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Replenishment versus retreat: the cost of maintaining Delaware's beaches

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Abstract

The dynamic nature of Delaware's Atlantic coastline coupled with high shoreline property values and a growing coastal tourism industry combine to create a natural resources management problem that is particularly difficult to address. The problem of communities threatened with storm damage and loss of recreational beaches is serious. Local and state officials are dealing with the conflicts that arise from development occurring on coastal barriers. Delaware must decide which erosion control option is the most beneficial and economically sound choice. Debates over beach management options began with the discussion of a long-term management strategy. Beach nourishment and retreat were the primary approaches discussed during the development of a comprehensive management plan, entitled Beaches 2000. This plan was developed to deal with beach erosion through the year 2000. Beaches 2000 recommends a series of actions that incorporate a variety of issues related to the management and protection of Delaware's Atlantic coastline. The recommendations are intended to guide state and local policy regarding the state's beaches. The goal of Beaches 2000 is to ensure that this important natural resource and tourist attraction continues to be available to the citizens of Delaware and out-of-state beach visitors. Since the publication of this document, the state has managed Delaware's shorelines through nourishment activities. Nourishment projects have successfully maintained beach widths. Moreover, tourism, recreational use, and real estate values continue to grow. The plan refers to retreat only as an option for the distant future.

1. Introduction

The dynamic nature of the coastline, the tremendous value of properties along the coast, and the economic value of the coastal tourism industry combine to create a

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natural resources management problem that is particularly difficult to address. In the State of Delaware, located on the East Coast of the United States, local and state officials are dealing with the conflicts arising from development occurring on coastal barriers. As the tourism industry in this area expands, development on these barriers increases. This development is in danger of falling into the sea, due to beach erosion and shoreline migration. Delaware must decide which erosion control option is the most beneficial and economically sound choice.

Beach erosion and shoreline migration are caused by two forces: storms and sea level rise. The position of the land/water interface is a product of water level (tide), sediment supply (sand), beach shape, and wave size. During the calm period of summer, the visible portion of the beach is very wide. Storms remove sand from the visible beach, depositing it in the shallow nearshore zone. The amount of change in the beach profile is dependent on the strength of the storm, length of the storm, tidal height, and condition of the beach before the storm. For the most part, the changes due to storms are temporary; although in some cases, the damages that result from one storm may require months or years for recovery. In the Mid-Atlantic region, 2–3 dozen winter storms typically occur per year [1].

The other force affecting the coastline is sea level rise. Sea level rise is caused by the gradual melting of the polar ice caps and thermal expansion of the surface layer of the ocean. This rise in water level in the ocean pushes the point where the land meets the sea in a landward direction.

2. Nature of the dispute

The real threat to American beaches is not storms or rising sea level. In natural shoreline retreat, the beach simply changes its location, while retaining its shape. There is no loss of sand in this process of "shoreline erosion". The problem lies in the fact that as humans locate houses, highways, and seawalls along a beach, shoreline retreat is blocked. The beach then backs up against these objects, having nowhere to retreat. This leads to a narrowing of the beach, as well as a reduction in the supply of sand on adjacent beaches.

The proximity of structures to the ocean has prompted state officials to attempt to halt erosion and migration. The problem of communities threatened with storm damage and loss of recreational beach is a real and serious one. Whether natural or man-made, the problem of diminished beach demands considerable planning and expenditures now and in the future.

2.1. Conflicting coastal uses

The conflict arises because communities and lawmakers disagree about how the beach should be stabilized so that the recreational and tourism aspects of the coastal can continue. Options include hard stabilization, soft stabilization, and relocation of homes. The issue is whether society should save the beaches or the buildings.

The second conflict arises due to the cost of these responses to shoreline erosion. Here the problem lies in the argument that the public in general should not be required to pay for private communities' erosion control methods. Moreover, because residents of other states also visit Delaware beaches, perhaps Delaware residents should not be the only people who pay for public beach management in their state. An on-site study conducted by Delaware Sea Grant found that visitors to Delaware beaches were primarily residents of Pennsylvania (28%) and Maryland (28%), with Delaware residents only making up 16% of the beach visiting population [2]. Due to these numbers, a conflict arises because Delaware residents believe that they should not have to submit extra state taxes to pay for beach management and erosion control if they are not the individuals visiting the beach. In this instance, "Who pays for beach preservation?" is the question often asked.

3. US beaches

The most predominant type of coastline in North America consists of barrier islands that extend from the south shore of Long Island, New York, to Mexico's Yucatan Peninsula, with few interruptions. A barrier island is one form of coastal barrier.

Coastal barriers are landscape features that shield the mainland from the forces of wind, waves, and tides. These features are extremely valuable for a number of reasons. They protect the mainland community from storms. Under normal conditions, waves directly attack only the aquatic habitats immediately adjacent to the coastal barrier. However, major coastal storms routinely affect the entire landward aquatic habitat. This habitat survives major storms because coastal barriers receive the brunt of the ocean's energy. Storm waves break on the barrier beach, leaving the diminished wave to travel landward into the wetlands. At the same time, wetlands store storm flood waters, easing flood pressure on the mainland. Without extensive sandy beaches, damage from violent storms would be much greater. Beaches are also valuable because they provide wildlife habitat. Fish, shellfish, birds, mammals, and other wildlife depend on barriers and their associated wetlands for feeding, spawning, nesting, nursery, and resting habitat. A barrier and its associated habitats form one ecological system, the health and productivity of which depend on the rational use of all of its component parts. Coastal barriers are also an important recreational resource used for walking on the beach, swimming, surf-fishing, boating, surfing, crabbing, bird watching, and recreating.

Barrier islands are the most dynamic real estate in the United States, and also the most sought after. They are the site of the most extensive beachfront development in the nation. The following quote exemplifies this development and the love of oceanfront location:

> We occupy the barrier islands like people who have built cities on the backs of giant sea turtles. Like all reptiles, turtles must breathe, but we so enjoy our perch we will not tolerate the beast moving even to keep a footing in water shallow enough for it to raise its head [3].

3.1. Beach preservation methods

Coastal managers attempting to preserve beaches and provide property protection consider three available responses to the shoreline erosion problem: (1) hard stabilization, (2) soft stabilization, and (3) relocation of threatened buildings.

Hard stabilization involves structures that either block and dissipate wave energy or trap sand to widen the beach. There are three major categories of hard stabilization: (1) shore-parallel structures on land, (2) shore-parallel structures offshore, and (3) shore-perpendicular structures.

The most common type of hard stabilization is the *shore-parallel structure on land.* Examples of these are seawalls, bulkheads, revetments, sandbags, and gabions. Seawalls are structures made of wood, steel, rock, or concrete that are designed to protect the upland from the impact of waves. They are built at low elevations and are not intended to block storm waves; instead, they function to halt retreat of the shoreline into the line of structures. The overtopping of seawalls is common in hurricanes, and walls fail for many reasons, including the build-up of water pressure (from storm surge) on the landward side, storm surge ebb flow tearing the wall apart, and scouring and undermining of the wall by direct wave attack. Bulkheads are generally indistinguishable from seawalls to the general public. The purpose of these is to hold back land from slumping or eroding into the sea, not to absorb wave energy, as the seawall is meant to do.

Revetments are a relatively inexpensive armor of rock facing on a dune or beach slope. As waves break against the revetment, much of the water contained in the wave is absorbed in the spaces between the rocks, reducing the erosion-causing backwash. Proper design of revetments requires carefully placed, heavy, wave-resistant material for the structure, properly angled and backed by filter cloth (a decay-resistant mesh fabric that allows water to escape but prevents soil loss).

Gabions are used to construct seawalls or revetments. They consist of rock-filled rectangular steel wire mesh cages piled one on top of another to form a wall. Although the wire is plastic coated, the mesh will eventually corrode and the gabion will rupture, spilling the rocks and causing the wall to disappear.

Seawalls introduce new and different problems to the coastal environment. Because the seawall does not absorb all of the wave's energy, some energy will reflect, and scour and erode the sediment in front of the wall. Some energy is also deflected along the wall to the adjacent unprotected property where it erodes the shoreline. The resulting narrowed beaches in front of seawalls lead to a reduced sand supply to adjacent beaches, further intensifying erosion of the neighboring beaches.

An example of the second type of hard stabilization, *shore-parallel structures offshore*, are offshore breakwaters. Breakwaters are designed to reduce wave energy and shelter a portion of the shoreline. The effect of breaking the wave energy is to interrupt the longshore transport of sand, which causes accumulation of sand behind the structure. As the local beach widens, the structures starve downdrift beaches of their sand supply. Offshore breakwaters became popular in the United States in the 1980s and 1990s.

Groins and jetties are examples of the third type of hard stabilization, *shore-perpendicular structures* that block the longshore flow of sand. With these structures, trapped sand is held as a beach deposit. Groins are walls, made of rock, wood, or steel that are designed to trap and hold sediment flowing in the longshore current, therefore rebuilding the eroding beach. They are useful in retaining the sediment already on the beach, or new sand deposited from a nourishment project. The difficulty with groins is that they trap sediment on one side and intensify erosion on the other, depending on the net littoral drift direction. Because of this, updrift beaches are widened, and downdrift beaches are "starved" of sand.

Jetties are similar to groins, but are constructed specifically to stabilize inlets and entrances to harbors. These structures are intended to make navigation safer and channel maintenance cheaper. These cause more extreme downdrift erosion than groins because they completely interrupt the longshore sediment transport system. More recent designs call for a sand bypassing system to be built along with the jetty. Most engineers feel groins and jetties are a losing proposition for beaches [1].

Hard stabilization structures are dependable methods of halting shoreline retreat and protecting the coastal property, when appropriately designed. In the United States, the many disadvantages associated with hard shoreline stabilization are only now understood after more than a century of use. These structures regularly end up degrading the recreational beach, are costly both in the short term and long term, destroy beach aesthetics, and make beach access difficult. Engineers have often tried, but failed, to protect development by stabilizing the beach. History has shown that "betting on beach stabilization is a high-risk wager" [3].

Soft stabilization techniques, another option for beach preservation, are those that add new sand to replace an eroding beach or plant new vegetation to hold sediment in place. A widely used soft stabilization technique is beach replenishment. This is the "modern method" of maintaining a healthy beach to help protect buildings as well as provide a recreational resource. The addition of new sand provides a wider buffer that removes the immediate threat to structures located too close to the water. On the East Coast of the United States, more than 100 beaches have been replenished since 1965 [1].

Replenishment is the process of taking sand from a "borrow" area, such as an offshore sand deposit, inlet tidal delta, or upland sand source, and depositing it on an eroded beach. The amount of sand is generally determined through the use of computer models and deposited on the beach according to an engineered design. The sand is brought from the borrow area to the beach by way of pipeline, dredge, or dump truck, and then smoothed into a beach profile by bulldozers.

Some view beach replenishment as throwing money, and sand, directly into the ocean. Others believe it is worth every penny because it restores the eroded beach, at least temporarily.

Part of the disagreement on the value of replenishment is due to the durability of the replenished beach. Durability, the time span before the beach effectively loses its

storm protection or recreation function, has been highly variable in beaches along the East Coast. The following statistics show this to be true:

- 26% of replenished US Atlantic Coast barrier island beaches effectively disappear in less than 1 year.
- 62% of replenished beaches last between 2 and 5 years.
- 12% of replenished beaches remain for more than 5 years.

For the states of Maryland, Delaware, and New Jersey, 1–3 year beach life spans are all that can be expected [4].

The environmental impacts of beach replenishment are assorted. The water turbidity caused by suspended sand and mud released during the artificial beach construction can harm sea life. Evidence suggests that settling mud smothers corals and dredges and other beach-building machinery physically destroys these communities [4]. The offshore dredge hole resulting from offshore sand mining may allow larger waves to attack the adjacent beach. The process of taking sand out of the water and placing it on a beach may displace or kill benthic (bottom-dwelling) organisms. Sand placement may smother organisms that live in the beach.

Intuitively though, replenishment is the environmentally preferable alternative to seawalls and other hard structures that do not preserve the beach in the long term. Soft stabilization appears to be the more environmentally sensitive approach, but questions of long-term impact remain. Nourishment must be repeated at regular intervals for the beach to maintain a somewhat static position. As suitable sources of replenishment sand become more scarce, costs and environmental impacts will increase.

Other soft stabilization techniques include dune building, sand fencing, and revegetation. Wide dune fields provide a main line of frontal defense against storm activity. Wherever dune removal for development occurs, the probability of complete overwash and destruction of property increases. Sand fencing and artificial plantings of dune grass to build (or rebuild) dunes are most effective when the property is set back far enough from the water line to provide adequate space for the dunes to build.

Relocation is another method of coping with shoreline erosion. If the homeowner acts proactively, she will build back from the shoreline in a more stable area. However, when the shoreline encroaches upon the homeowners' property, the amount of setback distance is no longer important. Relocation has been employed on the East Coast of the US for over 100 years and is increasingly becoming an acceptable option.

The most obvious type of relocation, referred to as strategic retreat, consists of removing the structure from the waterfront and moving it elsewhere, either in one piece or in sections. Another form of relocation is the demolition of the shoreline home, with rebuilding occurring elsewhere. Abandonment is also an economically sound option, especially where the cost of moving or protecting the building exceeds the building's value.

The obvious advantages of relocation are that the beach is preserved, and the property owner and community are saved the costs of shoreline stabilization. Another advantage is that the cost of moving is a one-time expense, whereas

hard and soft stabilization approaches are a continuous expenditure. The drawbacks are that it can be politically difficult, as well as costly, and the land is ultimately lost.

To perpetuate this beach preservation method, in 1987 Congress passed an amendment to the National Flood Insurance Program (NFIP), the Upton-Jones Amendment, to allow homeowners of threatened buildings to use up to 40% of the federally insured value of their homes for building-relocation purposes. The federal government decided it would rather disperse a relatively small amount of money to assist relocation of a threatened house than pay a larger amount to help rebuild it, only to see the rebuilt house destroyed in another storm.

The Upton-Jones Amendment was replaced in 1995 with the National Flood Mitigation Fund (42 U.S.C. sections 4104c, 4104d) [1]. This provided state and local governments with grants for planning and mitigation assistance for activities that would reduce the risk of flood damage to structures covered under the NFIP. Demolition and relocation activities are eligible for this grant assistance, but they must compete with other mitigation approaches, such as elevating and flood-proofing programs, beach nourishment activities, and technical assistance.

Several conditions dictate the choice of which option is best suited to treat erosion of any particular beach. If the primary goal is to preserve the beach, then either nourishment or strategic retreats are the desired options. If protection of property is the most important feature and the beach has little value, a seawall may be the best option. The affected community and local decision makers, as well as state lawmakers, must consider all aspects of the erosion control before deciding upon a specific option.

4. Delaware's ocean beaches

Delaware's Atlantic Ocean coastline is approximately 24 miles long, with much of the area designated as state parkland. A series of municipalities and unincorporated areas are interspersed along this coastal barrier. An estimated 21,355 people live in the Delaware beach communities and neighboring areas [5]. The average annual erosion rate in the beach communities varies between 2 and 4 ft/yr. Fig. 1 gives baseline information for Delaware beaches.

The major sectors of the Delaware ocean coastline are, from north to south, Cape Henlopen, Rehoboth Beach, Dewey Beach, Delaware Seashore State Park, Indian River Inlet, North Bethany Beach, Bethany Beach, South Bethany Beach, and Fenwick Island. Moderately wide beaches and well-developed primary and secondary dunes characterize these sections of the Atlantic Coast [6].

Cape Henlopen is located at the mouth of the Delaware Estuary. The Cape is the home of the Great Dune, the highest sand dune between Cape Hatteras and Cape Cod, which rises 80 ft above the shore. The eroding Atlantic coast provides sand to the longshore transport system which leads to a growth of the spit system located on the cape. This spit advanced northward into the Delaware Bay nearly 6000 ft between 1842 and 1976, at an average rate of approximately 45 ft/yr [6].

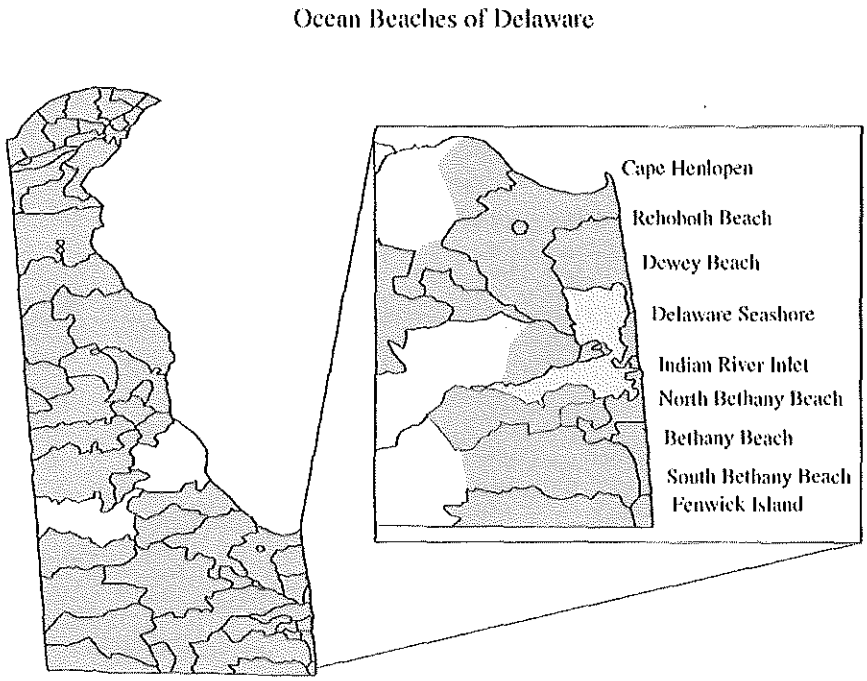

Fig. 1. Map of ocean beaches of Delaware.

Rehoboth Beach is the largest community in population and tourism infrastructure. It is heavily developed with accommodations (hotels, cottages, and condominiums) and has an active business community. A one-mile boardwalk fronts the ocean beach.

Dewey Beach, a smaller community, is located south of Rehoboth on the Atlantic coastal barrier system. Dewey is the host to many summer visitors at cottages, motels, and condominiums, and includes numerous eating establishments. Its recent erosion rate (1970–1977) is 6.8 ft/yr. Dewey Beach was the site of a $2.3 million beach renourishment project in 1994, and extensive dune restoration and revegetation in the spring of 1995 [6].

Delaware Seashore State Park is one of the areas of the Delaware coastline that the state owns. Bounded on the east by the Atlantic Ocean, and on the west by Rehoboth Bay and Indian River Bay, the 2018-acre park is a favorite of Delaware beach-goers. Water activities offered here are surfing (one of the few areas in the state where this is allowed), wind-surfing, crabbing, clamming, boating, fishing, and swimming.

The Indian River is located in the vicinity of an inlet noted during recent geologic and historic times. This historic inlet, according to documentation, continually migrated, closed, and reopened through natural processes. Stone jetties, constructed between 1938 and 1940, now stabilize the present inlet. Severe beach and dune

erosion on the north side of the beach necessitated periodic placement of sand for beach renourishment during the 1970s and 1980s. Because the inlet blocks the northward movement of sand, a sand bypassing system was installed at the inlet in 1990. This system pumps sand, using a jet pump, from the south beach to the north beach at a rate of over 200 ft^3/h [6].

North Bethany Beach is a private community located south of the inlet along Delaware's ocean coastline. This area is composed of large, single-family homes and spacious townhouses. Spanning both sides of Route 1, North Bethany bounds the Atlantic Ocean to the east and Indian River Bay to the west. North Bethany boasts some of the largest, most modern homes on the Delaware coast, and all units are within walking distance of the ocean or bay.

Bethany Beach is the second largest municipality along the Delaware coastal barrier system. It is less developed than Rehoboth Beach, but contains more development than Dewey. Bethany accommodates thousands of summer visitors and also maintains a 0.5 mile boardwalk.

It is known as one of the "Quiet Resorts" and boasts a year-round population of 340 persons.

South Bethany Beach is located at the point along the coast where the longshore transport direction of sand diverges. This shoreline has extensive shorefront development, and structural damage occurs even during minor storms. A shore-parallel stone revetment, located at the base of present oceanfront homes, protects the roadway. Beach renourishment was conducted in 1989, 1992, 1994, and 1998.

Fenwick Island is similar to South Bethany, both communities' landscapes dominated by beachfront cottages and houses. Fenwick lies on the Delaware-Maryland state line on the southern end of Delaware and is the southernmost of the Quiet Resorts. The only significant business activity occurs along the major beach thoroughfare.

In the last 50 years, Delaware's coast has become a major summer recreation attraction. An estimated 5.1 million person-trips are made to the Delaware beaches each year and the consumer surplus (the recreation/aesthetic value of the beach as revealed by beach visitors) for these visitors exceeds $380 million [5]. Visitors spend more than $573 million in beach trip-related expenditures each year [5]. These trip-related expenditures create jobs, profits, and state and local receipts within the beach communities and the state. With the construction of buildings, roads, and other infrastructure, the persistent movement of the shoreline now presents new problems.

5. Nature of local dispute

The state environmental agency addresses the problems involved in human occupation on Delaware's coasts. Current policies provide beach nourishment to the ocean beaches at a cost of approximately $1.8 million per year, "thereby mitigating the effects of long-term erosion and sustaining the ability to attract and accommodate beach visitors" [5]. Fig. 2 summarizes beach replenishment projects for all of these communities.

Project Location	Date	Volume (cy)	Cost ($)	Comments
Southern Coast '89				
Fenwick Island	9/21-10/28/88	333,500	1,572,993	Offshore Dredging: pumping sand onto beach from barge located offshore.
South Bethany	8/21-10/5/89	231,600	1,307,849	Offshore Dredging
Middlesex Beach	10/6-10/89	63,700	357,905	Offshore Dredging
Sea Colony	7/1-14/89	132,600	770,058	Offshore Dredging
Bethany Beach	6/5-30/89	284,500	1,630,241	Offshore Dredging
Total		1,045,900	5,639,046	
Southern Coast '92				
Fenwick (incorp.)	8/28-9/6/92	144,900	716,916	Offshore Dredging
South Bethany	9/17-10/12/92	192,749	905,786	Offshore Dredging
Bethany Beach	10/13-11/13/92	219,735	1,037,303	Offshore Dredging
Total		557,384	2,660,005	
Whole Coast '94				
Fenwick (incorp.)	9/18-19/94	8,236	32,396	Offshore Dredging
South Bethany	8/10-18/94	98,419	452,165	Offshore Dredging
Bethany Beach	8/1-10/94	184,452	838,953	Offshore Dredging
Indian Beach	07/30/94	4,778	20,435	Offshore Dredging
North Indian Beach	7/29-30/94	20,992	61,400	Offshore Dredging
Dewey Beach	7/1-29/94	592,878	2,402,230	Offshore Dredging
Total		909,755	3,807,579	
Whole Coast '98				
Fenwick (incorp.)	10/19-22/98	56,100	457,000	Offshore Dredging
South Bethany	9/21-28/98	168,900	707,635	Offshore Dredging
Sea Colony	9/18-21/98	128,000	419,479	Offshore Dredging
Bethany Beach	9/9-18/98	321,700	1,321,572	Offshore Dredging
Dewey Beach	7/12-23/98	453,500	1,948,000	Offshore Dredging
Rehoboth Beach	7/25-8/12/98	274,300	1,087,750	Offshore Dredging
North Shores	8/13-16/98	188,000	721,630	Offshore Dredging
Total		1,590,500	6,663,066	
Combined Total		4,103,539	18,769,696	

Fig. 2. Summary of nourishment projects on Delaware Ocean beaches, 1989–1998 (Source: Levinson, 2001 [11]).

In Delaware, citizens and lawmakers must determine the best option for beach preservation, each measure having its pros and cons. The tradeoffs for hardening the shoreline are weighed in this decision. In Delaware, the beach is primarily a place for enjoyment and relaxation, and preserving it is a major concern. Although groins have been successful at stabilizing the shoreline at Rehoboth Beach and have helped with shoreline stabilization at Bethany Beach, Delaware does not make extensive use of hard structures.

Nourishment has been the preferred choice of Delaware decision makers, although there are problems associated with it as well. The economics of nourishment favor treating long stretches of adjacent shoreline due to the high costs of mobilizing equipment for sand movement and the fact that larger nourishment projects increase the stability of the beach [7]. In Delaware, communities with public beaches are separated by communities with private beaches, and the areas with large coastal

development are separated by open park land. Therefore, planning for a long shoreline project in Delaware is difficult. Another issue in renourishment is the coordination of state and federal funding cycles, which are often difficult to harmonize.

Issues arise with the third option of beach management as well. If sea level continues its predicted rise, the only long-term option is strategic retreat. Nourishment costs will continue to escalate, making it more difficult to continue the soft stabilization approach, and the beaches will begin to disappear from their location in front of hard structures. Moving structures away from the shoreline may be the only way to preserve the beach in the long term.

Selection of retreat as the preferred option involves a number of political, economic, and social considerations. If relocation were chosen as the means to this end, someone must determine where to move the houses. However, some oceanfront buildings, such as condominiums and hotels, cannot be realistically moved. In addition to these two concerns, there are others such as the moving and land procurement costs as well, as the question of financial responsibility.

5.1. Beach management conflict

Delaware's Department of Natural Resources and Environmental Control (DNREC) is the state's environmental protection organization and takes the lead role in managing Delaware's shorelines. Since 1988, DNREC has opted for nourishment activities to manage the state's ocean shoreline. The nourishment efforts "have been sufficient to maintain beach widths in all communities; and tourism revenues, real estate values, and recreational use have all flourished during this period" [5]. Throughout these years, the federal and local governments have shared the costs of nourishment, and state expenditures have remained below $2 million per year. Delaware beach visitors and property owners have relied on nourishment to keep the state's beaches in a stable state, and their feelings about this have resulted in decisions to purchase property, make business investments, and plan vacations at a Delaware beach. Throughout these 12 years, Delaware's coastal communities "demonstrate[d] the positive value of nourishment" [5]. As competition for state funding is intense, the state must consider how to finance continued beach nourishment. The most desirable cost allocation will take into account the local, regional, and statewide economic benefits, as well as the gains reached from stimulation of economic activity within Delaware.

Debates over replenishment versus retreat began in Delaware with the discussion of a long-term management strategy. A number of unanswered questions lead to these discussions:

- Who should pay?
- Will it be successful in the long run, in light of sea level rise?
- Will it harm the environment?
- How much sand is available?
- Will it encourage development because people will gain a false sense of security?

Delaware's Environmental Legacy Program, formed to assess the management issues associated with "core" environmental assets in of Delaware, identified the phenomenon of beach migration as one of the most significant environmental problems of future decades [7]. The Environmental Legacy's Report recommended the development of a comprehensive management plan to deal with beach erosion, which would outline the dimension and scope of issues, problems involved, a recommended course of action, and an indication of the future costs to citizens of the state.

5.2. Factors in decision making

The Beaches 2000 Planning Group had the task of developing this comprehensive management plan for Delaware's Atlantic Coast beaches. This group was made up of representatives from the Governor's Office, the Delaware Geological Survey, the State Department, and the state environmental protection agency, DNREC. An Advisory Committee assisted the group and submitted recommendations leading to the final report. Representatives from the coastal towns (Mayors, Commissioners, Senators, and Councilmen) comprised the Advisory Committee. Other members of the Committee included reporters, contractors, environmental organization members (from such groups as The Nature Conservancy), and realtors.

The time given to the decision-making process was very short. The plan emerged from the committee meetings, held on a weekly basis for 6 months. The Advisory Committee first considered the plan and subsequently, submitted comments to the Planning Group. The Planning Group voted on the document at a public meeting, after which the Advisory Panel could respond to the votes.

When deciding between beach replenishment and retreat, the Beaches 2000 Planning Group scrutinized the direct benefits and costs of each type of shoreline protection. The direct benefits created by beach nourishment include the following: (1) protection and enhancement of property values; (2) recreational gains from a wider beach; and (3) protection of public assets, such as roads and power lines. Both residential and commercial properties benefited from the protection and enhancement of property values. Replenishment will affect beachfront residential property owners because it will raise the property values of their homes, as their properties will be better protected from storm damage, and public access to the beach improves [8].

Replenishment will affect beachfront commercial property owners also, as hotels and motels will gain in value from the wider beach provided. By providing immediate beach access to their renters, guests will presumably pay higher rent, which in turn means greater profits, and thus higher property value for the beachfront hotel. Again, a wider beach provides better protection from storms and erosion. State, local, and county governments benefit from this as well, as property taxes will rise, and the 6% state accommodations tax will bring in more revenue with the higher rents.

The greatest cost of a beach nourishment project is the payment made to a contractor for dredging or hauling sand, and placing it on the beach. Other costs

include damage to roads (if hauling is involved), congestion costs (again, if hauling is involved), and environmental costs. In addition to these, the nourishment project itself may trigger other expenditures within the state. For example, beach nourishment may increase the incentive to improve and upgrade properties around the nourishment area. This may occur because the value of the beach will increase, and the beach will provide better property protection [7].

Other costs include the state taxes that must be considered in the development of the state cost-share of a beach management project. These state taxes include the individual income tax, corporation income tax, motor vehicle and fuel tax, business and occupation gross receipts, cigarette taxes, alcoholic beverage tax, insurance taxes, real estate taxes, public utilities, lottery, and public accommodations [7].

After conducting a benefit/cost analysis, the planning group proposed initiation of a beach nourishment project in the Bethany/South Bethany Beach area of the Delaware Coast. Analysts estimated the cost for nourishment from an offshore sand source to range between $4 million and $7.2 million. Benefits from this project, coupled with periodic nourishment over a 10 year period, totaled $15 million. Benefits to beachfront residential property owners totaled $12.7 million. Local cost share for the project was estimated to be $6.49 million [7]. The planning group considered equity in the payment for this project and suggested that each town (Bethany Beach, Sea Colony/Middlesex, South Bethany) contribute about one-third of the project costs.

Studies conducted after the publication of Beaches 2000 specifically calculated the economic effects of a renourishment program versus a plan of retreat for Delaware Ocean beaches. Jack Faucett estimated the results of foregoing nourishment for another erosion control method. His "No Nourishment Scenario" allowed the shoreline to diminish according to the expected annual erosion rate over the next 5 years. This scenario discussed what would occur if Delaware ceased all nourishment efforts. Without ongoing nourishment, the beaches may erode at a rate of 2–4 ft/yr. This continual reduction in the size of the beaches would reduce the holding capacity of the beach, which would be most noticeable during the peak use periods. Beach visitors would notice this, and as the beaches become more crowded, choose to vacation elsewhere.

Faucett estimated the economic effects of this reduction in beach size, based on the reduced holding capacity of heavily used beach areas along the shoreline. During Faucett's 5-year period without nourishment, property values began to decrease in year 2, when replenishment does not alleviate the erosion occurring in year 1. He also estimated other economic losses for that 5-year period. More than 268,000 visitors would select other vacation locations, and because of that, more than $20.1 million of consumer surplus would be lost. Tourist-related revenues would decrease by approximately $30.2 million if nourishment ceases. "This reduction will cause the loss of 625 beach area jobs, reduce wages and salaries by $11.5 million, profits by $1.6 million, and state and local revenues by $2.3 million" [5]. Faucett estimated that beach area properties values would drop by nearly $43.3 million. In a *with*-nourishment scenario, conducted by Faucett, property values did not decrease due to erosion [5]. Erosion did continue, but because the state maintained a management

program, the nourishment was assumed not to have a price effect. In other words, with an ongoing state policy to protect the shoreline, the market realizes that erosion will be offset by future state nourishment activity. If no beach replenishment efforts were made, Faucett predicted the property value of the coastal area would fall by 2.91% after 10 years [5].

Another study conducted by George Parsons and Michael Powell analyzed the cost of beach retreat. They estimated the cost of allowing Delaware's ocean beaches to retreat over the next 50 years to be about $200 million in present value [9]. By comparing that estimate to current and possible future nourishment costs ranging from $4–7.2 million per project, the researchers concluded that nourishment appeared to be a reasonable solution.

All the research undertaken concluded that nourishment was the favored choice. Erosion control strategies must be scrutinized from two points of view: environmental and economical. In the environmental debate, nourishment is a middle ground between hard solutions and retreat. From an economic standpoint, nourishment is again the answer, because it appears to be least costly, while still permitting the protection of oceanfront structures and preservation of the beach. This information suggests that nourishment is an economically beneficial and environmentally sound policy for Delaware.

It is important to consider the perceptions of the citizens about beach replenishment. During on-site interviews with beach visitors, individuals expressed that replenishment should continue. Interviewees asserted that the state and local governments should continue to be the primary providers of funds to support beach nourishment. However, they also felt strongly that anyone who uses and benefits from the beach should help to support replenishment efforts [2]. These beach-goers believed that replenishment was a sensible strategy that should continue to permit enjoyment of the recreational benefits that Delaware beaches offer.

6. Conflict resolution

The issuance of Beaches 2000, the comprehensive management plan set forth for the State of Delaware, resolved this beach management conflict. Beaches 2000 recommends a series of actions that incorporate a wide variety of issues related to the management and protection of Delaware's Atlantic coastline. The intent of these recommendations was to guide the formulation of state and local policy, as well as private initiatives regarding the state's beaches, thus, ensuring that this important natural resource and tourist attraction continued to be available to the citizens of Delaware, as well as out-of-state beach visitors [7].

The Beaches 2000 final recommendations presented the decisions reached in this conflict. The recommendations are based on the best technical information available and incorporate the concerns raised by individuals and communities closely tied to the state's shoreline. For example, generally, property owners and tourist interests favored the recommendations because the project would protect their investments.

Real estate interests held similar views because nourishment would cause an increase in real estate values. Local governments supported the management plan but expressed concerns about funding. Some environmental groups opposed the recommendations because of the impacts on nearshore habitats. The document recommended specific actions to preserve the recreational value of Delaware's beaches into the year 2000. To this end, the Planning Group suggested renourishment for the areas of Fenwick Island, Bethany, and South Bethany Beach. They advised development of a beach erosion plan for the areas of Rehoboth Beach and Dewey Beach. For state-owned parkland area of the coast, it recommended management to allow for natural movement of the shoreline. For private communities located adjacent to or between public beaches, the report suggested incorporation into already proposed projects.

The recommendations discussed policy and funding aspects, based on the reality that coastal areas are part of a dynamic natural system subject to damage by coastal storms and gradual shoreline erosion. Because of this, the group suggested that transportation and safety infrastructure be rebuilt after being damaged in a way that recognizes the vulnerability of these coastal areas to storms and erosion. They proposed the idea of establishing a moveable building setback line to protect beaches and dunes and prohibiting new construction. They also suggested that deed restrictions note specific risks of building in imperiled areas. The Group also advised that prior to construction of any oceanfront structure on public beach land, the state should consider the annual average erosion rate for this piece of land, and place any structures far enough landward to allow for safe shoreline migration. They also urged that state and local governments to increase their efforts to educate the public about beach management issues.

The recommendations included a section on opportunities that exist along the undeveloped sections of Delaware's shoreline to guide development decisions in a way that will minimize the exposure to storm damage and erosion, and maximize environmental protection. This section suggested actions such as state support of measures to acquire undeveloped areas that preserve the natural and recreational features considered important to the public. It also advocated that the state encourage landowners to donate conservation easements or adopt uses of their land which are compatible with preserving the natural beaches.

Implementation of some of these recommendations will require extra funding. The guidance presented suggestions for funding allocations, as well. This advice begins to answer the question "Who pays for beach preservation?". This section began by recommending that the state not adopt a project if total costs exceed total benefits. The plan encouraged the state to adopt a policy wherein private beach communities that do not promote public access should pay the full cost of any beach management project for that specific community. The recommendations' guidance suggested that Sussex County should establish a beach preservation tax district to tax non-municipal areas, and the money be used to help pay for beach erosion projects. Communities that have accessible beaches should be required, according to the plan, to contribute 50–75% of the construction and maintenance costs for a replenishment project occurring on their beach. By the issuance of a

detailed action plan, the state hoped to implement a sliding scale of state monetary involvement.

In addition to the above measures, the management plan also noted that additional policy direction was required to address state action in the event of a major coastal storm or sea level rise. To address these needs, the recommendations proposed that a "Post Storm Plan" become part of the state's plan, in order to provide guidance to the Governor and state legislature when a storm occurs. This plan would cover such issues as nourishment needs and priorities, reconstruction limitations, land acquisition, and state aid for disaster relief. This report should consider actions to address the consequences of long-term sea level rise. The underlying concept is that as nourishment becomes more expensive and defensive mechanisms are no longer sufficient, the state should implement policies of strategic retreat. The shift in policy should be such that the "citizens of Delaware will have continued access to recreational beaches into the next century and that provision of these beaches will be done in an environmentally sound and cost-effective manner" [7].

7. Results of conflict resolution

Since the issuance of Beaches 2000, all of Delaware's developed public ocean beaches have now been nourished [10]. The economic consequences from the resolution of the conflict are large. Falk et al. conducted a study to assess individuals' willingness-to-pay for a day on the beach. Without replenishment, the mean willingness-to-pay for a day on the beach was $3.01. With beach replenishment, individuals willingness-to-pay rose to $3.70, or $0.69 more than they were willing to pay for a day at the existing beach with no nourishment [2]. Because the recommendations of the Beaches 2000 management plan are aimed at continuing beach replenishment, it appears that beach visitors' willingness-to-pay will increase for Delaware beaches. Therefore, the number of individuals patronizing Delaware's seaside areas will likely stabilize or increase. Delaware beaches may even expand their number of beach visitors, as officials in other states decide against replenishment. Given many beaches to choose from, people may opt to visit a wide coastal area with great recreational value.

The recommendations as put forth by the Beaches 2000 management plan will have an impact on urban and regional planning, as well. Replenishment of beaches has raised property values in some areas, and has, in a number of cases, led to increased density of development. It is important for a community to deal with the issue of development restrictions before it replenishes the beach. One of the recommended actions called for in Beaches 2000 was that state, county, and municipal governments adopt zoning and land-use controls that discourage development in high-risk coastal areas.

8. Conclusion

As humans build on coastal barriers, they inhibit the natural system of beach replenishment. Because humans prefer to control nature instead, they build walls and structures, trying to defy the forces of waves, winds, and tides. Nature will prevail, and humans have just recently begun to realize this. As coastal development increases in the United States, so does concern over sand-starved beaches, and sentiment has shifted towards beach preservation.

Selection of the best option for beach stabilization is difficult. Decision makers must account for the value of the beach, the value of the structures located there, and the cost of each individual erosion control method. Delaware's priorities are maintaining open and accessible beaches for the public and preserving the beachfront structures, and the state has chosen replenishment as the preferred option.

Many US residents visit the beaches for vacation and relaxation. The public cannot enjoy the scenic and cultural values of the coast anywhere else. Beaches are a natural resource that is important both spiritually and economically, and preservation of this resource is a prime concern. Therefore, we must learn that if we are to maintain these cherished beaches, we cannot continue to destroy them, but instead must allow their dynamic nature to continue unhindered.

9. Study questions

1. What factors should policymakers consider when choosing a soft solution as the preferred option for beach management? How does the process of selecting these factors incorporate both science and policy?
2. Who or what was the driving force behind the inception of the Beaches 2000 Planning Group? Why is this important? What was the mission of the Beaches 2000 Planning Group, and how did it attain its goal?
3. How does a sliding scale of monetary involvement occur in the state, and is this a realistic process (i.e., will local governments eventually end up paying for their communities' beach nourishment, as opposed to the state continuing to pay into the future)? What are the obstacles to this process?
4. What are the policy implications for the State of Delaware in choosing an eventual plan of retreat? Why did Delaware not choose retreat as their immediate plan?
5. What arguments can you suggest for and against partial federal funding of beach nourishment projects? Is it fair to condition funding for nourishment on a community's willingness to increase beach access?
6. If federal, state, and local governments share the cost of the project, who should own the newly renourished beach?
7. What are "acceptable" reasons for choosing beach nourishment.
8. In your opinion, was the creation of a unit (The Beaches 2000 Planning Group) the most appropriate way to resolve this dilemma? Do you think the state's

resources should be spent to continually adapt this plan (monitoring the beaches and revising/updating guidance) or do you think the plan should remain a static document?

9. Do you think that the research adequately considered the environmental costs of beach replenishment?

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