Island and Folly Beach have experienced a major sand deficit and consequently have eroded significantly. Jetties were completed at Murrells Inlet



Accretion and erosion trends from Bull Island to Seabrook.

only within the last decade, but already there are positive effects at the southern end of Garden City and the early stages of erosion along Huntington Beach State Park to the south.

Each inlet constitutes a natural boundary dividing the beaches to either side of it, so that each island can be considered a partially closed "compartment" filled partly with sand and partly with water.

Coastal Compartments

Clearly then, South Carolina's inlets are of critical importance to the evolution of our shoreline. In effect, each inlet constitutes a natural boundary dividing the beaches to either side of it, so that each island can be considered a partially closed "compartment" filled partly with sand and partly with water. Since the process of sand bypassing is episodic rather than continuous, adjacent beaches become dependent on the timing and rate of sand movement from ebb tidal deltas to the shoreline. If more sand enters the compartment from the north than leaves to the south, the beach will build up, moving the shoreline seaward. But if no sand enters the compartment from the north for a long time, sand losses at the southern end will soon cause erosion all along the beach.

The barrier islands around Charleston illustrate the compartmented but interdependent nature of our coast. Moving from north to south and considering each island as a separate unit, the history of sand bypassing at each inlet suggests that we can expect the following long term trends to predominate over the next several decades:

- ***Dewees Island:*** Severe erosion comparable to its losses, averaging 20 feet per year during the past 40 years;
- ***Isle of Palms:*** Accretion because of major sand bypassing from Dewees Island and an historical trend of more than five feet of deposition per year;
- ***Sullivans Island:*** Accretion because of surplus sand bypassing from Isle of Palms and sand trapping by Charleston Harbor's north jetty;
- ***Morris Island:*** Erosion because of a cutoff in sand supply after the Charleston Harbor jetties were constructed almost a century ago;
- ***Folly Beach:*** Erosion because of a cutoff in sand

supply as well as loss of sheltering by the natural ebb-tidal delta of Charleston Harbor which existed before construction of the jetties;

- ***Kiawah Island:*** Accretion because of periodic inlet bypassing events, which account for extensive buildup of the island during the past century;
- ***Seabrook Island:*** Variable periods and zones of accretion and erosion because of the instability of Captain Sam's Inlet.

Certainly, the above generalizations discount localized, or short-term variations such as the shoal bypass event at Isle of Palms (discussed earlier), which produce nearby areas of accretion and erosion. Nor does this summary identify the principal cause of erosion in each case. Dewees Island's erosion for example, has nothing to do with the Charleston jetties or high wave energy. Instead, it occurs because of too much protection from waves by large tidal deltas which blanket the entire shoreline. Ironically, wave action is minimal most of the time along Dewees Island. But after storms erode the beach and dunes this "normal" wave action is insufficient to rebuild the shoreline. Daufuskie Island also has a high erosion rate because of these factors.

These brief illustrations point up the variations in South Carolina's shoreline and the dramatic differences in erosion between adjacent islands. Thus, while Kiawah is a model of stability, some residents of nearby Folly Beach try almost any type of shore protection structure to save their property. Such conflicting experiences tend to indicate that beach erosion is by no means a universal problem in South Carolina.

COASTAL DEVELOPMENT

Natural changes in South Carolina's system of inlets and barrier islands occur gradually, even subtly, over periods of tens or hundreds or even thousands of years. The most dramatic events are storms. But distinctions between rapidly eroding or slowly eroding areas become lost where coastal development exists or is proposed. To front beach owners, a short term erosion trend associated with changes at an inlet is just as bad as a steady long term trend if it impacts their property.

Coastal development is driven by demand for coastal real estate and people's willingness to offer or accept mortgages on such property. Since the typical life of a mortgage is 20 to 30 years, one would expect buyers and lenders to be concerned about beach erosion occurring during that time frame.

But the demand for beachfront property has skyrocketed since World War II, while the supply of such property remains fixed. With federal subsidies for flood insurance under the FEMA program since the late 1960s, investment in coastal property is all but guaranteed to provide a generous return. Property values in many areas are doubling every five years or less, so that coastal property has become a favorite investment.

More than any natural process, the combination of rising demand, accelerating property values, and government insurance subsidies has created the beach erosion "problems" we have today.

More than any natural process, this combination of rising demand, accelerating property values, and government insurance subsidies has created the beach erosion "problems" we have today. Where there is no development, the beach's shifts with changing tides and sand supply are largely ignored. But where there are structures, we are attentive to even small changes, especially if we own property that is threatened.

As much as any place on South Carolina's coast, Myrtle Beach illustrates the problem. Virtually undeveloped at the turn of the century, by the late 1930s Myrtle Beach had a small community of beachfront cottages and a few hotels. As recently as 1955 cottages dominated the three-mile section south of the pavilion that marks the center of Myrtle Beach and South Carolina's Grand Strand. Most of the lots in this area were over 350 feet deep, with houses set toward the back of each lot, close to Ocean Boulevard. Natural dune fields remained between the houses and the beach, and even after Hurricane Hazel flattened the area in 1954, most of the platted lots remained intact, recovering after the storm.

Myrtle Beach illustrates the problem -- At $10,000 per foot for beachfront property, income-generating development has been accompanied by a proliferation of seawalls that contribute to other problems, including reduction of the sand supply from natural dunes and narrowing of the high-tide beach.

During the 1960s and 1970s, however, almost every cottage was replaced by a motel. Because they were much larger than the single-family houses they replaced, motels and their parking lots filled most of the area of each lot, reducing the setback of the development from the beach. During this period there were no restrictions, other than prudence, on developing property up to the edge of the foredune. Natural erosion along this shoreline averaged less than one foot per year, so there were few problems until the development encroached too close to the beach.

Hurricane David, in 1979, brought the first scare to owners of many of these new structures when it cut away 10 to 20 feet of the foredunes. This single event temporarily increased the average erosion rate for Myrtle Beach. But more importantly, it prompted more motel owners to build seawalls or other types of structures to protect their buildings; by 1983, 30 percent of Myrtle Beach was armored. The proliferation of seawalls contributed to other problems, including reduction of the sand supply from natural dunes and narrowing of the high-tide beach. Development trends in the past decade have continued to exacerbate the problem, with highrises replacing motels, and parking garages, pools, and related structures taking up all remaining areas of each lot. At $10,000 per foot of shoreline for beachfront property, income-generating development has taken over the dunes along the Grand Strand.

The significance of economic factors is clear in the Myrtle Beach experience. Because of booming property values, the frame of reference governing the feasibility of development has shrunk from several decades to a few years, and a dune buffer previously measured in tens of feet has shrunk to no buffer at all. Even if nature is cooperative and maintains a low erosion rate at Myrtle Beach --currently less than one foot per year-- the density of development up to the active beach ensures that erosion will continue to be a problem.

Scouring caused by presence of seawall; the seawall doesn't cause large-scale erosion, but does accelerate erosion of high tide beach by blocking exchange of sand from dunes.
(Photo courtesy of SC Coastal Council)

Establishing a Common Framework

Just as the lack of definitive data on shoreline movement in many coastal areas exacerbates the beach erosion problem, so does the absence of an acceptable time frame for addressing it. We also tend to focus on erosion "hotspots" where development is threatened, even if nearby property is accreting. Popular articles on beach erosion are notably lacking in any common reference to time and quite notorious in their selection of "representative" photos. The "shoreline debate" that has flared in the press during the past decade is

We would have a much better chance of defining and dealing with the problem of beach erosion if everyone accepted a common time frame and considered the problem on a regional basis.

Fifty years provides a reasonable time over which to make plans for protecting property, saving the beach, or scaling back development.

fueled by imprudent development constructed with a "five-year return" in mind. Yet five years is obviously not the time frame anyone considers once a building, with its aura of permanence, is completed.

At the other extreme in the debate are those who view the problem over the next millenium. While the geologic evolution of our coast is measured at this scale, it is totally impractical for planning and coastal zone management.

It seems we would have a much better chance of defining and dealing with the problem of beach erosion if everyone accepted a common time frame and considered the problem on a regional basis. Some basic guidance can be found in today's flood insurance regulations and setback planning in coastal states which typically entail time frames of 30 to 100 years. Flood insurance, for example, is based on the predicted highest waters occurring in 100 years. Florida considers a 30-year erosion rate in establishing a zone where construction is prohibited along the beach. Myrtle Beach has a development ordinance based on a predicted 50-year erosion rate. This rate is based on long-term averages over an eight mile shoreline, recognizing that some beaches will experience more rapid retreat for a period of time and others may contradict the regional trend.

If we adopt a common time frame and divide the South Carolina coast into a set of compartments having similar exposures to the ocean, we may be able to reach a consensus regarding solutions to erosion or placement of controls on development. Fifty years provides a reasonable time over which to make plans for protecting property, saving the beach, or scaling back development. It also stretches our predictive ability near the limit when we deal with physical processes and shoreline change in a setting such as South Carolina. Assuming this time frame is acceptable, what shoreline trends are likely to predominate in the next half-century?

SHORELINE INVENTORY

Armed with erosion surveys conducted to date (see bibliography for a fairly complete list of studies), it is now possible to predict future shorelines accurately for some of our coast, or inaccurately for all of our coast. Noting the hazards of such undertakings, what follows is a first attempt at most of the coast. We are at a point in the state's regulatory history when hard questions are being asked about coastal development. That there is a need for greater building setbacks in some areas is indisputable. But the extent of the problem is exaggerated, at least from the standpoint of our continued fixation focus on certain eroding areas. When one considers the entire coast of the state, there is indeed cause for optimism.

The following shoreline inventory addresses the beach erosion problem over approximately fifty years and considers it by distinct compartments, or reaches, and according to differences in development.

If some sandy shorelines along the inlets are omitted, South Carolina has about 181 miles of ocean beach. Fully 42 percent of this total is undeveloped and held in trust as wildlife preserves, research domains or state parks (Table 2). This protected category includes the entire coast between North Inlet and Capers Inlet (more than 40 miles). Other shorelines, such as Edingsville Beach, are undevelopable because all the high ground has already been washed away. In all there are almost 70 miles of natural beach free from erosion problems associated with development. The remote nature of many of these areas, such as Cape Romain, make them ideal wildlife habitats.

Another 10 percent of the coast is presently undeveloped (Table 3) but privately owned, and thus possibly subject to development sometime in the future. In these sections, more than in any other coastal areas of South Carolina, development can be planned to accommodate erosion during the next 50 years or longer. Some sections, such as Dewees

Table 2

Preserved open coast

Site	Status	Miles
Myrtle Beach State Park	(P)	1
Huntington Beach State Park	(P)	2
Cape Litchfield - Coastal Barriers Resource Act (CBRA)	(O)	1
Debidue - Baruch Foundation	(W)	2
North Island - Yawkey Foundation	(W)	8
South Island, Cedar Island, Murphy Island - Yawkey Foundation	(W)	12
Cape Romain - Cape Romain National Wildlife Refuge	(W)	7
Raccoon Key - Cape Romain National Wildlife Refuge	(W)	5
Bulls Island - Cape Romain National Wildlife Refuge	(W)	7
Capers - South Carolina Heritage Trust Preserve	(W)	3
Folly Beach Park - Charleston County	(P)	1
Kiawah - East End (CBRA)	(O)	2
Captain Sam's Inlet - Conservation Zone (CBRA) Beachwalker Park	(O,P)	2
Botany Bay Island (south) - Washover Barrier	(O)	3
Edingsville Beach - Washover Barrier	(O)	2
Edisto Beach State Park	(P)	1
Pine/Otter Island - Washover Barrier	(O)	4
Hunting Island State Park	(P)	4
Pritchards Island - University of South Carolina Research Preserve	(W)	2
Capers Island/St. Philips Island (Trust - CBRA)	(O)	5
Turtle Island - South Carolina Heritage Trust Preserve	(W)	2
		76

Preserved coast totals 76 miles (42% of total coast of 181 miles)

W = wildlife preserves (48 miles)
P = public parks (11 miles)
O = other probably undevelopable (17 miles)

Island, have very high erosion rates, but other tracts have been remarkably stable.

Table 3
Private undeveloped open coast*

Site	Miles	Erosion Status
Waites Island (CBRA)	2	E>1
Grand Strand (various tracts)	2	E<1
Debidue Island (north)	2	S
Dewees Island (CBRA - 1)	2	E>1
Morris Island	3	E>1
Botany Island	1	E>1
Hilton Head (various tracts)	2	variable
Daufuskie (portions)	2	E>1
Other (miscellaneous)	1	variable
Total	17	

Private undeveloped coast totals 17 miles or 9% of total coast of 181 miles.

S = stable
E<1 = erosion at less than 1 ft/yr
E>1 = erosion at greater than 1 ft/yr

* Includes Coastal Barriers Reserve Act (CBRA) zones probably developable without federal insurance.

Thirty-one miles or 37 percent of our developed shorelines appear to be reasonably safe from erosion in the next 50 years.

About 50 percent of our shoreline (Table 4) consists of areas that are developed and where erosion is, consequently, of most concern. The available data suggest that a large percentage of our developed coast has been either stable or accretional in the proposed 50-year time frame. Examples include Isle of Palms, Sullivans Island, Kiawah Island, and the ends of Hilton Head Island. Thus, 31 miles or 37 percent of our developed shorelines appear to be reasonably safe from erosion in the next 50 years.

Table 4

Developed open coast

Site	Miles	A	S	E<1	E>1
North Myrtle Beach	12	1	3	8	
Myrtle Beach	9		1	8	
Surfside	5			5	
Garden City	5	1		3	1
Litchfield Beach	4		1	1	2
Debidue	1				1
Isle of Palms	7	5	1	1	
Sullivans Island	3	2	1		
Folly Beach	5				5
Kiawah Island	7	5	2		
Seabrook Island	3	1		1	1
Edisto Beach	5	1		1	3
Harbor Island	1				1
Fripp Island	3				3
Hilton Head Island	12	6			6
Daufuskie	2				2
Totals	88	22	10	30	26

Developed open coast totals 88 miles or 49% of total coast of 181 miles.

A= accretion
S = stable
E<1 = erosion at less than 1 ft/yr
E>1 = erosion at greater than 1 ft/yr

Other large sections, including most of the Grand Strand, Litchfield Beach, parts of Debidue Island, and the southern end of Edisto Beach, have experienced little or no change over the past 50 years. Erosion problems in some of these areas are, as discussed earlier, often the result of encroaching development rather than of any dramatic events of nature.

Along 30 miles of beach, natural erosion is of the same range as sea-level inundation during the past century. For example, mean sea level in South Carolina has risen 0.8 feet in the past 100 years. This rise is equivalent to erosion of 0.3 to 0.5 feet per year simply from inundation of the land (given the average slope of a beach). In Myrtle Beach, where erosion has averaged 0.6 feet per year since 1955, sea-level rise could account for much of the loss. But, at its present rate, or even at a doubling or tripling of the rate predicted in the next century, sea-level rise alone cannot account for the 8 foot-per-year erosion rates along Daufuskie Island and some other areas near inlets.

The heart of South Carolina's beach erosion problem lies along those 26 miles or so of beach that are developed and are apparently experiencing more rapid erosion.

The heart of South Carolina's beach erosion problem lies along those 26 miles or so of beach that are developed and are apparently experiencing more rapid erosion. Principal among these areas, in terms of our 50-year perspective, are large portions of Pawleys Island, Folly Beach, parts of Edisto Beach, Fripp Island, and central Hilton Head Island. Whether anything can be done to save these beaches and their developments depends largely upon better definition of the problem in each place. Little is known about the rate of erosion on Fripp Island, for example, or about the total amount of sand lost, because quantitative surveys are lacking. In many of these cases, determining long term erosion rates is guesswork made even more difficult by the presence of seawalls, groins, and related shore-protection structures.

When one considers the entire state a relatively small percentage of the coast is in critical condition, that is, developed and eroding rapidly. Importantly, many of our erosion "hot spots" are isolated from nearby areas by the natural boundaries created by tidal inlets. Folly Beach's erosion trend, for example, is separate and distinct from Kiawah's, one inlet away. The diversity of erosion trends as well as development histories suggests the need for flexibility in managing future coastal development and protecting our beaches from one area to another. South Carolina's compartmented coast makes this easier than most shorelines in the United States.

The 42 percent of our coast that is protected from development is relatively easy to manage because development has been restricted. Of the 76 miles thus preserved, however, only 11 miles have been made accessible for public parks.

MANAGING THE SHORELINE

Future demands on our beaches can only increase, given rising population and migration into the coastal zone. But the shoreline 50 years from now does not have to look like New Jersey's, with its massive seawalls and numerous groins. Nor can we expect all of South Carolina's beaches to be untrammeled as they are along Bulls Island. The shoreline inventory indicates areas where planning and beach restoration will return the greatest rewards.

The 42 percent of our coast that is protected from development is relatively easy to manage because development has been restricted. Of the 76 miles thus preserved, however, only 11 miles have been made accessible for public parks. Easy-access beaches with plentiful parking are in short supply. In Charleston County, for example, one would be hard-pressed to find over 2,000 legal parking spaces near the beach for day trippers. Each of our metropolitan areas along the coast needs convenient public access beaches in order to accommodate the majority of people who do not own coastal property or who cannot afford to rent beachfront accommodations.

Management of roughly 17 miles of privately owned but as yet undeveloped beaches is also relatively easy. For these areas erosion histories should be carefully reviewed and future shorelines predicted before development setback lines are drawn. As Table 3 indicates, erosion rates vary from tract to tract but, by and large, a 50-year projection of erosion rates would not render any of these lands undevelopable. Some areas such as Waites Island and Morris Island offer potential sites for high-use public beaches if they can be acquired and linked to the mainland by bridges. Morris Island, with considerable improvements, could be developed as a noncommercial urban park along the lines of Jones Beach, New York. Other areas can be considered for deeding to the state and preserved in trust in return for tax credits. Botany Island, for example, was partially deeded to the Nature Conservancy and will have restricted development along a small number of interior lots.

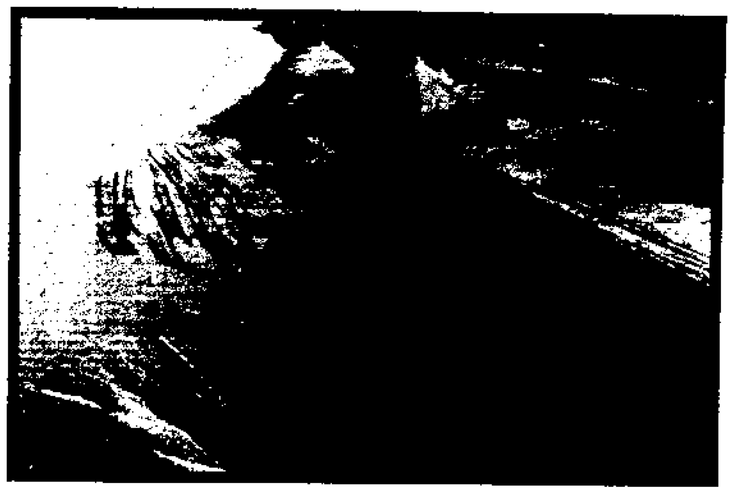
Dune protection with vegetation and sand fences; sand fences are only effective where there is a high tide beach seaward of dune.
(Photo courtesy SC Coastal Council)

The 32 miles of developed shorelines that are stable or accreting should lock in existing setbacks and enjoy the wide margin of safety they have in relation to other areas of the coast.

The 32 miles of developed shorelines that are stable or accreting should lock in existing setbacks and enjoy the wide margin of safety they have in relation to other areas of the coast. Some of these places, however, are located along inlet deposition zones and owe their positive trends to losses from nearby areas. Such is the case with Sea Pines (at the southern end of Hilton Head) and the southern end of Garden City. If the patterns and rates of sand movement are known, it may be possible to borrow some sand from accreting zones to temporarily restore adjacent eroding zones, as long as development is left with a buffer. This type of sand recycling should follow the natural sand transport patterns for an area. It is a particularly important option for situations in which shoals have attached to the shore, causing rapid buildup in one place and erosion in another. Where overall sand budgets are positive, such projects will not produce long-term problems. Most importantly, they can be done at a fraction of the cost of beach nourishment from an inland or offshore source. This

Costs for sand scraping from accreting zones and transfer to nearby eroding zones typically range from $1 to $2 per cubic yard (current prices). Beach nourishment from inland or offshore sources typically costs from $5 to $10 per cubic yard.

has been proven in several places from Isle of Palms to Seabrook. Costs for sand scraping from accreting zones and transfer to nearby eroding zones typically range from $1 to $2 per cubic yard (current prices). Beach nourishment from inland or offshore sources typically costs from $5 to $10 per cubic yard. Studies have shown, that if sand scraping is completed during winter months, environmental impacts are minimal and beach habitats generally recover quickly. Such options provide the most cost-effective alternative to seawalls in these situations and preserve our recreational beaches.



Sand scraping from accreting areas (bulge formed by detached ebb tidal delta); erosion at top of picture due to refraction.
(Photo courtesy SC Coastal Council)

The best option for the 30 developed miles that are eroding at less than one foot per year seems to be nourishment from an external source combined with setbacks for replacement construction.

For the 30 developed miles that are eroding at less than one foot per year, sand scraping is not viable over the long term. But neither are seawalls. The best option for these areas seems to be nourishment from an external source combined with setbacks for replacement construction. The City of Myrtle Beach has set up a model program. Recognizing that hotels cannot be torn down very easily and that erosion rates there are low, the city implemented a three-part plan involving a 50-year setback line for redevelopment, a community-wide beach nourishment project, and an annual monitoring and maintenance program. Each of these elements is critical to the city's plan to have a beach 50 years from now, as well as thousands of convenient hotel rooms for beach users.

While costs of nourishment and related beach maintenance at Myrtle Beach have exceeded $5 million since 1980, these beach restoration measures largely paid for themselves in savings from property damage prevented during last year's New Year's Day storm. Since much of the mileage of coast eroding at less than one foot per year is contiguous between Little River Inlet and Murrells Inlet, each local nourishment project in the Grand Strand has the potential to help its neighbors. Evidence shows that the success of beach nourishment is directly related to length of the project. Along the Grand Strand, low erosion rates make this even more likely.

The developed beaches that are eroding at greater than one foot per year pose the greatest challenge for future management. Aside from improved monitoring, future management should focus on maintaining a recreational beach. This cannot be accomplished with seawalls.

The remaining developed beaches that are eroding at greater than one foot per year pose the greatest challenge for future management. Most of these areas already have some sort of shore protection in place, most commonly seawalls and groins. Unfortunately, many of them represent the few accessible beaches we have. Aside from improved monitoring, future management of these areas should focus on maintaining a recreational beach. This cannot be accomplished with seawalls. Groins, breakwaters, and terminal jetties have the potential to retard the rate of erosion and may have to be an integral part of each site-specific plan, but beach owners must recognize that seawalls will ultimately reduce the amount of usable beach in these settings. If individual property owners pool the resources they plan to apply in constructing and maintaining seawalls with the resources of the community, they will be in a better position to maintain a beach by way of nourishment. Clearly, the entire beach-user community benefits from a maintained beach. But the oceanfront owner benefits most through improved shore-protection and reduced maintenance costs to seawalls.

One community in Georgia elected to armor the shoreline as erosion accelerated during the 1970s. Owner after owner built low-sloping concrete seawalls or rock revetments as erosion threatened each property. In five years' time, over $5 million had been invested in the two-mile-long seawall. The average expenditure was $500 per foot of shoreline. Today, there is almost no low-tide beach--let alone a high-tide beach--in the area. And one can find the eroded sand in the inlets at either end of the island. If the community had banded together at an early stage, they might have found alternatives to costly seawalls. Sand scraping from accreting zones at the inlets or construction of a permanent pipeline for dredging sand to a feeder beach in order to keep pace with erosion would have been more effective and of comparable cost. Ironically, continued erosion in front of the seawall increases the vulnerability of the wall each year so that more rocks have to be added over time. If a beach were maintained in front of the wall, owners' maintenance costs would be reduced substantially and the entire community would have a more viable beach.

Lack of consensus for solutions within our beach communities is the greatest problem we face among those areas eroding more than one foot per year.

Some communities in South Carolina have taken the same approach as that unfortunate Georgia community. The longer erosion occurs, the more difficult beach restoration will be. Initial nourishment costs will be highest where seawalls are exposed to waves at mid tide or low tide. Where some high-tide beach remains, initial nourishment costs will be lower and periodic renourishment can be accomplished on a pay-as-needed basis. The hardest part of the solution is gaining community-wide support. Lack of consensus for solutions within our beach communities is, perhaps, the greatest problem we face among those areas eroding more than one foot per year. But it is clear that individual seawalls are not the ultimate solution of choice by the majority of our citizens.

SUMMARY

When one goes beyond a superficial assessment of the issue, it becomes clear that South Carolina's beach erosion problem is probably not as serious as most people believe. A relatively small percentage of the developed portion of our coast is eroding badly, and we now possess much more information to help us evaluate each problem area. Although global sea-level rise and periodic storms are contributing factors, beach erosion is largely a result of human activity.

Recent concern about beach erosion has prompted proposals for legislation to strengthen South Carolina's coastal zone management laws. We need to adopt a common time frame of at least 50 years and acknowledge the effect of a compartmented coast on the movement of sand within each beach community. If we can adopt such a framework, we may be able to reach a consensus regarding solutions to erosion or placement of controls on development.

With many erosion studies available to us and some successful beach restoration projects in the state, there is cause for some optimism. South Carolina is one of the few states in which development and beach erosion problems break down into discrete, manageable compartments. At one extreme there is Myrtle Beach with its dense development close to the ocean; at the other there is a 40 mile line of protected and relatively inaccessible barrier islands forming one of the greatest wildlife preserves of the East Coast. South of Charleston two developed islands next to each other provide a study in contrasts. Management strategies for Kiawah's accreting beach would differ from those for Folly's eroding beach, one inlet away. Each area is unique and requires a tailored solution.

Of 181 miles of ocean shoreline, 59 miles are protected wildlife preserves or public parks, 17 miles are probably undevelopable, 88 miles are presently developed close to the dunes, and the remaining 17 miles are privately owned and are subject to possible development in the future. Each of these coastal areas requires a different management strategy.

Better understanding of the beach erosion problem is essential to improved management.

We can apply passive land-use controls such as setback lines in areas that are undeveloped, or developed and accreting. But we have to take a more proactive approach where erosion is threatening existing development.

To the extent possible, we should attempt to solve most of our erosion problems with "soft" solutions like sand nourishment, using innovation to locate sand and move it economically. But if solutions are not forthcoming and the balance between private oceanfront development and preservation of the public beach remains at odds in some areas, then we should consider setting aside more of South Carolina's oceanfront for public parks. Better understanding of the beach erosion problem is essential to improved management, and public perception might change dramatically if we make more of our beautiful coast accessible.

Managing our coast requires a better understanding of its dynamics. Here dunes are protected by boardwalks and walkovers.
(Photo courtesy of the SC Coastal Council)

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A number of oceanfront communities and the South Carolina Coastal Council have funded beach-monitoring, and it is largely this database which has given us detailed knowledge of the coast. In particular, the programs at Myrtle Beach, Kiawah, and Seabrook have been very instructive. Some of these communities have implemented beach-restoration projects on the basis of shoreline monitoring results. Periodic beach monitoring is now an integral part of the South Carolina Coastal Council's management of the coast.

Finally, I wish to thank Margaret Davidson, Executive Director of South Carolina Sea Grant, for encouraging me to write this paper. I have received fine editorial and technical assistance from the Sea Grant staff as well as the staff at Coastal Science & Engineering, Inc.

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During the past decade, he has conducted research throughout the South Carolina coast as well as sites in New England, New York, Maryland, North Carolina, Florida, Texas, and Alaska. He has also directed projects in Kuwait, France, West Africa, and the U.S. Virgin Islands.

Dr. Kana's research interests include beach erosion and coastal processes, impacts of sea-level rise, shore-protection planning, waves, and tidal inlets. He has written over 100 technical reports and publications on these topics and serves as a reviewer for several professional publications.

Dr. Kana was project director for Myrtle Beach's $4.5 million nourishment project in 1985-1987 and developed the plan for relocating Captain Sam's Inlet near Seabrook in 1983. He has served as an expert witness on beach erosion and estuarine processes and as an advisor to the South Carolina Coastal Council. He is a registered marine geologist in South Carolina and a member of Who's Who in Frontier Science & Technology.

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