REALISM IN RESPONSE TO SHORELINE EROSION PROBLEMS: A CALL FOR A NEW WORLD ORDER

by

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INTRODUCTION

The gun emplacements that faced seaward, waiting for the enemy, are now falling into the sea; lost to the unanticipated force of shoreline retreat. North Carolina's civil-war Fort Fisher, Portugal's 19th century Forte Novo, and hundreds of WW II bunkers on both sides of the Atlantic are victims of the sea-level rise and coastal erosion. The sea is not selective, and post-WW II coastal development of houses, businesses, roads, and utility services are lost or threatened daily. Society now chooses to arm the shore against nature; to stabilize the position of the shoreline. Too often this decision to stabilize is like an out-dated Maginot Line, exacting a severe price economically and environmentally, while not providing a long-term solution.

The problem of stabilization is not only a problem of what is engineeringly feasible versus what is environmentally sound, but one of whether to protect private property or public beaches, and who should pay for the type of protection chosen, and for how long. Coming up with reasonable responses to shoreline retreat is all the more difficult because solutions usually are sought in a crisis atmosphere, when the beach is under the doorstep, or the cliff edge at the foundation. Short-term solutions are devised for long-term problems. The long-term nature of the shoreline erosion crisis is accentuated by the global sea-level rise. Western society's socioeconomic concepts of property rights and the attitude of being able to use/treat private property without regard to adjacent property or public domain does not bend to the natural dynamics of the shore, or common sense.
WHAT ARE THE OPTIONS?

Traditionally, hard stabilization is the solution of choice. The mighty seawalls of the Romans set a trend to out-engineer nature. The late 20th century has seen movement toward soft stabilization; an attempt to engineer by imitating nature. The realization that society may have to bend with natural dynamics is leading more and more in the direction of relocation of shorefront development as the most viable long-term solution; already encouraged by and framed in some legal codes. The long term reasoning is (Kaufman et al., 1985) that we can strategically retreat now or we can retreat in tactical disarray in the future.

What are the advantages/disadvantages of each option?

The following is a view engendered by experience on the U.S. East and Gulf Coast barrier island systems. These generalizations probably apply in most areas of the world.

I. Hard Stabilization

A. Wave Blocking Devices (the seawall family)

1. Advantages

Seawalls are the best choice if society's only goal is to protect property.

2. Disadvantages

Seawalls result in beach degradation (narrowing to complete loss), as well as loss of recreational value (e.g., debris on beach, danger to swimmers or other beach users, access loss, and general loss of esthetics). Construction and maintenance are costly.

B. Sand Trapping Devices (groins; breakwaters)

1. Advantages

These structures build up the local beach, thereby improving beach quality and storm protection. Recreational value may be improved.

2. Disadvantages

Trapped sand is robbed from the littoral drift causing shoreline erosion in the downdrift direction. At the same time, the structures block lateral beach access for recreation, may pose a danger to swimmers, often contribute debris to the beach, and are unsightly. Historically, such structures lead to more stabilization. Construction and maintenance are costly.

II. Soft Stabilization

A. Beach Replenishment

1. Advantages

This option is best if society wishes to maintain a beach, and protect property developments that people are unwilling to move. The quality of an eroding beach is maintained, or improved, and its role of storm protector preserved. When sand is eroded, it may benefit downdrift shorelines. Recreational and esthetic qualities are maintained or improved.

2. Disadvantages
Beach nourishment must be viewed as temporary; very costly to install and maintain. Usually the impact on the native marine biota is negative. Suitable replenishment/nourishment sand may not always be available.

B. Bulldozing

1. Advantages

This very short-term, crisis response may give a very short-term sediment gain, and contribute to beach maintenance for short-term protection. Short-term costs may be lower than other options, but this is false long-term economy.

2. Disadvantages

Bulldozing provides extremely temporary nourishment to the upper beach, and actually may erode the lower beach, resulting in beach narrowing. No new sand is added to the littoral system, so the process must be repeated after each storm. The process disturbs the beach biota.

III. Relocation (Move or Demolish Development)

A. Advantages

Relocation is the best solution if a community's only priority is to save beaches. This long-term solution is a policy of noninterference with the migrating beach. Beach quality and storm protection, esthetics, recreational value, and biota are conserved.

B. Disadvantages

This approach is politically the most difficult, as well as costly, although no more so than other options for the long term. Demolition may be required, or a move away from the shorefront, losing recreational access. Land loss will occur.

The implementation of the relocation option, and avoiding creating new problem areas through shoreline development requires legislative regulation, economic incentives and disincentives, and/or cost sharing. These legal solutions can be at the federal, state, or local government level and include coastal zone management or planning, zoning, construction setback requirements, "rolling" setbacks where the regulated zone migrates with the shoreline (e.g., buildings must be moved as they come into the erosion zone, or buildings destroyed/damaged by shoreline erosion can not be reconstructed/repaired), or prohibitions against certain types of structures (e.g., no high-rise buildings). Economic disincentives include higher premiums to insure structures in the erosional zone, or passive disincentives such as the prohibition of loans/grants to construct/replace roads and services in a coastal erosion zone. Incentives include such programs as allowance to use insurance monies to move a threatened structure, or low-interest loans for the same purpose.

All of the stabilization options and approaches must be viewed as a long-term commitment. Unfortunately, the "crisis atmosphere" negates long-term planning. The public generally is not fully informed of the long-term implications of all of these approaches. For example, beach replenishment should never be viewed as a short-term solution. Likewise, long-term commitment is different than long-term feasibility. Will the federal, state, or local government be able to continue to pay for beach nourishment in 30 years, 50 years, and so on? Will a quality sand supply remain available? Maintenance also must be part of the long-term plan and its feasibility. Chicago is a mega-example of the potential problem. The city's artificial-fill coast is protected by miles of seawalls, revetments, and groins. Maintenance of
this complex of shore hardening structures was neglected for decades, until a storm/flood/erosion crisis in 1987. The esthetic and economic value of the shorefront was greatly reduced and the city now faces massive repair and replacement at a very high cost (Chrzastowski, 1991).

ANSWERS TO CRITICAL QUESTIONS

Ideally, decisions to attempt new shoreline stabilization or maintain existing stabilization should be guided by a balanced set of objectives (e.g., is the community priority to protect property, preserve recreational beaches, or both?). Communities need to ask the right questions, even more so in shoreline-erosion crisis situations. The following responses to such stabilization and structural solution questions are those that we believe coastal engineers and geologists should be giving.

Predicting sand behavior

Can We Predict the Behavior of Beach Sand?

No. All coastal engineering practices and all shoreline response alternatives require knowledge of sand movement for their successful implementation. Thus predicting the behavior of beach sand, whether it involves life span of a replenished beach or the downdrift impact of a groin, is of critical importance. But we cannot predict the behavior of sand in a time frame of use to mankind. There are a number of reasons for this:

1. The basic assumptions that underlie most engineering equations for sand transport are highly questionable. Such assumptions usually include (a) all sand transport is by wave orbital/seafloor interactions, (b) storm driven currents do not carry sand offshore, and (c) there is a seaward depth of closure beyond which sand is not transported offshore. Frequently the models assume that a storm will not occur.

2. Coastal processes must be chaotic, but they are not treated as systems in chaos. Sediment movement is in chaos because storms which dominate coastal processes are controlled by the atmosphere which is a system in chaos. One cannot predict the frequency, magnitude, direction, duration, and fetch of the next storm, large or small. Sediment movement is also controlled by wave motion and local currents which obey non-linear fluid dynamic equations. Nonlinear systems have non-periodical solutions.

Seawalls

Do seawalls cause erosion?

Yes. If you measure erosion by change in volume of the subaerial beach. Often it is argued that the wall was put in because of erosion (as measured by shoreline retreat) and therefore the wall didn't cause the erosion. True enough! Since the real societal question is whether or not the wall damaged the beach, it is best to use the term degradation rather than erosion in describing seawall-beach interactions.

Do seawalls degrade beaches?

Yes.

How do seawalls degrade beaches? (Pilkey & Wright, 1988; Tait & Griggs, 1991)

1. Placement degradation - some walls are placed seaward of the high-tide line.

2. Passive degradation - Shoreline retreat continues after the wall is emplaced thus narrowing the beach. Any wall built at the back of an eroding beach (and most are) will result in eventual beach loss.
3. Active degradation - The wall actively causes erosion by wave reflection, etc. The effectiveness of active beach degradation is controversial however (Kraus 1988). Most arguments as to whether walls degrade beaches or not are arguments as to whether active degradation occurs. These arguments over a mechanism should not be confused with the generic question; do seawalls degrade beaches?

*Are there exceptions?*

Of course, but these are few in number. Most claims of exceptions are based on short term observations. A common example is a wall built immediately after a storm where the beach widens, at first, due to storm recovery.

*How long does it take for a seawall to degrade beaches?*

Perhaps anywhere from 2 to 60 years. Two to three decades is a common time span for degradation on U.S. East Coast beaches. For this reason, short term declarations that a seawall has caused no problems are meaningless. The fact that seawalls may take a long time to cause serious damage requires politicians to take a very long view on the subject, a most difficult thing in most political systems.

*What is the very long term impact of seawalls?*

Narrowed beaches, higher wave energy leading to bigger and better seawalls (Hall and Pilkey 1991).

*Do seawalls protect buildings?*

**Yes.**

*Do seawalls protect bluffs?*

To the extent that bluff retreat is due to subaerial processes (running water erosion, chemical weathering, frost wedging, etc.) walls don't protect bluffs (Norris, 1990). Much depends on the height and composition of the bluff.

*Why do seawalls fail?*

Inadequate engineering.

**Groins**

*Do groins cause erosion?*

**Yes.**

*Are groins effective in general?*

A subjective answer is that the net impact of groins and groin fields, worldwide, has been negative. That is, more is lost in terms of shoreline damage than has been saved in terms of shoreline buildup. This situation varies widely, of course.

*Where can groins be used without causing damage?*

At the extreme end of a sand transport system, such as at the tip of a cuspate foreland is one such location. Secondly, groins can, on long stabilized shorelines, provide the only beaches for a community. This is the situation in Mommouth Beach and Seabright, New Jersey where, without groins, there would be no beaches.
Can groins increase the durability of replenished beaches?

Yes, providing there is a significant longshore component of sand movement from the replenished beach. Once the replenished beach retreats landward of the tip of the groin however, reduction in sand supply of downdrift beaches will commence.

Offshore breakwaters

How do breakwaters differ from groins?

Groins and breakwaters both trap sand and build out beaches. They also both cause sand deficits in the downdrift direction. The major difference between groins and offshore breakwaters is that the latter will cause storm waves to break offshore and will thereby afford an additional measure of protection for beach front buildings.

One device solutions

In the U.S. and especially on the Great Lakes, there are dozens of companies selling single shoreline stabilization devices that are alleged to work anywhere, anytime to protect buildings or build up beaches. These structures are generally given catchy names, such as sand grabber, wave buster, surge breaker, sea scape and sta-beach (no suggestion is made as to whether these particular devices or approaches do or don't work). The one-device companies often support their device using a wide variety of claims some of which follow:

1. It worked in Florida. Usually the place where it allegedly worked is at least 500 miles away.

2. Professor "Jones" of State University tested and evaluated the structure. Sometimes Professor Jones's tests are inconclusive. Most often such tests are made under very restricted conditions.

3. This device will work on any kind of shoreline. This is never the case. Each shoreline situation requires a different approach.

4. Thousands of Cubic meters of sand pass by here and our device will only grab a small fraction of it.

5. This device will not impact on downdrift beaches. Anything that holds sand artificially in one place will impact on neighboring beaches.

6. This device brings in sand, not normally in the littoral system. Nonsense.

7. Here is a photo showing the success of our structure. Such photos must be examined closely. Some before and after photos used by salesmen are very misleading. Common tactics are comparing high and low tide and high and low lake level scenes or before and after storm recovery photos.

8. The device didn't work in Pleasant Beach because local officials didn't allow us to put it in correctly. This, or some variety of this, is a common explanation for failure of a device to work as advertised. But a company that puts in a device knowing it's not put in correctly is at fault, not local officials.

9. This device has been published in the engineering literature. Scientists and engineers know that publication in the technical literature guarantees nothing about quality. In addition, much of the coastal engineering literature is not refereed.

10. This is low cost shore protection. There is no low cost, long term shoreline
protection on ocean shorelines.

**Beach replenishment**

*Can we predict the lifespan of artificial beaches?*

No. On the U.S. East Coast predictions have been dismal and are almost always over optimistic (Pilkey and Clayton 1987). This means that costs have also been underestimated. Storms are primarily responsible for loss of artificial beaches and we will not be able to predict beach durability until we can predict storm frequency and intensity.

*Is beach design and prediction of lifespans hopeless?*

No. The Gold Coast, Australia experience (Smith, 1990) shows that a local statistical model based on long term observations is useful in predicting replenished beach durability (with error bars). Using current engineering models to design beaches has frequently failed.

*Do replenished beaches provide effective storm protection?*

Yes, if large enough volumes of sand are involved. Often, however, a replenished beach is good for only one significant storm.

*Do replenished beaches erode faster than natural beaches?*

In general, yes.

*Do replenished beaches substantially recover from storms?*

No, in general this does not happen on U.S. East Coast barrier islands. Smith (1990) reports a well documented 80% recovery of a storm-lost beach on the Gold Coast.

*Why is there so much disagreement over the rates of loss of replenished beaches?*

Replenished beaches disappear at dramatically different rates along their length. Thus it is often a judgement call concerning beach lifespan. Often artificial beaches disappear most quickly along reaches which were the most critically eroding to begin with.

*Does replenishment sand moved offshore count for anything?*

No, especially not as far as the beachfront community is concerned. The assertion that the sand will permanently reside offshore and help buffer storm waves is probably not true. To begin with, the sand does not permanently reside offshore and also such offshore replenishment sand has little impact on storm wave dampening because the storm surge effectively negates its role.

*Does beach replenishment impact significantly on the biota?*

Yes, especially in hard ground and reef areas. However, the requisite systematic and long term studies of replenishment biota impacts have never been made on any coast.

**Relocation**

*Is the relocation alternative a permanent solution?*

No. How "permanent" depends on how far back buildings are moved and what is the potential rate of shoreline retreat?

*Why move back when we could replenish or armor?*
Seawalls destroy beaches and replenishment is very costly.

*Is the relocation option costly?*

It depends. The U.S. Federal Flood Insurance Program intends to encourage relocation via insurance premiums.

*Is the relocation option costly compared to replenishment or armoring?*

It depends on the situation. Moving Miami Beach and Atlantic City, New Jersey back from the retreating shoreline is much more costly than moving back communities of single family homes.

*Will we move Manhattan back?*

Not likely. In the case of major cities, diking and armoring will likely prevail in case of major sea level changes.

**A FINAL WORD**

A new order of coastal scientists and engineers must develop new strategies in selecting solutions to shoreline retreat from a broader menu of possible solutions. Each approach must involve evaluating realistically the natural setting as well as the socioeconomic objective. Application of standardized formulas, standardized models, and "one size fits all" engineering has proven inadequate; it is unrealistic in the face of nature's chaos, as archaic as "one device" shore-hardening structures. Old established ports and urbanized/industrialized shorelines, where the priority is protecting property, will still require seawalls and groins. Shore hardening should be a nonchoice for most communities that wish to preserve recreational and protective beaches. Soft solutions, particularly beach nourishment, should not be sold to the public without their full knowledge of the required economic commitment and practical feasibility, i.e., the option is expensive, requires a long-term commitment, and a continuous future quality sand supply. The engineering community should apply their expertise to the technology of relocation in which beaches can be conserved, buildings saved in many instances, and the impact of future erosion reduced.

**REFERENCES CITED**


