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Beach Protection and Restoral Techniques and Their Application to the Rhode Island Coast

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BEACH PROTECTION AND RESTORAL TECHNIQUES
AND THEIR APPLICATION TO THE
RHODE ISLAND COAST

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Introduction

Some of the more common features along our coastline are the various man-made structures that border the shore. It may or may not be obvious that these walls and rock mounds are often someone's attempt to protect or restore a beach or other shorefront property. Beach erosion is an incessant problem for coastal communities. Effects vary with location and season and are dealt with by a variety of structures and dredging operations. The success of beach protection projects is not always easily discernible, but often their failure is obvious. Construction costs are high and there is little apparent coordination between projects along the same coastline. There is activity from both public and private interests. One purpose of addressing this topic is to centralize information about the issue in a form that lends itself to a better understanding of beach protection for those who have interests that touch not only on the engineering aspects, but also on the costs and underlying justifications.

It is the purpose of this paper to investigate the techniques and designs for beach protection today, and to show that efforts are largely motivated by the economic value involved. The primary cause of beach erosion will be addressed through a discussion of coastal processes. The construction and purposes of the common engineering structures will be
explored along with examples of the materials presently being used. The east-coast beaches of Florida with their traditional recreational lure will provide good examples of large-scale efforts to protect high-cost waterfront investments. The state of Rhode Island provides an example in contrast to the long stretches of publicly-owned beaches in Florida. Rhode Island shoreline varies considerably along its length and is also chiefly privately owned. Contemporary projects in Rhode Island provide examples of sometimes shortsighted, and always costly endeavors in both the public and especially the private sectors.

Coastal Processes Affecting Erosion

Developing an understanding of what causes erosional problems on our coastlines is crucial to the further investigation of the efforts being made to protect and/or restore beaches and waterfront property. Some of the coastal processes that bring about (or add to) erosion of the shoreline are quite obvious to anyone who ventures near the shore during a storm. The pounding of a wind-driven surf relentlessly tears into the gentle slopes of a favorite beach, pulling off layers of soft sand in the outwash of receding waves. With more careful observation one might even note a flow of sand and water along the coastline brought about by waves hitting the beach at an angle. If much time has been spent near the shore the aftermath of a violent storm has probably been seen. The shoreline may not only be in disarray, but the lines of the beach may be different as well. Sandy stretches that used to be high and
dry may have migrated or disappeared altogether. These are often the unfortunate (and obvious) effects of a sporadic occurrence of nature. This is the erosion that makes the headlines of the newspaper, the aftermath of a memorable storm. But certainly all the structures seen on the coast are not designed to protect against that once-in-a-lifetime storm.

It is probably safe to assume that for some time it has been noted that there are changes which occur to a coastline with a seasonal frequency and with even longer periods of time. More modern studies in the last twenty or thirty years, however, have brought a greater understanding of coastal processes. The physics of the surf zone can now be modeled with a degree of accuracy. What is being found, for the most part, is that coastal erosion is just a natural result of a land and sea interface, it is ongoing, and it is a process that can not easily be dealt with in an isolated manner.

Wave action and longitudinal transport

Two effects seem to dominate in the erosion of a coast. First, as mentioned previously, is the action of the waves. Water waves can be thought of as reflections of the transmission of power. Waves are almost entirely the result of the action of wind blowing across the surface of a body of water.¹ This energy imparted to the water medium may eventually end up

¹Some waves are seismic in origin (tsunamis) and others can be the result of a passing ship or boat. Both of these are certainly significant causes of some types of erosion, or at least on some occasions, and in some locations, but certainly the wind waves are predominant.
absorbed by the shoreline. The interaction would certainly involve the power necessary to move sand particles. That is why there is gouging out of a beach by wave action. The effect can be extreme in a storm, as noted previously, but it is also apparent in any scale of wave action. There is a gradual erosion of the shoreline of a bay, estuary or even a (larger) salt pond by continual, though seemingly weak, wave action. Wave action, then, is one of the significant coastal processes that must be considered when dealing with erosion.

The other coastal process that is of significance for consideration is that of transport. Under this category will be included all longitudinal transport of sand along a shoreline whether it is caused by prevailing wind waves, near-shore circulation in bays, or even estuarian river flows. These processes are certainly not derived from the same mechanisms, but it is believed that the net effects are similar enough and are dealt with similarly enough to be considered together.\(^2\) In general, a water mass moving along a shoreline will tend to pick up and carry unconsolidated matter of a size small enough to be affected by the power of the mass movement. It follows that stronger currents will pick up more and/or larger pieces of material. These currents also tend to deposit matter when the load-carrying capability has been decreased (due to a decrease in velocity and such). This last aspect will become particularly important when

\(^2\)This generality is supported by the author for the sake of simplicity.
structural design is explored later in this paper. Wave action and longshore drift are the two significant processes that become the subject of addressal in coastal erosion protection and restoral techniques.

Methods of Beach Protection and Restoral

It has been said that beach erosion and hurricane or storm surge are the two natural phenomena that most concern society as it looks at its coasts. It is a fact that erosion will affect a coastline regardless of whether the land has been developed or not. It is noted, however, that when there is a value attached to the present state of a beach or coastal area, the protection or restoral of that area becomes an object of human effort and expenditure. As one looks at the methods that are used in beach protection and restoral, certain findings emerge. First, there are many approaches available to shoreline stabilization. There are probably no two areas of coastline that can be considered to have exactly the same characteristics and so there are many and varied "solutions" to the same basic problem of erosion. Second, as data has improved along with engineering skills, more modern approaches are being adopted. Public reaction to the efforts has not always been positive, however, because of the failure of earlier projects. Ignorance and poor planning and craftsmanship still exist, and have resulted in ineffective or unsuitable projects which sully the basic idea of protection and restoral.

Neill Parker summarized it well when he stated that "poorly conceived and improperly designed protection projects function poorly at best, disastrously at worst. Well conceived and properly designed protection projects function as they are intended." The underlying key to success in these efforts, then is said to lie in the proper planning and implementation of the project. Before an approach can be rationally selected, the problem must be "identified and described, its causes determined, and objective established." This is not always an easy task, and the conclusions may not satisfy the desires of the parties concerned. Only after this groundwork, however, can the choice of "tools" be properly made.

**Structural methods**

The tools of protection and restoral efforts may be structural or non-structural. In order to later deal with the application of various methods, it is felt that a general review of the subject would be appropriate. The structural methods include those engineering features most commonly associated with shoreline protection. Some structures can be thought of as "rigid sea defense lines." These are the structures "intended and designed to establish and hold a line that limits the sea's encroachment." Examples would be seawalls, bulkheads, and revetments. The first two are

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4 Parker, p. 5.
5 Ibid.
6 Ibid., p. 6.
generally vertical structures built parallel to the shoreline, or perpendicular to the direction of the effective wave force, and on the shore itself (see figure 1). Seawalls and bulkheads can be built from a multitude of items such as stones, concrete blocks, timber and even steel. These structures are designed to protect against the wave-induced erosion discussed earlier. They do tend to maintain the land behind them by blocking the onslaught of wave action, but they also have several drawbacks. One drawback is a relatively high cost of construction. Another more important one involves the effect of the vertical face on wave action. The force of waves striking the wall is actually deflected downward causing substantial digging out of the front of the wall. Often a beach area in front of a bulkhead will erode away at a much quicker pace than it would have naturally. The third structure considered as a rigid defense line is the revetment.

Revetments are built on the shore itself (see figure 2), and tend to be popular (especially as noted in a study of Rhode Island applications) through their simplicity and price. Basically, a revetment is a blanketing structure that creates an armor face over an existing feature. Sometimes an artificial slope is built before the installation of a revetment, but the effect is the same. The facing of the revetment is of a resistant material such as stone or concrete built right over the scarp or embankment. Popular types of armor facing include riprap, rock, patch asphalt, wire fence with rock, cast concrete, blocks, tires, sand bags, mat (fiberglass,
Figure 1. Seawalls and Bulkheads

Figure 2. Revetment
steel, aluminum), rubble, and even grass. The choice of facing is often dependent on cost and availability of the materials needed as well as the degree of protection required and the peculiarities of the particular stretch of shoreline. The armor facing is designed to protect against wave-induced erosion although it will inhibit longshore transport of shore materials as well. Some problems associated with revetments are the breakdowns which occur through insufficient design considerations (too small of rocks can be washed away, for example), and the effect that the inhibition of longshore transport has on the down stream beaches which have their nourishment cut off. Whereas longshore transport is a cause of erosion, it must be kept in mind that this is a natural process of give and take. Another category of structural methods is that of the structures which purposely disrupt this longshore transport.

Natural land structures that jut out from a shoreline often seem to provide a catalyst for beach development. Man-made structures are sometimes used in this same way to capture and retain sand from the longshore drift. Groins provide the obstacle to the transport. Groins are finger-like structures which project outward from the beach (see figure 3). They are often built of stone, but wooden pilings and concrete have been popular in the past. Sand accumulates on the updrift

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Longshore drift

Figure 3. Groins
side of the structure and can build or rebuild a beach. Cost is a factor with groins and sufficient sand must be available in the transport system to allow a groin to be effective. A distinct problem with the transport disruption brought on by a groin is the starving of sand for the beaches down drift of the structure. There is, as well, significant erosion of the immediate downdrift side of the groin itself. Two other structures that resemble groins in construction are jetties and breakwaters. Jetties have a similar effect on longshore transport as groins, but they are larger and even more expensive. They are usually built to protect navigational inlets by attenuating the effects of waves. Jetties are not usually used to restore beaches or protect against erosion. In fact there are designs such as Weir jetties which provide a gap to allow the longshore sand movement to pass through. An offshore breakwater is normally built parallel to the shore, as opposed to the perpendicular jetty, and provides for a protected entrance or harbor. It too can catch sand, but that is not usually the intended effect. Breakwaters are usually made of rock and have nearly inhibitive construction costs.

Non-structural methods

Non-structural methods of dealing with coastal erosion and beach restoral are gaining in popularity and use. The goal is to stabilize and protect a shore through measures that closely approximate natural processes.\(^8\) This almost always

\(^8\)Parker, p. 7.
includes replacing beach material at the site through either dredging operations from off shore with direct transport to the site, or from bringing in material from some other location. It can be especially advantageous to use this method in conjunction with dredging operations in a basin or entrance way that would be undertaken anyway. It is particularly important when considering a restoral and nourishment project that a "comprehensive and detailed understanding and definition of the erosion and sand transport mechanisms" be developed, since it is "absolutely essential to the planning, design and operation of a restoral and/or nourishment project."9 For example, restoring a beach with incompatible material might not only detract significantly from the recreational appeal of the area, but the material may erode even faster than the original sands. The economic impact of either loss after the large initial investment in the project could be substantial.

Most beach nourishment projects involve mechanical means of material placement. One alternative proposal that bears mention here (as a possible future application) is that set forth in a thesis project at the College of Engineering of the University of Florida.10 The concept is for nature-assisted nourishment utilizing the existing sand transport processes and beach slope relations. A shallow slope on a

9Parker, p. 7.

beach tends to promote deposit of material in contrast to the effects of a steep slope. The suggestion was to remove material from a steeply sloping shoreline to create a shallower slope. The material removed could be used to build or fortify back shore dunes. Natural processes would then support sand deposit on the new beach face. One major assumption is that the nearby water mass carries sufficient sand. This concept would certainly be an attractive alternative cost-wise, though the application would probably be very limited.

Other efforts in the way of non-structural methods would be those associated with the beach structure itself (dunes, etc.), and with the proper restrictions to commercial/private development in the coastal zone. The significance of the protection of dunes has often been seen after the fact. Sand dunes and other such topographical features play an important role in the maintenance of the entire shoreline system. Dunes can be stabilized artificially with fences or naturally with grasses or other vegetation. Since upper beach sand movement is mostly caused by direct wind effects, however, the subject will not be discussed further in this paper. The other effort introduced is that of wise utilization of the shoreline areas. This becomes particularly important when dealing with the barrier beaches. Construction on barrier beaches or any other fronting shoreline has, in the past, been a major contributor to the chain of effects that eventually bring about the destruction of a coastline. Barrier beaches themselves offer the most effective form of
14 shoreline protection. Proper legislative actions or other restrictive policies are good methods of helping to divert future problems of this type.

The History of Concern

Now that the basic methods of beach protection and restoral have been introduced, it is helpful to take a brief look at the historic development of the concern over shoreline erosion to see what has been done, and why. For the most part the key consideration is value. On an extreme, one could imagine a totally apathetic view towards coastal erosion if the coastline did not have at least some particular value to someone. Aside from the improved engineering, it seems apparent that much of the thinking concerning the protection of a shoreline has not changed significantly over time. Those who own land on a body of water are concerned for the preservation of that land. If they have the misfortune to have the property in an area of high natural erosion, they would want to do something about that. Generally speaking, that "something" was probably an engineering structure of a type discussed earlier. The project would be of a magnitude as great as could be afforded by the individual (at least up to the requirements for the intended result), and would probably be undertaken without regard to the effects the project might have on adjoining property. Unfortunately, it seems the

private sector still acts with the same motivation and dis­regard today. In a larger sphere, however, there has developed over time a national, and more responsible concern for coastal erosion.

In 1968 a National Shoreline Study was initiated by Congress as a response to increasing concern over the national problem of erosion of the U.S. coastline. Over 24 percent of the coastline was found to be undergoing significant erosion. Each coastal state was handled separately with identification of their unique characteristics and problems. The present condition of any existing protective structures and their effects were noted. Besides finding that shores and beaches served a wide variety of purposes, it also became evident that private ownership of many stretches of shoreline precluded a comprehensive and systematic approach to shoreline protection. Many of the required methods would be too costly for the average private owner and federal assistance could not generally be extended to the projects of private citizens. The federal projects themselves tended to be inadequate because they reached only the short sections of the public beaches. It was noted because of the study that "effective shoreline protection can only be achieved by a coordinated effort along an extensive section of shore." No far-reaching policy

12Tippie, p. 3.
13Ibid.
14Ibid.
changes have been incorporated since the Study to bring the private sector into a comprehensive plan, but action was taken to increase the awareness in the private sector of the erosion problem and the methods available to combat it through a demonstration and testing program.

The National Shoreline Erosion Demonstration Program was a five year program created by Section 54 of the Shore Erosion Control Demonstration Act of 1974. The threat to public property was handled by State and/or Federal support. In the private sector, however, help was seldom available. Often individuals were ill-advised or else they could not afford the projects proposed by coastal engineers. State and Federal research was found to be insufficient to meet the needs of the private sector. The demonstration and testing program was supposed to provide data on various devices, methods of construction and costs. Public education was improving, especially in the Great Lakes region. The sea coasts had not yet benefited much from similar local initiatives, however.

The Cost Factor

The willingness of private individuals to involve themselves in specific coastal protection methods is certainly a function of education, but it is also a function of cost.


16 Ibid.

17 Actually, cost versus benefits, though a given private
There are extremes of cost in shoreline protection schemes. On the high cost end are such projects as the San Francisco seawall, very large and very expensive; or the Galveston seawall in Texas that cost $4,000 to $5,000 per front foot\(^\text{18}\). On the low end are the institutional types of protection, such as zoning ordinances that restrict development to areas behind the dunes. These are essentially no-cost endeavors. Since private individuals have a major part in the overall program of shoreline protection, and since those individuals are probably looking for a solution somewhere in between the cost extremes just mentioned, it is necessary to take a look at the cost factors that they really are up against.

In 1971, the Army Corp of Engineers in their National Shoreline Study listed some 20,500 miles of eroding shoreline on the Atlantic, Pacific, Gulf and Great Lakes coasts.\(^\text{19}\) This included both sheltered and exposed beaches. In 1976, construction of beach protection was given an estimated cost of between $50 and $1,000 per lineal foot.\(^\text{20}\) Assuming an average cost of $200, the total figure would be $21 billion, and, of course, costs have certainly risen since then. Seventy percent of the land in question is privately owned, so one can see the enormity of cost to be borne by the private individual may not be consciously making that distinction. Publicly-funded projects, however, will utilize formally prepared cost-benefit analyses.

\(^{18}\) Tippie, p. 12.

\(^{19}\) McCartney, p. 5.

\(^{20}\) Ibid.
There is a need for the availability of low-cost methods. The National Shoreline Erosion Demonstration Program in 1974 was designed to develop and demonstrate to the public methods for low-cost shore protection. Application in sheltered areas (maximum wave height of six feet) was to be considered. It might be appropriate to point out that a good half of Rhode Island's shoreline could easily be considered sheltered areas. The criteria for low-cost protection was that the method had to cost less than $50 per front foot for materials without the use of heavy construction equipment, and less than $125 per front foot for materials and placement using heavy equipment. The structures also had to be able to function suitably for at least ten years. There are no definitive answers to the question of low-cost methods, but there are indications of applications that might fill the bill—depending on several factors, many of which are going to be local in nature. As with all construction costs today, costs of coastal protection projects continually rise. However, in order to gain an appreciation for the relative costs of various methods and the level of expenditures in general, the following discussion of some of the factors is made.

21Tippie, p. 3.
22Edge, Housley, and Watts, p. 2889.
23Again the reader is reminded that these figures are not upgraded for inflation over the past five years.
As alluded to earlier, the cost of some coastal protection methods is generally beyond the means of the average private owner, and is best left to the public projects with state and federal funding. It was mentioned earlier that revetments are a popular form of shore protection. Their relative ease of construction, multitude of material choices and relatively low costs are probably all factors. Local costs of materials might support a choice of stone as opposed to pre-cast units, for example. Revetments can cost between $75 and $150 per shoreline foot (1975 dollars).24

Seawalls and bulkheads have been widely used in the past and there is much information concerning prices of their construction. Standard construction materials such as steel, concrete or timber pilings will vary in cost. Simple bulkheads cost about the same as revetments ($75 to $150 per foot), but seawalls are considerably more at $200 to $500 per foot. These structures can probably have successful low-cost variations. Cost effective alternatives might employ aluminum, asbestos, fiberglass and other synthetics in their construction.25

Groins may cost from $100 to $350 for each foot of shore protected, and jetties would be even more. An accurate determination of longshore transport is essential for any consideration of groins as low-cost alternatives. Breakwaters


have limited use in the U.S. for shore protection.\textsuperscript{26} As mentioned earlier they are usually used to create a safe harbor or anchorage and are normally quite costly. Some interest is being shown in floating breakwaters (such as tires). These could protect against smaller waves and provide low-cost protection in sheltered areas.\textsuperscript{27}

Non-structural methods such as beach fill and periodic nourishment might be an answer to some problems. Fill can cost about three dollars per cubic yard.\textsuperscript{28} Used without a retaining or capture system (structural method) would necessitate periodic renourishment which is a definite long-term cost factor. A major drawback in this method is the financial risk involved if the erosion rate exceeds predictions or nourishment costs prove to be above estimates.\textsuperscript{29}

When examining the decision process for utilization of shore protection methods it can be seen that both private and public endeavors are decided upon by the same basic parameters--cost and benefit. This has been previously mentioned, but a closer look at the actual application is appropriate. The private individual is motivated by the value the individual places on the property. Given a few choices the individual may have for a satisfactory solution, and barring such external requirements as permits, the decision might be made solely on

\textsuperscript{26}\textit{Edge, Housley, and Watts}, p. 2890.

\textsuperscript{27}\textit{Ibid.}


\textsuperscript{29}\textit{Parker}, p. 8.
the cost. All costs will be carried by the owner, usually, and the best protection for the money will be sought. Here is where countless cases of misguided owners show up with revetments that wash away in a couple years, bulkheads that collapse, or fill that is lost with the first small storm. Reliable guidance during the decision phase is very important, and the Army Corp of Engineers will provide free technical assistance. Other factors which influence a decision might include considerations of aesthetic appeal. If, for instance, all the neighbors of an individual had bulkheads, the individual might be inclined not to put up a revetment, even though that might be a suitable method. Some applications might lend themselves to consideration of multiple uses. For example, the use of a seawall as a dock for a small boat. Again, at the level of the private owner it is not felt that decisions are made with any but personal interests in mind.

Public decision making in the area of shore protection is more formalized than that of the private owner. Projects are often quite large and expensive, but still must be tied to some identifiable benefit. Often the reconstruction or preservation of areas will have the benefit of recreational use for the local citizens. The Army Corp of Engineers is tasked with making studies for state and federal projects. Much of the information available on the subject of shore protection is a result of the years of work by the Corp and

30Federal funding for private use will only be given if the private owner suffers due to a Federally sponsored activity.
its research center. When the Corp makes a study and gives proposals on request of a state or city (as in the case of the Orchard Beach project for the City of Warwick, R.I.) that proposal includes a formal cost/benefit analysis. Funding for public projects varies with the application. Federal funding covers all costs of projects on federally-owned property. However, federally-owned property is a small fraction of the nation's coastline. For example, in Rhode Island there are only about five miles of federal property. Public lands (state or city owned) can receive 70 percent federal funding if it can be shown that the property has specific public recreational value. An example of this would be a public beach. Other publicly-owned land without direct recreational value can be protected with 50 percent federal funding. In the past it seems the Army Corp of Engineers favored structural methods to a large degree, but the method most often supported by the Corp today is beach restoration and periodic nourishment (often as a combination of non-structural and structural techniques). \(^{31}\) The National Park Service is going one step further in their present thinking by advocating basically a hands-off attitude. The Park Service has, for example, abandoned programs to protect their stretch of the Cape Cod coastline, allowing, instead, for nature to take its course. \(^{32}\)

\(^{31}\)Parker, p. 8.

\(^{32}\)From a discussion with Mr. George Seavey of the Coastal Resources Center, University of Rhode Island.
Contemporary Applications

As previously mentioned, coastal erosion is not limited to any particular coastline of the U.S. In order to take a look at some of the present-day applications of protection and restoral methods in the U.S. examples from two east coast states will be used—Florida and Rhode Island. These choices were made because of the type of the shorelines they represent and the nature of coastal processes they must contend with. Some of the costs for public and private endeavors will be discussed as well as general analyses of results.

Florida

The State of Florida is well known for its expanses of sandy beaches. In fact, the recreational lure of the coastline through tourism heavily supports the economy of the state. Hundreds of miles of beaches make up the west, or Gulf Coast, and there are certainly a good number of miles of beaches edging the numerous islands of the Florida Keys, but attention in this paper will be directed toward east coast projects. For the most part, the east coast of Florida is fairly straight and unbroken except for an occasional inlet or river. The beaches are relatively low with gentle slopes devoid of any major rock formations. The beach material varies with location. Predominantly in the southern beaches is found sand made up of crushed coral and shells. Coral provides the substratum for much of the southern end of the state. Northern beaches have finer sands of common minerals. The beaches are affected by
wind waves off the Atlantic Ocean especially when backed by the extreme winds and storm surge of a hurricane. There is also significant longshore transport of material along the face of the coast. Often the beach system is backed by an intracoastal waterway creating what are essentially barrier beaches, among which one of the most famous, Miami Beach, will be discussed later. Popular engineering structures in the past seem to have included groins, jetties, seawalls and bulkheads. Groins were often built of wooden or concrete pilings with steel webbing. Large rocks and boulders made up some of the jetties and seawalls. Bulkheads were often of concrete and steel. Non-structural methods of beach protection and restoral—particularly beach fill and nourishment, are becoming a more significant part of Florida's efforts.

Bal Harbor Village project

Some of the effects and ramifications of a beach restoral project can be seen in the case of Bal Harbor Village near Miami as discussed in Henry von Oesen's editorial in the October 1980 _Shore and Beach_. Remembering that value of the shoreline is normally the main factor bringing about the initiation of a beach restoral project, one can easily see the reason the project was begun. Beachfront property in danger of being eroded was worth over $2,000 per front foot and ocean-front buildings averaged $56,000 per foot of beach. The investment in protection was still substantial,

however. In the first four and a half years since the project was completed the beach has lost 25,000 cubic yards of material. This comes to about $40,000, or $24 per day. Protection costs, at least in this case, seem to be open ended. Bal Harbor is not the first case of seemingly futile expenditures on beach protection and restoral. After spending millions to save beaches along Cape Hatteras and other areas, the National Park Service decided, as mentioned earlier in this paper, that it is best to just leave nature alone.\textsuperscript{34}

Miami Beach project

Leaving nature alone may not be the most acceptable alternative in everyone's eyes, however, especially if the survival of a resort city is at stake. In Florida, beach front property is heavily developed along many stretches of shoreline with little regard for the former natural structures. This is especially apparent along the southern half of the coastline, including Miami Beach. The City of Miami Beach is situated on a barrier island at the northern end of Biscayne Bay. In his editorial, Henry von Oesen spoke of the Miami Beach Project. Miami Beach is a resort city which felt the effects of their popularity in the land booms of 1920 and 1950. Construction was uncontrolled. People built right on top of the dunes. In 1926 a hurricane devastated the area. Groins and concrete seawalls sprung up in an effort to preserve the beach. Over time, these engineering structures met the

\textsuperscript{34}Henry M. von Oesen, pp. 2-3.
problem with predictable (little) success. More recently, the
Florida legislature gave the go-ahead for one of the most
ambitious projects ever attempted for beach restoration. The
Army Corp of Engineers project on Miami Beach was to be completed
in 1981, and was to result in 10.5 miles of new beach with an
average width of 250 feet. The new beach would also be backed
by sand dunes of twenty by two and one-half feet. The fill
would be dredged from an area two miles offshore, pumped to
the beach and spread out by earth movers. The project would
take over two years and cost 64 million dollars. Hopefully,
with the added structural methods (groins) employed to help
hold this new beach, the City (and State for that matter) will
have felt justified in this approach.

Florida east coast projects in general

Beach restoral projects in Florida are not limited to
Bal Harbor and Miami Beach. The entire state presents a good
case for analyzing the effects of such projects. Thirty
million yards of material have been put on Florida beaches in
the last ten years.35 The overall success of such efforts
might be seen when, for example, many areas of coast are sub­
jected to the potential erosional power of a hurricane. Such
a study was made fairly recently and outlined in the article
"David and the Beaches" by Colonel James W. R. Adams. Main
points of his study follow. The project was essentially an
"analysis by videotape of the effects of Hurricane David on

35Adams, p. 5.
It was found that in Dade County (Miami, Miami Beach), where there had been a nourishment project, the debris line was well forward of the berm, one hundred feet from the water. The previous (before nourishment) high water line had been at the seawall. This is where the full force of the water would have been with the obvious possibilities of extreme erosion (recall the effects of water wave action on a vertical wall), and damage to existing structures. Farther north in Broward County, where there has been no nourishment project, it was found that storm waves had struck existing structures and seawalls with potential for damage ("potential," because David was not really a very severe storm, relatively speaking). Again moving north along the east coast to Delray Beach, protected by a project, the debris line was well short of seawalls. Vero Beach, another ninety miles north, had no project. Hurricane David came ashore at that location. There was severe shoreline erosion noted, with extensive property damage as well. Colonel Adams summarized his findings as follows:

Reviewing David's impact on the beaches, there is visual evidence that beach nourishment projects protect the coastline. A major hurricane moving landward perpendicular to the shoreline would have caused erosion even in those places protected by Federal nourishment projects. However, in such a storm the nourished beaches would have fared much better and prevented major structural damage to shoreline facilities.\(^{36}\)

This was, then, an overall look at how the State of Florida has applied protection and restoral techniques to their

\(^{36}\)Adams, pp. 3-5.
unique shoreline and coastal processes. To take a look at a significantly different coastline and applications that often include those of private individuals, the State of Rhode Island will be discussed.

Rhode Island

Rhode Island has a coastline quite different than that of Florida. It might be expected that coastal protection methods would differ, and to some degree they do differ to accommodate the unique problems of the New England shore. Application of methods will be discussed as well as some of the proposals for future projects, but first a discussion of the coast as noted by the National Shoreline Study and other studies will be addressed.

The Rhode Island coastline

In 1972 the Army Corp of Engineers' study of Rhode Island found approximately 340 miles of shoreline in this small state. This included the shoreline of Block Island and Narragansett Bay, the latter which gives this New England state a particularly unique coastline. More than half of the 340 miles is exposed to the Atlantic Ocean, and just over two thirds of the exposed coast contains beaches. About one third of the Bay coastline is beach. Most of the southern coastline from Connecticut to the Narragansett Bay consists of strings of protective barrier beaches. The material found on most beaches is unconsolidated matter left during glacia-

...
Of the 190 miles of exposed coastline about 145 miles are privately owned. Most of the shoreline in the Bay is privately owned. It was found that 335 miles of the Rhode Island coastline is eroding.\footnote{State of Rhode Island, \textit{Program}, p. 52.}

Studies of the Rhode Island coastline have identified erosion areas of particular concern as well as some of the measures that have already been taken to combat it. Twenty-five miles were considered critically eroding. These included portions of the south shore barrier beaches, parts of Block Island's coast, and Newport's Cliff Walk. Erosion of the Block Island shoreline is exemplified by the 300 feet of the state beach lost in the last 100 years, and the 500 feet that disappeared from Matunuck Point since 1914. The southern barrier beaches present the most significant problem for Rhode Island and are eroding at a rate of about five feet per year.\footnote{Ibid.} They are most susceptible to erosion due to small sand size and low elevation.\footnote{Jon C. Boothroyd and Abdullah S. Abu Al-Saud, \textquotedblleft Erosion Management Guide\textquotedblright\ (Draft copy, 1978).} Sea level rise of about a foot per century is also a natural contributor to the recession of the barrier beaches.

The Rhode Island Coastal Management Program, in its chapter on coastal erosion points out that \textquotedblleft a variety of factors influence erosion rates including the composition of the shoreline, the volumes of sediment (mud, sand, gravel) present, wind and wave conditions, vegetative cover and human...\textquotedblright\ 37

\footnote{State of Rhode Island, \textit{Program}, p. 52.}

\footnote{Ibid.}

\footnote{Jon C. Boothroyd and Abdullah S. Abu Al-Saud, \textquotedblleft Erosion Management Guide\textquotedblright\ (Draft copy, 1978).}
activities which weaken the shoreline's capacity to withstand erosional forces. The application of various protection and restoral methods in Rhode Island is designed to accommodate just those factors. Techniques in use in Rhode Island (or projected) fall into the two categories of structural and non-structural. From the Corp of Engineers survey it is seen that existing structures on the mainland were limited to "a few low seawalls, bulkheads or groins fronting private property" along the south shore. The only large structures noted were the state and federal breakwaters at Point Judith. One exception to this was, however, the "extensive massive stone and concrete seawalls" that front the property around Cliff Walk in Newport. On Block Island it was also noted in the survey that there were only low bulkheads in use in some areas, and only state and federal jetties of any larger size at the entrance to Great Salt Pond. Public and private structures on the shoreline of Narragansett Bay are much more numerous.

The use of structural methods in Rhode Island

When reviewing the various structural applications of beach protection methods around Narragansett Bay it is convenient to discuss them according to the individual type of structure. Groins are not predominant, but are found along

40 State of Rhode Island, Program, p. 52.
42 Ibid., p. 29.
many beaches and barrier spits in Rhode Island. They are used in areas of various beach material such as glacial outwash (Oakland Beach) and glacial till (Warwick Point).43 A few rock groins can be found in Little Compton and Narragansett, and rubble-mound groins at Sandy Point Beach in Portsmouth.44 According to one source (Boothroyd and Al-Saud), groins in Narragansett Bay are not effective in the longterm because of their small size and the lack of sufficient material in the drift system. Another similar but larger structure, a jetty, is also found in Rhode Island. A jetty, as mentioned earlier, is normally associated with a channel to stabilize it, to block sediments from being deposited in the channel by long-shore drift, and to decrease shoaling by increasing the velocity in the channel.45 There are jetties at the Bullock Cove tidal inlet near Barrington,46 at the breachways in Charlestown, and at Narragansett.47 Breakwaters are also apparent around Rhode Island. They are generally of rubble-mound and rock construction. Breakwaters can be found in Cranston and North Kingstown.

The largest of any of the structures in Rhode Island is the breakwater at the Harbor of Refuge in Narragansett.48 The only significant aid that a breakwater in Rhode Island provides

43Boothroyd and Al-Saud.
44Tippie, pp. 18-27.
45Boothroyd and Al-Saud.
46Ibid.
47Tippie, pp. 18-27.
48Ibid.
against erosion is by providing a secluded shoreline. Seawalls of sorts are common around the Bay and are also of rubble-mound construction or concrete. Concrete walls are found in almost all areas, though many could probably be classified as bulkheads. Bulkheads and revetments are the two most common structural features on the Rhode Island coastline. Bulkheads come in all types and sizes from steel sheets and piles at Quonset Point to the concrete vertical faces on private properties. They are found all around the Bay, but are extensively used in the cities of Cranston, East Providence, Jamestown, Newport, North Kingstown, Pawtucket and Providence. Bulkheads are probably so popular in Rhode Island because they work very well in the environment of the Bay. They offer good protection against even most storms that are encountered. Revetments were mentioned as being as popular as bulkheads. They are found in every area of Rhode Island coast. Most are made of rock. Their popularity is probably derived from their relative cost (inexpensive) and ease of construction. One drawback that tends to make many existing revetments in Rhode Island ineffective is the use of too small of stones. This was a problem mentioned in the earlier discussion of revetment construction, and the real-life ramifications are in evidence around Narragansett Bay.

49 Boothroyd and Al-Saud.

50 Examples of locations of the various structures in and around Narragansett Bay were drawn from Shoreline Erosion in Rhode Island, Virginia K. Tippie, editor.
In general, there are three main uses for the engineering structures in Narragansett Bay. First, they are used for "foundations and walls for commercial structures such as tank farms." Examples of this are Quonset Point, Providence Harbor, Bristol Harbor, the Naval Base, and Newport Harbor. Second, the structures are used to protect "state or municipal facilities such as parks and roads." Colt State Park in Bristol, or Ocean Drive in Newport are examples of this application. Finally, the third use of the structure is said to be for the protection of private homes. Older homes and more expensive newer homes on the water tend to have concrete bulkheads. New construction often incorporates riprap revetments. Cost is significant in considerations of the type of structure in Rhode Island. Riprap revetments are the cheapest, especially with small stone and small volume (however, the effectiveness is questionable). Revetments with larger stones and large volumes will be obviously more expensive. Concrete bulkheads are usually next in cost, followed by a combination of bulkhead and rubble-mound seawalls. The most expensive item would probably be a concrete seawall and would be beyond the means of most private property owners in Rhode Island. Along with structural methods, there are also some non-structural endeavors toward the protection of the Rhode Island coast.

51 Boothroyd and Al-Saud.
52 Ibid.
The use of non-structural methods in Rhode Island

Non-structural techniques in Rhode Island do not approach the enormity of the fill-and-nourishment operations in the state of Florida. However, the awareness of the value of a natural approach toward shore protection is gaining favor. Non-structural methods are the methods preferred by the Coastal Resources Center in Rhode Island. Sand fences and vegetation have been found effective to help stabilize the sands on barrier beaches thus slowing down their migration. Fencing and brush were used successfully at Middletown Beach, Weekapaug, Watch Hill and the Dunes Club in Narragansett, though grass is needed for full stabilization. Salt marsh grasses can sometimes be used to stabilize when the beach is sheltered. Narragansett Bay dredged material has provided support for the natural development of salt marshes in Rhode Island. Because of this it is thought by the Resources Center that "man-made salt marshes are a feasible method of shoreline protection in Rhode Island." Beach nourishment has not, in the past, been widely used in Rhode Island. Opportunities have come up where material dredged by the Army Corp of Engineers could have (and logically should have) been used as beach nourishment. In one case at Pt. Judith, the material was deposited away from the beach. In another case, off Little

53Tippie, p. 1.
54Ibid., p. 11.
55Ibid.
Compton, the Corp decided that it would cost too much to use the dredged material as fill. There is another project at Oakland Beach that has been approved which will include beach nourishment and which will be discussed later. The Army Corp of Engineers has been mentioned before, but because of the nature of their involvement in matters of coastal erosion no discussion of Rhode Island's coastal protection would be complete without a look at some of the Corp's past work and proposals.

Public projects in Rhode Island

The Army Corp of Engineers has become involved in the coastal erosion problems of Rhode Island in three cases that bear mention in this paper. First, a project to protect the Newport Cliff Walk is a good example of methods used to solve an erosional problem. It is significant that the land and bluffs have both historic and economic value, because the project was expensive. Authorized in 1965, the project involved a plan to protect 18,000 feet of coastline from Newport Beach to Bailey Beach. The methods to be used included some backfilling, dumping of riprap, building of stone slope revetments, and repairs to existing seawalls. Only 8,800 feet were completed by September of 1972 and work was stopped due to lack of local funds. A total of $1,245,000 was spent of a projected total of $1,830,000.

Another project which would have included structural methods combined with beach nourishment was the multipurpose

56This information is based on a discussion with Mr. George Seavey at the Coastal Resources Center on two occasions in February, 1981.
project in Westerly, Rhode Island. This was an ambitious project authorized in 1965, but which has even today not yet been funded. Chances of implementing the project do not look good. It involved raising and widening three miles of beach, building three large groins to stabilize the beach and thirty-one semiconcealed groins at 500 foot intervals. The estimated cost was 12.7 million dollars. The trend toward the use of nourishment and structural methods to hold the fill by the Army Corp of Engineers has become evident again in the newest proposal for a project in Rhode Island—Oakland Beach.

Oakland Beach in Warwick is the newest example of a coastal protection/restoral project by the Army Corp of Engineers in Rhode Island. It must be considered an example of the state of the art of the thinking and planning behind a contemporary project. Oakland Beach is a two thousand foot stretch of city-owned shorefront property. It has provided an important source of recreational activity for the area in the past. Because of its location and the shape of the coastline it has been subject to heavy erosion in divergent directions. The shoreline presently loses 3,700 cubic feet of material per year, or two feet of its beach. With only about 57,000 cubic feet of material available, the beach will be gone in forty years. The project is a cooperative one between the City of Warwick and the Army Corp of Engineers. It entails construction of a new beach and prominent groins to help hold the material. Periodic nourishment of the site will be required. Federal funding will cover seventy percent of the estimated
$719,000 initial cost. Nourishment will cost about $10,000 per year. This is certainly a significant undertaking. The costs are substantial, but the recreational value of the area was apparently enough to justify the project through a formal cost/benefit analysis.

Private projects in Rhode Island

It is somewhat easy to imagine a city spending thousands of dollars on many and various public projects. Restoring and protecting its beach is just one of them. It has been mentioned, however, that in Rhode Island a very large portion of the coastline is privately owned. Sometimes costs for shoreline protection have been quite substantial in the private sector as well. In a review of recent private projects on file at the Rhode Island Coastal Resources Council it was found that significant expenditures were being planned to protect privately owned property from erosion. Average costs of protection methods in Rhode Island seemed to run less than $200 per foot (probably due to the use of local rock material in construction), but overall costs were still remarkable. One project was to build a revetment to protect one hundred feet of shore at the Hundred Acre Cove. The total cost estimate was $5,000. Another project involved repairing a granite riprap retaining wall at $4,000, or over $100 per foot. A similar repair to a concrete wall involved $3,400. Other projects included replacing an old seawall with a rubble-mound revetment and strengthening another riprap wall. One new construction project estimated a cost of about $75 per
foot for a riprap wall, but the four hundred foot wall was going to cost that private owner $30,000! Perhaps the largest project of a private individual, and one that certainly indicates how far an individual is willing to go to protect his land, is the construction proposal for a riprap revetment on twelve hundred feet of shoreline in Little Compton. This project, to be funded by the owner, was estimated to cost $96,000, but at eighty dollars a foot, this is probably relatively inexpensive. These are only a few examples of present-day efforts to provide shoreline protection in Rhode Island. In May of 1976 at a Coastal Resources Management Council workshop the point was brought up that these types of small-scale, private efforts to fight coastal erosion are "never really satisfactory."57 When someone protects one short stretch of shoreline, invariably someone else suffers. As expressed by members at that workshop, however, the "realities of ownership...in Rhode Island" have "dictated" this course. With three hundred of the three hundred and forty miles of Rhode Island shorefront being privately owned, individual efforts will continue to be extremely costly, and often dissatisfying.

Conclusions and Recommendations

In summary, it has been found that shoreline erosion is a significant concern in both the public and private sectors of coastal states. Forces of waves and currents

become more and more an adversary as individuals and communities endeavor to protect their coastal resources. The value of those resources has risen considerably as the country's population has migrated to the coasts. The value of the coastal property drives the initial protective response and dictates the extent of the allowable expenditure. Present efforts to offer beach protection and restoral are basically patterned after the older "proven" techniques. Modern engineering and technology has come up with better materials and construction, but costs are always on the rise. Physical structures are still used to trap sand and absorb the energy of the sea, but natural methods of beach-fill nourishment and stabilization are being preferred, especially in large-scale public projects. Florida projects have shown how successful beach nourishment techniques can be, particularly for beaches in the southern hurricane paths. Rhode Island has provided an example of public and private response to the varied conditions of the many miles of its diverse shoreline.

Beach protection has progressed to some extent over the last several decades. Certainly a heightened awareness has come about through the positive efforts of scientific study and the increasingly obvious economics of saving a valuable resource. Through construction on and valuation of our coastline we have put ourselves into a dilemma. We are now in a position where we can not afford to abandon efforts to save our waterfront investments, but we can hardly afford the never-ending costs associated with their protection.
Though Florida has shown success to a degree in recent protection efforts for its substantial coastline investment, it is by no means a final solution. So many efforts in the past have been both wasteful and even more damaging than helpful. Continuing on with a do-whatever-you-can or can-afford attitude is not the answer either. The burden-of-proof permit mechanism of the Rhode Island Coastal Resources Council, though perhaps not the most efficient system, is at least a step in the right direction. It allows some selectivity of coastal applications through a screening process by an engineering and science staff. There is still no apparent requirement for coordination of efforts among different private parties, however. Another weakness noted is that of education and availability of low-cost methods. It appears that the private citizen is not very knowledgeable in the basic principles which will ultimately be governing their choice of protection method. Likewise, it is not obvious that low cost alternatives to erosion protection are being pursued. It is recommended that as little interference with nature as possible be undertaken, but if some application is found necessary, then efforts to limit the construction of engineering structures should continue, and emphasis on natural approaches towards beach protection and restoral should remain. It is further recommended that an active effort be made by coastal states, possibly through their coastal councils (or similar bodies), to provide information to concerned property owners on the coastline about the erosion process and the structural and non-structural
options available to them. Finally, greater awareness of community responsibility in the coastal zone should lead to actions to limit construction and development on critical areas such as barrier beaches, so that as time goes on we are not forced to take short-sighted and drastic action to protect those developments.
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