3. Shoreline engineering: the impossible dream?

Rising sea level, diminishing sand supplies, and barrier island migration have caused shoreline retreat along much of the American coast. The common response to this natural process has been to try and stop it — stabilize the beach so it no longer moves landward.

Shoreline engineering is a term that refers to methods of changing or altering the natural shoreline system in order to stabilize it, that is, to hold it in place. Shoreline stabilization is a synonym for shoreline engineering. Stabilization methods range from the simple planting of dune grass to the complex construction of large seawalls using draglines, cranes, and bulldozers. Stabilization is usually carried out in response to a recognized danger to buildings located next to a beach. Examples of such stabilization abound on Florida’s east coast: Fernandina Beach, Jacksonville Beach, St. Augustine Beach, Daytona Beach, Cocoa Beach, Vero Beach, Jupiter Island, Palm Beach, Hillsboro Beach, Fort Lauderdale, and Key Biscayne, to name just a few. Sometimes stabilization, especially beach replenishment, is carried out both to prevent buildings from falling into the sea and to increase the recreation value of a beach. This is the case in Jacksonville Beach, Pompano Beach, Jupiter Island Beach, and Miami Beach.

Local rhetoric to the contrary, most shoreline engineering is carried out to save buildings and not beaches. Beaches never need saving. When left alone in their natural state, beaches change their position in space but always remain “healthy” strips of sand. Another way of saying this: if we allow all of the cottages and condos to fall in as the shoreline erodes, the beaches will remain perfectly healthy and usable by all who wish to fish, swim, picnic, surf, camp, hike, stare at the surf, or whatever. It may not be realistic on the Florida political scene to allow 20-story condos presently located at the surf’s edge to topple into the ocean as the beach retreats, but it should be made clear to all concerned that the natural beach itself never needs man’s help and that shoreline stabilization becomes necessary only when man builds his structures too close to the sea. Man is the only enemy the beach knows (figs. 3.1 and 3.2).

The economic and environmental price of stabilizing a beach can be stiff indeed. Replenishment of beaches costs on the order of $1 million to $6 million per mile. Seawalls cost $300, $800, and even $1,000 per foot of shoreline.

There are, of course, a few situations in which stabilization is an economic necessity. Channels leading to our major state ports such as Miami and Jacksonville, for instance, must be maintained, and damage to local beaches may be an acceptable price. In other cases recreational value may be used as justification for groins and replenishment. For example, Jones Beach, New York, may have hundreds of thousands of swimmers on a single summer weekend day. Such beaches can be considered to be national treasures and if their maintenance requires a great deal of tax money and even
Fig. 3.1. This beach scene of 1909 clearly shows that Palm Beach has lost a great deal of beach in the interim and that the formality of beach attire has changed during the same time period. Photo courtesy of the Palm Beach Historical Society.
some damage to nearby beaches and structures, so be it. Perhaps Fort Lauderdale’s jammed beaches fall in the national treasure category.

There are three major types of shoreline stabilization: (1) beach replenishment, (2) groins and jetties, and (3) seawalls. These are discussed below in order of increasing environmental damage.

**Stabilizing the unstable**

**Beach replenishment (nourishment)**

If you must “repair” a beach, *beach replenishment* is the most gentle approach. Replenishment, sometimes called nourishment, consists of pumping or trucking sand onto the beach and building up the dunes and upper beach that have been lost to erosion (fig. 3.3). Sufficient money is almost never available to replenish the entire beach that extends out into the water to a depth of about 30 to 40 feet. Thus, only the upper beach is covered with new sand. In effect, a steeper beach is created (fig. 3.4).

The steepened beach quickly becomes less steep, because a replenished beach erodes very rapidly as the beach system attempts to come to a more natural profile. Experience suggests that (depending on a number of factors such as the grain size of the sand) erosion of a replenished beach will occur at a rate that is at least ten times that of the natural beach. Even more fundamental than steepening as a cause of erosion is the problem of sea-level rise (discussed in chapter 2 and later in this chapter).

For beach replenishment, sand is either pumped from the back side of the island, from a nearby inlet during periodic dredging, from a pit on the island, or from the continental shelf; most often it is taken from the shelf. Sand from the landward side of the island tends to be too fine; it quickly washes off the beach. Furthermore, dredging in back of the island disturbs the ecosystem, and the resulting hole affects waves and currents there, and this can cause harm.

The best source of sand environmentally, but also the most costly, is the continental shelf. Extreme care must be taken not to destroy coral colonies and other organisms away from the imme-
Molding sand recently pumped up on a beach with a bulldozer, Lauderdale-by-the-Sea. Photo by Bill Neal.

Fig. 3.3. Why replenished beaches disappear faster than natural beaches.

The adjacent shoreline will likely be affected. Off the Connecticut coast wave patterns were altered by a hole dredged on the shelf, and the replenished beach quickly disappeared as a result. This may be part of the reason why the Pompano Beach and Jupiter Island Beach nourishment projects disappeared so quickly.

Beach replenishment also can create a false sense of security about storms because past damage is concealed. In addition, the value of property behind a nourished beach is maintained or increased, and this spurs an increase in development, including...
condominiums. This has happened at Jacksonville Beach. The growth in development density will increase the demand and political pressure from the community for continuing rounds of beach replenishment. The presence of beach-front condominiums makes the building relocation alternative response to the eroding shoreline an impossible dream.

Fig. 3.5. Removing coral fragments from a replenished beach to increase the "swimmability" North of Hollywood Beach. Photo by Bill Neal.

Fig. 3.6. A pocket of coral head fragments on Miami Beach. Photo by Orrin Pilkey, Jr.
Beaches cannot be replenished ad infinitum. Sand supplies become exhausted, more distant, and always more costly. Naturally sand supply diminishes as the stabilized island, held in place where we think it "should be," becomes more and more out of equilibrium with the rising sea level. Past experience tells us that, inevitably, the island community will resort to more drastic stabilization measures such as a seawall.

The most celebrated replenishment project of recent years took place in Miami Beach where 15 miles of beach were replaced at a cost of $68 million. Completed in 1981, the project unquestionably has revitalized the tourist industry of Miami Beach (figs. 3.7 and 3.8), and at the same time the new beach is a very important element in hurricane protection. Before the storm waves can begin to smash into buildings, they first must smash into and remove the new beach.

The new Miami Beach is the envy of many coastal communities with narrowed or nonexistent beaches, but the $68 million price tag to benefit 10 miles of shoreline makes it a very costly solution. The costs do not end here. The new Miami Beach will gradually disappear in response to normal erosion processes and the rising sea level. It will need frequent re-replenishment or what the Corps of Engineers calls beach maintenance. In a big storm it could all disappear almost overnight, but that is one of the purposes of the beach; to sacrifice itself to save the community from direct wave attack.

There is a possibility that the new Miami Beach berm will

Fig. 3.7. The "old" Miami Beach, 1972. The principal reason that the beach disappeared in Miami Beach may simply be that buildings were built virtually out on the beach. Photo by Orrin Pilkey, Jr.
up largely of hard quartz sand. The new beach is made up of the
much more delicate shells of marine organisms, some of which are
microscopic in size. At the other end of the size spectrum are
cobbles of limestone and reef fragments that are hazards to the
bare feet of swimmers. The fine size and delicate nature of much
of the new Miami Beach is responsible for the murky water in a
surf zone once renowned worldwide for its clarity.

Beach replenishment seems to be the wave of the future for
all the Florida shore. It is certainly an approach preferable to the
old New Jersey method of building bigger and bigger seawalls. In
the summer of 1983 Pompano Beach was pumping up its second
major beach in just a few years. Almost certainly in 2 to 5 more
years the new beach will have largely disappeared and will need
re-replenishment at an additional cost of millions. In the case of
Pompano Beach there is a good likelihood that the sand is being
pumped from too close to shore, and the new beach may simply
be “falling back” into the hole whence it came. Expert geological
or oceanographic advice is needed to choose an offshore dredging
date, but so far Florida beach replenishment projects seem to be
the exclusive realm of the engineering profession.

Hobe Sound (Jupiter Island Beach) is now replacing its beach
for the third time since 1974. In all, this very exclusive and wealthy
community will have spent more than $7 million in a decade to
maintain about 5 miles of beach. The money is entirely raised
from the 400 or so families on the island, and, as a consequence,
the community’s beach front remains private property except for
a public park. When state or federal tax money is used, as on
Pompano Beach and Miami Beach, convenient public access must be maintained.

There is an additional problem that must be addressed (fig. 3.3) when beach replenishment is contemplated: we observed a high density of turtle tracks and turtle egg nests on Hobe Sound beach at the location of the ongoing 1983 summer replenishment project. Burial of turtle nests will, of course, prevent their hatching.

In general, the minimum cost of beach replenishment is approaching $2 million per mile in the United States. Consider that virtually thousands of miles of American shoreline have buildings crowded close to the beaches, and that all of these communities will soon be in danger from shoreline erosion because the sea level is rising. If the majority of these communities seek to stabilize their shorelines, the potential cost to taxpayers, local and federal, is tremendous. So much so in fact that a taxpayers’ rebellion is brewing, as reflected by the passage of the barrier island bill in the 1982 session of Congress (see chapter 5). This legislation removes all future expenditures (federal subsidies) on presently undeveloped barrier islands. Future federal support for beach replenishment most likely will become more and more difficult to obtain.

In summary, beach replenishment is unquestionably superior to other forms of stabilization. However, it upsets the natural system, and it is costly and temporary, requiring subsequent replenishment projects to remain effective. The Corps of Engineers refers to its beach nourishment projects as “ongoing,” but “eternal” might be a better word. Also, serious economic questions can be raised when the facts associated with beach nourishment are considered—especially since it is not the general public (which pays for these projects through taxes) that typically receives the greatest benefit from them. Cries for beach nourishment projects invariably come from those with direct economic interest associated with beach use—that is, from owners of cottages, motels, beachwear and gift shops, and other commercial ventures in the community, especially owners whose buildings are in danger of falling into the sea. Beach nourishment paid for with tax money is a form of government subsidy for the “well-off.”

Thus, there are many problems associated with beach nourishment, but you can say this for it—it is a lot better than the following types of stabilization.

**Groins and jetties**

_Groins and jetties_ are walls extending into the ocean from the shore, perpendicular to the shoreline. A jetty, often very long (sometimes miles), is intended to keep sand from flowing into a ship channel; jetties frequently come in pairs, one on each side of the channel. Groins are much smaller walls built on straight stretches of beach away from channels and inlets. They are intended to trap sand flowing in the longshore (surf-zone) current. There are groins present today on many Florida beaches; in fact, it is hard to find a developed community without at least a few groins. Groins can be made of wood, stone, concrete, steel, nylon bags filled with sand, and even wrecked cars.

Both groins and jetties are very successful sand traps. If a groin is working correctly, more sand should be piled up on one side of
Fig. 3.9. A nesting loggerhead turtle.
it than on the other. The problem with the groin is that it traps sand that is flowing to a neighboring beach. Thus, if a groin on one beach is functioning well, it must be causing erosion elsewhere by starving another beach (fig. 3.10). The same is true, of course, for jetties. Sand trapped on the north side of Florida’s east coast jetties is usually destined for the next island to the south (fig. 3.11).

Miami Beach illustrates the results of groin use. After one was built in the 1920s, countless others had to be constructed—in self-defense. Prior to the 1980 beach renourishment project, Miami Beach looked like a military obstacle course, with groins obstruct-
ing both pedestrian and vehicular traffic. Groins and other forms of shoreline engineering, combined with too-close-to-the-beach construction, destroyed what remained of Miami Beach after the 1926 hurricane.

Most inlets between Florida’s barrier islands are jettied, and severe beach erosion problems have resulted. As mentioned above, usually sand is trapped on the north side of the jetty while to the south the beaches are eroding. Adding to the problem is hopper dredging. Most of Florida’s inlets are “cleaned out” periodically by hopper dredges that dump their loads at sea. The sand thus lost entirely from the beach system would be better pumped up on the southerly side of inlets. However, this is much more costly than dumping at sea. Floridians would improve their beaches considerably if they would outlaw hopper dredging and then come up with extra funds to pump inlet channel sand onto the adjacent beaches on a routine basis.

One way to reduce the bad effects of jetties is by pumping sand across inlets (sand bypassing). A well-known example of this can be found in the permanent pumping station at Lake Worth Inlet at the north end of Palm Beach (fig. 3.12). This station pumps sand from the north side of the jetty to the south side. The pumping station must help to some degree, but the offset of North Palm Beach Island and the general lack of beaches in Palm Beach attest to the fact that there is still a sand shortage.

The beach buildup on the north side of Florida’s jettied inlets may cause erosion elsewhere, but at least it provides a wide beach for the upstream community. Unfortunately, more often than not, buildings creep out onto the new beach, thus losing the safety and aesthetic advantage afforded by the broad beach. In one east coast case a 26-story condominium has been built next to the beach just north of a jetty. This massive building is in danger from both the beach and the inlet, 2 very dynamic environments during a storm.

Fig. 3.12. The sand bypass system on the north side of Lake Worth Inlet. Photo by Bill Neal.
Better to have built away from the inlet and back from the beach. Examples of construction creeping out on the new beach next to a jetty include buildings in Fort Lauderdale, Jupiter Inlet Colony, and Singer's Island.

**Seawalls**

*Seawalls*, built parallel to the shoreline, are designed to receive the full impact of the sea at least once during a tidal cycle. Present in almost every highly developed coastal area, seawalls (fig. 3.13) are very common along the East Florida shore. Also common along the Florida shore are *bulkheads* and *revetments*. Bulkheads are a type of seawall placed farther from the shoreline in front of the first dune—or what was the first dune. They are meant more to hold back the land than to hold back the sea. Revetments are usually stone facings placed on eroding dune scarps or bluffs (fig. 3.14) or at the base of seawalls (fig. 3.15) to slow storm-wave erosion. These are frequently made of loose stacks of large stones. A wave breaking on a stone revetment will lose part of its water volume in the spaces between the rocks, and this reduces the erosive effect of the backwash of the wave. The Corps of Engineers’ shore protection manual, the “bible” of engineering at the shore, notes that seawalls, bulkheads, and revetments have the same deleterious effect on the beach.

Building a seawall, bulkhead, or revetment is a very drastic measure. Such structures harm the environment in the following ways:

1. Walls reflect wave energy, ultimately removing the beach and steepening the offshore profile. The length of time required for this damage to occur is from 1 to 30 years. The steepened offshore profile increases the storm-wave energy striking the shoreline; this in turn increases erosion.

2. Walls increase the intensity of longshore currents, which hastens removal of the beach.
3. Walls prevent the exchange of sand between dunes and beach. Thus, the beach cannot supply new sand to the dunes on the island, and the beach cannot flatten as it tends to do during storms.

4. Walls concentrate wave and current energy at the ends of the wall, which increases erosion at these points.

The emplacement of a seawall or other hard structure is an irreversible act. By gradually removing the beach in front of it, every seawall must eventually be replaced with a bigger ("better"), more expensive one (fig. 3.16). Although a seawall may extend the lives of beach-front buildings in normal weather, it cannot protect those on a low-lying barrier island from the damage (fig. 3.17) caused by hurricanes; it cannot prevent overwash or storm-surge.
flooding. In fact, floodwaters may be trapped and held behind such a wall during a storm.

If a wall is truly massive like the one in Galveston, Texas, it can save lives and protect property even during hurricanes. Hurricane Alicia (1983) passed just west of Galveston, and 50,000 people rode out the storm in town. The massive Galveston-type wall is far too costly for most communities. It was built in response to the 1900 storm that killed 6,000 people. If a storm with the intensity of Hurricane Camille (1969, Mississippi) were to strike Galveston with 50,000 inhabitants still on the island, the death toll would be similar to the 1900 catastrophe.
The long-range effect of seawalls can be seen in New Jersey. In Monmouth Beach, New Jersey, a few years ago the town building inspector told of the town’s seawall history. Pointing to a seawall he said, “There were once houses and even farms in front of that wall. First we built small seawalls and they were destroyed by the storms that seemed to get bigger and bigger. Now we have come to this huge wall which we hope will hold.” The wall he spoke of, adjacent to the highway, was high enough to prevent even a glimpse of the sea beyond. There was no beach at all in front of it; instead there were remnants of old seawalls, groins, and bulkheads for hundreds of feet out to sea.

Hardly a beach community in Florida exists without revetments and seawalls (fig. 3.18), and the situation is deteriorating. Some communities and counties are doing better than others in preventing their construction. For example, the new construction in beach areas south of St. Augustine includes few seawalls, but south of Daytona there are condos being constructed simultaneously with seawalls jutting out on the beach.

If the techniques of shoreline stabilization have such a poor long-range survival record and cause so much destruction, why are they used? The answer is (1) seawalls have been very successful in protecting buildings, and jetties have been very successful in maintaining channels; (2) only recently have we begun to understand the great environmental damage done by these structures. When the earliest of these structures were built, they were thought to be “solutions.” Most shoreline engineering projects have a design life of less than 20 years, and long-term geologic effects beyond, say, 50 years are simply not considered. Our experiences with the erosive effects of the Charleston jetties, the Cape May, New Jersey, jetties and seawall, the Miami Beach groin field, and numerous other projects should send a clear message to Floridians that the long-term consequences must be considered, figured into cost-

Fig. 3.18. Most of the heavily developed Florida islands are completely bulkheaded on the back side. This example is in Hallandale Beach. Photo by Orrin Pilkey, Jr.
benefit ratios, and entered into the final decision of whether to pursue a stabilization project or not.

Some states such as North Carolina and Maine are in the process of legislating against seawalls. These states are recognizing that the recreational beach is the property of all citizens and must not be harmed, even if buildings must fall into the sea. However, compared to the heavily developed areas of the Florida shoreline, the North Carolina and Maine shores look like a pristine wilderness.

Sea-level rise: built-in obsolescence

There are several reasons why shoreline stabilization is growing by leaps and bounds in East Florida, but the most important and fundamental reason is that the sea level is rising. (See chapter 2 for a discussion of sea-level rise and its effects on barrier islands.) In Florida this rise may amount to more than 1 foot per century. All along the American shore, what we now call beach erosion may largely be a response to the rising sea.

Figure 2.7 shows a hypothetical island responding to a hypothetical rise in sea level. The island becomes thinner and moves back. If the island is prevented from doing this and is held in the original position, it will become increasingly precarious as the years go by. As an extreme example, imagine what would happen if engineers had tried to hold an island in place when it first formed at the edge of the continental shelf 12,000 years ago. Now it would be 150 feet or so below sea level, and the seawalls indeed would have to be spectacular in size! Stabilization is an attempt to hold back a sea that is rising, but shoreline structural designs do not take this phenomenon into account. Obsolescence is built into the structures.

Questions you should ask, or how to talk to your consultant

When a community is considering some form of shoreline engineering, it is almost invariably done in an atmosphere of crisis. Buildings and commercial interests are threatened, time is short, an expert is brought in, and a solution is proposed. Under such circumstances the right questions are sometimes not asked. The following is a list of questions you might ask if you find yourself a member of such a community.

1. Will the proposed solution for our shoreline erosion problem damage the recreational beach? in 10 years? in 20 years? in 30 years? in 50 years?
2. How much will maintenance of the solution cost in 10 years? in 20 years? in 30 years? in 50 years?
3. If the proposed solution is carried out, what is likely to happen in the next big northeaster? southeaster? mild hurricane? severe hurricane?
4. What is the natural erosion rate of the shoreline here during the last 10 years? 20 years? since the late 1930s when the first coastal aerial photography took place? since the mid-1800s (the time when the first accurate Florida shoreline maps were surveyed by the old U.S. Geodetic Survey)?
5. What will the proposed solution do to the beach front along
the entire island? Will the solution for one portion of an island create problems for another portion?

6. What will happen if an adjacent inlet migrates? closes up? What will happen if the tidal delta offshore from the adjacent inlet changes its size and shape? Or what if the channel moves?

7. If the proposed beach erosion solution is carried out, how will it affect the type and density of future beach-front development? Will additional building density and location controls on beach-front development be needed at the same time as the solution?

8. What will happen 20 years from now if the inlet nearby is dredged for navigation? if jetties are constructed two inlets to the north? if seawalls and groins are built in front of nearby communities, especially to the north?

9. What is the 30- to 50-year environmental and economic prognosis for the proposed erosion solution if predictions of an accelerating sea-level rise are accurate?

10. If stabilization—for instance a seawall or revetment—is permitted here, will this open the door to seawalls elsewhere on the island? (The answer to this question has always been “yes” in Florida, as well as in most other coastal states.)

11. What are the alternatives to the proposed solution to shoreline erosion? Should the threatened buildings be allowed to fall in? Should they be moved? Should tax money be used to move them? Why not? If we can spend tax money for seawalls and nourishment, why not for relocation?

12. What are the long-range environmental and economic costs of the various alternatives from the standpoint of the local property owners? the beach community? the entire island? the citizens of Florida and the rest of the country?

13. Does the proposed solution meet with the approval of objective (noninvolved) consulting geologists and engineers?

A philosophy of shoreline conservation: “We have met the enemy and he is us”

In 1801 Postmaster Ellis Hughes of Cape May, New Jersey, placed the following advertisement in the Philadelphia Aurora:

The subscriber has prepared himself for entertaining company who uses sea bathing and he is accommodated with extensive house room with fish, oysters, crabs, and good liquors. Care will be taken of gentlemen’s horses. Carriages may be driven along the margin of the ocean for miles and the wheels will scarcely make an impression upon the sand. The slope of the shore is so regular that persons may wade a great distance. It is the most delightful spot that citizens can go in the hot season.

This was the first beach advertisement in America and sparked the beginning of the American rush to the shore.

In the next 75 years six presidents of the United States vacationed at Cape May. At the time of the War Between the States it was certainly the country’s most prestigious beach resort. The resort’s prestige continued into the twentieth century. In 1908
Henry Ford raced his newest model cars on Cape May beaches. Today, Cape May is no longer found on anyone’s list of great beach resorts. The problem is not that the resort is too old-fashioned but that no beach remains on the cape.

The following excerpts are quoted from a grant application to the federal government from Cape May City. It was written by city officials in an attempt to get funds to build groins to “save the beaches.” Though it is possible that its pessimistic tone was exaggerated to enhance the chances of receiving funds, its point was clear:

Our community is nearly financially insolvent. The economic consequences for beach erosion are depriving all our people of much needed municipal services. . . . The residents of one area of town, Frog Hollow, live in constant fear. The Frog Hollow area is a 12 block segment of the town which becomes submerged when the tide is merely 1 to 2 feet above normal. The principal reason is that there is no beach fronting on this area. . . . Maps show blocks that have been lost, a boardwalk that has been lost. . . . The stone wall, one mile long, which we erected along the ocean front only five years ago has already begun to crumble from the pounding of the waves since there is little or no beach. . . . We have finally reached a point where we no longer have beaches to erode.

**Truths of the shoreline**

From examples of Cape May and other shoreline areas, certain generalizations or “universal truths” about the shoreline emerge quite clearly. These truths are equally apparent to scientists and engineers who have studied the shoreline and to old-timers who have lived there all their lives. As aids to safe and aesthetically pleasing shoreline development, these general truths should be the fundamental basis of planning on any barrier island.

**There is no erosion problem until a structure is built on a shoreline.** Beach erosion is a common, expected event, not a natural disaster. Beach erosion in its natural state is not a threat to a barrier island (fig. 3.19). It is, in fact, an integral part of island evolution (see chapter 2) and the dynamic system of the entire barrier island. When a beach retreats it does not mean that the island is disappearing. The beach retreat is part of the larger process of island migration. Whether the beach is growing or shrinking does not concern the visiting swimmer, surfer, hiker, or fisherman. It is when man builds a “permanent” structure in this zone of change that a problem develops.

**Construction by man on the shoreline itself causes erosion.** The sandy beach exists in a delicate balance with sand supply, beach shape, wave energy, and sea-level rise. This is the dynamic equilibrium discussed in chapter 2. Most construction on or near the shoreline changes this balance and reduces the natural flexibility of the beach. The result is change that often threatens man-made structures. Dune removal, which often precedes construction, reduces the sand supply used by the beach to adjust its profile during storms. Beach cottages—even those on stilts—may obstruct the normal sand exchange between the beach and the shelf during
Shore stabilization projects are in the interest of the minority of beach property owners rather than the general public. If the shoreline were allowed to migrate naturally over and past the cottages and hot dog stands, the fisherman and swimmer would not suffer. Yet beach property owners apply pressure for the spending of tax money—public funds—to protect the beach. Because these property owners do not constitute the general public, their personal interests do not warrant the large expenditures of public money required for shoreline stabilization.

Exceptions to this rule are the beaches near large metropolitan areas. The combination of extensive high-rise development and heavy beach use (100,000 or more people per day) affords ample economic justification for extensive and continuous shoreline stabilization projects. For example, to spend tax money for replenishing Coney Island, New York (or perhaps Fort Lauderdale, Florida), which accommodate tens of thousands of people daily, is more justifiable than spending tax dollars to replenish a beach that serves only a small number of private cottages or condos. In the case of the former, the beach maintenance is in the interest of the public that pays for it, whereas in the latter case the expenditures amount to a handout of public tax money to mostly well-off property owners. As our coastal population increases, however, and if the same mistakes continue to be made, the frequency of cases where large expenditures are required will only increase, as will the taxpayers' burden to underwrite these "eternal" projects.

Shoreline engineering destroys the beach it was intended to save. If this sounds incredible to you, drive to New Jersey and examine

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Fig. 3.19. An eroding beach on an undeveloped portion of Hutchinson Island. Since trees do not grow on the beach, the stumps are proof of erosion. Photo by Bill Neal.
some of their shores. See the miles of “well-protected” shoreline along the northern New Jersey shore—shoreline without beaches (fig. 3.20)! If you do not want to drive to Sea Bright, New Jersey, try Palm Beach.

The cost of saving beach property through shoreline engineering is usually greater than the value of the property to be saved. Price estimates for shoreline engineering projects are often unrealistically low in the long run for a variety of reasons. Maintenance, repairs, and renourishment costs are typically underestimated because it is wrongly assumed that the big storm, capable of removing an entire beach replenishment project overnight, will somehow bypass the area. The inevitable hurricane or northeaster, moreover, is viewed as a catastrophic act of God or a sudden stroke of bad luck for which one cannot plan. The increased potential for damage resulting from shoreline engineering also is ignored in most cost evaluations. In fact, very few shoreline engineering projects would be funded at all if those controlling the purse strings realized that such “lines of defense” must be perpetual.

Once you begin shoreline engineering, you can’t stop. This statement, made by the city manager of a community on Long Island sound, is confirmed by shoreline history throughout the world. Because of the long-range damage caused to the beach it “protects,” this engineering must be maintained indefinitely. Its failure to allow the sandy shoreline to migrate naturally results in a steepening of the beach profile, reduced sand supply, and, therefore, accelerated erosion (see chapter 2). Thus, once man has installed a shoreline structure, “better”—larger and more expensive

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Fig. 3.20. A New Jerseyized beach, Monmouth Beach, N.J. Photo by Orrin Pilkey, Jr.

—structures must subsequently be installed, only to suffer the same fate as their predecessors.

History shows us that there are two situations that may terminate shoreline engineering. First, a civilization may fail and no longer build and repair its structures. This was the case with the Romans, who built mighty seawalls and ports. Second, a large storm may destroy a shoreline stabilization system so thoroughly
that people decide to stop trying. In the United States, however, such a storm is usually regarded as an engineering challenge and thus results in continued shoreline stabilization projects. As noted earlier, rubble from two or more generations of seawalls remains off some New Jersey beaches!

Our solutions are these:

1. Design to live with the flexible shoreline environment. Don't fight nature with a "line of defense."
2. Consider most man-made buildings near the shoreline to be temporary.
3. Base decisions affecting beach-front development on the welfare of the public at large rather than the minority of shorefront property owners.
4. Let the lighthouse, beach cottage, motel, or hot dog stand fall when its time comes.