Rethinking Coastal Zone Management: Case Study of Dade County, Florida

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ABSTRACT

This paper examines the practice of managing coastal erosion. The factors necessary to facilitate effective coastal zone management are explored and then demonstrated through the use of a case study. The case in question is Dade County, Florida. Dade County, which includes the city of Miami and the town of Miami Beach, was selected because it is currently viewed as an overwhelming success by the coastal erosion prevention community. The political, technical, and economic ramifications of the Dade County Beach Program are analyzed. First, how a beach erosion control project is selected is explained while providing a history of the federal involvement in managing the coastal zone, especially where relevant to the Dade County program. Next, how erosion control measures and coastal erosion fit into the larger framework of coastal zone management is explained. The major factors that affect the success of a coastal erosion program are then examined. A statistical analysis of the factors that determine a community's likelihood of receiving federal monetary support for local coastal zone management is included. The economic situation, specifically the development of the cost-benefit ratio, of choosing Dade County as a site for a beach project is illustrated. Some engineering design problems that have occurred in Dade County are then examined and critiqued. This examination brings into perspective the limits that should be placed on the physical size of the region that is managed. Dade County is then brought into perspective within a national coastal zone management program.

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Contents

Introduction

This paper examines the practice of managing coastal erosion. The factors necessary to facilitate effective coastal zone management are explored and then demonstrated through the use of a case study. The case in question is Dade County, Florida. Dade County, which includes the city of Miami and the town of Miami Beach, was selected because it is currently viewed as an overwhelming success by the coastal erosion prevention community. Also the Dade County Beach Erosion Control Program has been used as a model for other programs.

The paper is divided into eight separate chapters. The first chapter explains how a beach erosion control project is selected while also providing a history of the federal involvement in managing the coastal zone, especially where relevant to the Dade County program. Chapter 2 illustrates what erosion control measures are available and how coastal erosion fits into the larger framework of coastal zone management. The third chapter examines the major factors that effect the success of a coastal erosion program.

Chapters 4 through 7 take the major factors as defined in Chapter 3 and show in specific detail by use of a case study. Chapter 4 serves as an introduction to Dade County's beach program. Chapter 5 is a statistical analysis of the factors that determine a community's likelihood of receiving federal monetary support for local coastal zone management. Chapter 6 is a description of the economics, specifically the development of the cost-benefit ratio, of choosing Dade County as a site for a beach project. The seventh chapter explores the engineering design problems that have occurred in Dade County. This chapter brings into perspective the limits that should be placed on the physical size of the region that is managed.

Finally, Chapter 8 attempts to bring Dade County into perspective within a national coastal zone management program.

1. Beach Erosion Control

This chapter explains how a beach erosion control project is selected along with a history of federal involvement in managing the coastal zone.

Under the current political climate where reducing the role of the federal government is a priority, an attempt to re-examine the ideas behind coastal zone management with particular attention to reducing coastal erosion and mitigating storm damage is pertinent. Of all the facets of managing the coastal zone, the money spent on maintaining recreational beaches is the greatest and also the most publicly noticeable component of coastal zone management.

This analysis uses the Dade County, Florida project as a case study. Dade County has been seen as the pinnacle of managing coastal erosion. There are certain assumptions underpinning coastal zone management in general and tools available to the coastal zone manager. Dade County has nuances that makes it different than any other beach project. Dade County has been seen as an example of how to effectively manage a beach. The State of Florida and other states when trying to draw on the lessons learned from Dade County have not realized and allowed for the differences between other sites and Dade County. There are many things unique to the situation in Dade County that cannot be copied. The lessons learned from Dade County must be understood within the context of Miami Beach. If the federal government's role must change, then we must first prioritize what can and needs to be done and then move forward from there.

1.1 Development of a Beach Project

Wide, sandy beaches are one of America's most popular and prized attractions. They provide outdoor recreation for millions of all ages and interests and from all walks of life. But they must do more than this. They also provide the best natural defense against storm and hurricane induced flooding.

The sands of the beaches are constantly moving. The same winds, waves, tides, and currents that carry sand away from one area of shore replace it with sand from another area unless and until other influences interfere. Near shoreline structures essential to the well being of society may interrupt the flow of sand along the shore, and structures on tributary rivers may reduce or eliminate supplies of sand. When the natural equilibrium is upset, whatever the cause, erosion of some beaches results.

The restoration and protection of America's shoreline are everyone's concern. Congressional recognition of national concern has produced legislation which permits the Corps of Engineers to join local forces in the fight against beach erosion. Today, as much as 70 percent of the cost of protecting publicly owned shores may come from federal funds if certain conservation, development, and use requirements are satisfied. Projects not meeting these requirements may still be as much as 50 percent federally funded. Shore protection may be structural - groins, seawalls, bulkheads, jetties, sand replenishment, or natural - sand conservation, vegetation. Careful study must precede selection of method.

The Corps of Engineers has been developing methods of shore protection since 1930. Continuing investigations by the Corps' Coastal Engineering Research Center expand knowledge and understanding of the physical phenomena, principles, techniques, and procedures related to the protection and restoration of our beaches and shores. Continuing construction of shore protection and restoration facilities reinforces the technical and construction knowledge that produces sound economical solutions.

1.2 Population Change and Beach Erosion

Beach and shore erosion is one of the Nation's pressing problems. The United States' shorelines, including those of the Great Lakes, total about 94,000 miles. The number of

Americans using these shoreline is steadily increasing. At present, 75 percent of the population of the United State lives in states bordering on the oceans and Great Lakes; 12 of the 13 largest cities are located in the coastal zone. The unrelenting pressures generated by this growing population and its demand for shoreline land for homes, industries, transportation terminals, recreation and marine foods quicken interest and concern in the protection and restoration of beaches and shores. At the federal level, this interest and concern have led to increasing involvement in shore protection. The increasing federal interest has been paralleled by expanding interest on the part of the coastal states.

Before 1930, federal interest in shore problems was limited to the protection of federal property and improvements for navigation. At that time, an advisory Board on Sand Movement and Beach Erosion appointed by the Chief of Engineers was the principal instrument of the federal government in this field. In 1930, Congress assumed a broader role in shore protection by authorizing creation of the Beach Erosion Board. Four of the seven members of the Board were Corps of Engineers officers and the other three were from state agencies. It was empowered to make studies of beach erosion problems at the request of, and in cooperation with, cities, counties, or states. The federal government bore up to half of the cost of each study but did not bear any of the construction costs unless federally owned property was involved.

In 1946, the Corps was given additional authority, and federal contributions to construction costs were permitted when projects protected publicly owned shores. In 1956, further amendment of the basic beach erosion legislation authorized federal involvement in the protection of private property if such protection was incidental to the protection of publicly owned shores, or if such protection would result in public benefits. The federal role was again expanded in 1962 when legislation was enacted to increase the proportion of construction cost borne by the federal government to make the total cost of studies of federal responsibility. Legislation in 1968 directs the Chief of Engineers to make an appraisal, investigation and study of the erosion problems of the coasts of the United States and the shorelines of the Great Lakes, including estuaries and bays thereof. This study is not expected to generate recommendations for construction to protect specific problem areas, but it will appraise coastal erosion problems from the natural viewpoint, will array the problem areas in meaningful priority order, will inventory the shoreline, an increasingly valuable resource, and will provide sound information for planning and action at all governmental levels.

Hurricane protection is closely related to shore erosion control and protection. After the great hurricanes of 1954 and 1955 caused the loss of 200 lives and flood and wave damage totaling more than $1 billion, Congress directed the Corps of Engineers and other concerned federal agencies to develop protective measures. This legislation led to improve hurricane forecasting and warning services, and to authorizations for the construction by the Corps of Engineers of projects for hurricane protection. The federal government pays 70 percent of the construction cost of such projects. In many locations, broad comprehensive planning develops multiple-purpose projects providing shore protection, beach restoration, and hurricane protection which benefit public recreation and navigation, and protect and preserve fish and wildlife.

In 1986, the Congress redefined the Corps' responsibility in both the study and construction of civil works projects. The federal share of construction costs for shore protection projects may be as high as sixty percent for hurricane and storm damage reduction at public shores, and fifty percent at public parks and conservation areas. Congress reintroduced cost sharing for feasibility and pre-construction studies, equally shared by federal and non-federal interests.

Recognizing that coastal erosion problems have continued to plague the nation's shores, Congress has funded the construction of eighty two specifically authorized projects. These projects span a combined shoreline distance of approximately two hundred twenty six statute miles. This represents 0.3 percent of the nation's shoreline of 84,240 miles.

The United States Army Corps of Engineers undertakes specific studies relating to shore protection at the request of and authorization of Congress. Congressional authority to conduct a study is by a resolution adopted by the Committee of Environment and Public Works of the United States Senate, a resolution of the Committee on Public works and Transportation of the House of Representatives, or by an act of Congress. Reconnaissance studies are one hundred percent federally funded. Feasibility studies are cost shared between the federal government and the non-federal study sponsor on a 50/50 basis.

1.3 Corps of Engineers Involvement

As the federal interest in shore protection and beach restoration has increased, so has the involvement of the Corps of Engineers. By various legislative actions, the Congress has directed the Chief of Engineers to carry out the policies and programs established to protect and restore the Nation's shorelines.

Under these legislative authorities, the Corps of Engineers researches the causes of beach erosion, investigates and studies specific beach erosion problems, and constructs or, in certain cases, reimburses local and state governments for constructing shore protection and beach restoration projects.

In the early 1930s the Corps of Engineers began investigations of the various forces at work along coasts and shores. Today, the Corps' Coastal Engineering Research Center is deeply involved in investigations of shore processes, storm frequencies, and storm-tide elevations. Research into remedial measures is accomplished at the Center by its engineers and scientists. In addition, many significant programs are carried out by universities and private research organizations under contracts with the Center. Much of the field work essential to these research efforts is accomplished by staff members of the various Corps of Engineers Districts. The results of this research are published and widely disseminated in the United States, and are also supplied on an exchange basis to foreign institutions and agencies. As a result of this exchange, the Coastal Engineering Research Center is well informed of world-wide research progress.

The research program is the base on which the planning and construction programs depend. Without research, the effectiveness of completed projects might be uncertain and costly overdesign or failure might be common. The shore protection programs are the payoff in terms of preservation of natural beaches and recreational areas as well as the protection of life and property. Here the battle with the relentless sea is actually fought.

Shore protection and beach restoration projects may be categorized in a number of ways. For the purpose of this discussion it is convenient to group projects in two programs - one consisting of projects specifically and individually authorized by Congress and the second consisting of projects for which individual authorization by Congress is not required. Hereafter in this discussion these programs will be referred to as the regular project program and the small project program, respectively. The latter program is limited to projects for which the federal share of construction cost will not exceed $500 thousand. In addition, if the erosion is attributable to federal navigation works, mitigating measures costing not more than $1 million can be constructed entirely at federal cost without specific Congressional authorization.

1.4 Project Development

Shore protection and beach restoration projects begin with a local request for help. Any person or group of persons desiring assistance in combating beach erosion can obtain information and advice from any Corps of Engineers District or Division office. Eroded publicly owned shores and shores eroded because of federal navigation works are eligible for federal assistance. Privately owned shores may be eligible for federal assistance if there is public benefit such as that arising from public use. Parties desiring information, advice, and assistance in combating beach erosion can usually be most effective by acting through and in cooperation with the state, county, or city agency concerned with beach and shore use and management. The agency, in turn, can reinforce its effectiveness by early consultation with the appropriate District or Division Engineer to explore any question of eligibility and applicability of the small project program, or the program for mitigating erosion cause by federal navigation works. If either of these programs is applicable, the Secretary of the Army can authorize a beach erosion study at the request of the responsible local agency. If the study shows the project to be justified and the local interests involved are willing and able to cooperate as required by law, the Secretary of the Army can authorize construction of the project and allocate funds for that purpose from available civil works appropriations.

Beach erosion studies for the regular project program must be individually authorized by the Congress. Usually, the study authorization is granted by a resolution approved by the Public Works Committee of either the Senate or the House of Representatives. Less frequently, it is included in a River and Harbor Act adopted by the Congress and approved by the President. If consultation with the District or Division Engineer indicates that the small project program is inapplicable, the local interest involved, acting through the community's elected representatives in the Congress, should request the Congress to authorize and fund a beach erosion investigation and study. The District or Division Engineer will begin the study as soon as the necessary authorization and funds are provided.

Normally, the local interests sponsoring the study and the District or Division Engineer responsible for its prosecution will continue consultations, exchange information, and make plans for conducting the study while the authorization and fund allocation actions are in progress.

The investigation and study are intended to determine whether a federal project is justified and, if so, whether its construction is feasible. One of the early concerns of the Engineer Office directing the study is the determination of the desires and opinions of all parties affected by, or having an interest in, the protection, improvement, and use of the shore area concerned. To this end, a public hearing is held at the beginning of the study. If the situation warrants, additional hearings are held as the study progresses. The study thoroughly examines the problem and identifies the causal factors. After careful analyses of the impacts of all applicable remedial measures on the erosion problem, on other shore areas, on the regimen of the coastal waters, on aerial shore processes, on marine life, on ecological values, and on shore uses, a general plan for shore protection and beach restoration is devised. If comparisons of the costs of construction and the benefits resulting from the construction show the project to be a sound and prudent public investment, and if the local sponsoring agency affirms willingness and ability to provide the required cooperation, the report on the study recommends adoption of the project. Before the report is submitted to the Congress, it is reviewed by the Board of Engineers for Rivers and Harbors, the Chief of Engineers, the Governors of affected states, and all interested federal departments.

Projects authorized for construction by the Congress are considered by the Congress as it formulates the annual appropriation bill. As soon as funds are provided, the responsible District Engineer carries out the detailed engineering work essential to construction and prepares construction drawing and specifications. Contractors submit bids based on these drawings and specifications and a construction contract is awarded to the successful bidder. The District Engineer continues to consult and coordinate with the local sponsoring agency while engineering and construction are underway. Upon completion, the protective works are turned over to the sponsoring local interests for operation and maintenance in accordance with the authorizing legislation. Section 215 of Public Law 90-483 permits local interests to expedite construction of authorized projects for which federal funds are not immediately available. Under certain circumstances if local interests proceed with construction at their expense, the federal share of the cost of that construction can be reimbursed from later appropriations. Such reimbursement cannot exceed $1 million.

1.5 Local Cooperation

The state or political subdivision faced with shore protection and beach restoration problems usually selects one of its agencies to represent local interests and cooperate with the Corps of Engineers. This agency becomes an integral part of the federal-local team and works with the responsible District or Division Engineer during the investigation, planning, engineering, and construction phases of project development. Often, this same agency operates and maintains the completed project.

The legislation establishing the federal shore protection and beach restoration programs declares it to be the policy of the United States to assist in the construction, but not the maintenance, of works for the improvement and protection against erosion by waves and currents of the shores of the United States, its territories and possessions. In its present form, the legislation spells out the conditions for, and the extent of, federal participation. Basically, it relates federal participation to public benefit and requires the active participation of the sponsoring local interests. Under this concept, federal participation is greatest where the protected shore areas are publicly owned and appropriate facilities to encourage full public use are provided. As much as 70 percent of the construction cost can be borne by the federal government in such cases. At the opposite end of the scale, where the protected shore area is privately owned and there is no public use, no federal funds can be provided. Between these extremes, federal participation in providing protection is proportional to public use and benefit. The remaining costs are borne by the sponsoring local interests. Additionally, local interests are normally required to provide all necessary lands, easements, and rights-of-way, hold and save the United States free from claims for damages, prevent water pollution which would affect the health of bathers, maintain the completed works, and assure continued public use of the protected area.

The need for shore protection projects began when man entered the coastal area, intending to remain there and be a participant in the battle of the land against the sea. Shore protection projects have evolved as a reaction to the affluence of man that has allowed over fifty percent of the nation's population to live within the nation's coastal zone.

The nation's coastal areas include some of the most rapidly growing and densely populated counties in the United States. The 451 coastal counties account for twenty percent of the nation's total land area. However, if the land area of Alaska is excluded, the coastal county land area comprises only eleven percent of the remaining national total. From 1969 to 2010, the coastal population will have grown from eighty million to more than one hundred twenty seven million, an increase of almost sixty percent.

Participation in shore protection projects is limited to beach restoration and protection, not beach creation or improvement unless such improvement is needed for engineering purposes. In addition, the federal cost share is reduced proportionately to the extent that a project protects private shores from beach erosion and land loss.

Participation by the federal government is limited to projects which prevent or control storm damages caused by beach erosion and coastal storm inundation and flooding. Other measures such as land acquisition are not eligible for participation. The federal government does not participate in any work relating to recreation facilities at shore protection projects. The Corps is prohibited from expenditure or financial assistance for areas of the nation's coast specifically prohibited by the Coastal Barrier Resources Act.

An assortment of alternatives are examined as possible solutions to the erosion and storm damage problems at a given location. Various alternative plans are formulated during these studies to ensure that all reasonable alternatives are evaluated. The No Action plan is always examined. Non-structural alternatives are also investigated including zoning changes, building code modifications, a moratorium on construction, condemnation of land and structures, and a no-growth program. Structural alternatives considered typically include beach fill with periodic nourishment, groins, revetments, offshore breakwaters, relocation of structures and seawalls. For most areas in Florida, initial restoration of a beach with subsequent periodic nourishment best meets the federal objectives.

The commitment of a project sponsor of a federal shore protection project is subject to compliance with certain items of cooperation, effected through a binding contract called a project cooperation agreement. The sponsor must agree to fund the non-federal share of project construction, and provide all needed lands, easements, rights-of-way, reallocations, borrow and disposal areas needed for construction. Operation and maintenance costs of the project are a one hundred percent non-federal expense. Periodic nourishment is considered construction for cost sharing purposes.

Shorelines are rarely stable and are subject to constant change from natural processes and man's activities. Storms and flooding may drastically change the character of coastlines in a very short time. Most states consider the legal boundary static - not moving. States define the seaward property boundary with respect to mean high tide. Since high tide lines fluctuate, so too will property boundaries. Therefore, an individual who owns coastline property may gain or lose land due to the processes of accretion and erosion.

The federal Coastal Zone Management Act of 1972 (CZMA), was passed "to preserve, protect, develop, and wherever possible, restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations." The CZMA provides federal funding for states to develop and administer coastal programs. This Act is the federal legislation which provides federal funding for coastal erosion protection. It also gives authority to the Army Corps of Engineers to determine when beach erosion control techniques are necessary.

Local municipalities differ in the placement of the seaward coastal boundary. Legally there are precedents both on a federal and a state level. Initially, in 1972, the Corps of Engineers designed beach re-nourishment plans on a county by county basis in the State of Florida. Some towns north of Miami, as well as Broward County, were not included in the initial Dade County beach maintenance program. Because of exclusion of part of the natural system, there now exists the problem of substantial accretion in Golden Beach. Golden Beach is in Dade County near the northern county border and was not included in the initial Dade County beach management plan. As a result of this accretion the beach in the town of Dania suffers from erosion. Dania is near the southern county border of Broward County and like Golden Beach was not included in the initial Dade County beach management plan. See Figure 1.

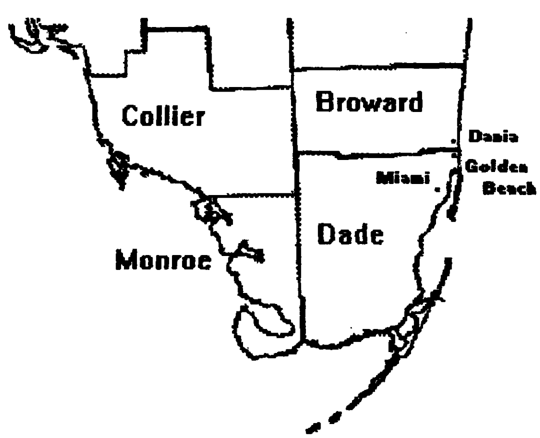

Figure 1. Map of region including the towns of Dania and Golden Beach. (1990 Census Map)

1.6 Impacts of Tourism

Tourism is the world's largest industry, and the beaches, the weather, and the sea in southeastern Florida are a great attraction to tourists from other counties, helping our balance of trade, and providing many jobs that benefit the economy in general. Tourism is a vital part of the coastal economy. Florida's tropical climate and broad sandy beaches have made it a popular vacation destination for tourists from America and around the world. In 1972, over 25 million tourists visited the state. Coupled with the large beach-going population resident in Florida, this made for approximately 270 million beach visits that year, according to the Florida Department of Commerce's Office of Coastal Zone Management.

Our beaches are the playground of the nation, and represent the greatest single public park system we have, stretching as they do along most of its coastline. Many miles of beaches are located in our towns and cities, or nearby, readily available to local residents with short or no traveling distance. They serve as the vital function of urban parks, as well as recreational centers for visitors from inland regions of America and abroad.

Florida's goals and policies in regard to beaches and coastal construction include items such as beach access, the erosion control line (ECL), the public trust doctrine, sand management at inlets, and possible funding sources from implementation of the state's goals. Dade County, Miami Beach, and Bal Harbour each made extensive plantings of vegetation and access improvements along the dunes. The hurricane protection aspect of the project (which is only for Miami Beach, Surfside and Bal Harbour) has not been tested by a direct hit, but the dune constructed for this purpose and a wide beach are still in place, after Hurricane Andrew. It was planned to provide only partial protection from a hurricane storm surge, wave setup and run-up equal to or greater than the September 1926 hurricane; the local sponsor must inform interests affected, at least annually, of the possibility of hurricane flooding.

Owing to increasing demand for living and recreation on the coast, coastal engineers and scientists must continue to make advances in the quantitative functional design and structural design of both systems and components, and in the collection, evaluation and presentation of environmental data of sufficient quality and quantity to meet the requirements. Most coastal projects are subject to complex combinations of conditions and processes, not simple ones. Reliability of predictions and quantification of risks associated with the performance of systems and components require improvement. Government officials need reliable information on the necessity of proper maintenance and the costs involved. Monitoring and evaluating existing projects are useful in helping to fulfill these needs. A major part of the evaluation is to identify (and/or verify) the causes of the erosion that led to the need for beach nourishment.

The most important events that caused major beach changes since 1900 were the creation of Government Cut and Bakers Haulover Inlet through the barrier island by dredging, the jetties built at their entrances, and the September 1926 hurricane that hit the Miami area. The beaches are relatively protected from open Atlantic Ocean waves by the Bahamian Islands and Banks, but waves are generated locally by winds blowing over the fetch from the Bahamas to the Dade County shore. Alongshore transport of sand occurs in both directions, with the net transport being towards the south. The beach sand is largely calcium carbonate, rather than the quartz sand found along Florida's northeast coast; the source of much sand is local. Sand for the project was dredged from pockets in trenches between limestone reefs located 6,000 to 10,000 ft. offshore and approximately parallel to shore. It was pumped to shore and placed along the beach.

With the beginning of the real estate boom in southeastern Florida and along other oceanfront resorts, the delicate balance existing between the natural erosive and accretive forces was upset. To accommodate and maximize oceanfront development, many natural dunes were destroyed to make way for hotels, boardwalks, roads, and houses. In many places, dunes were bulldozed away merely to provide picture window views of the ocean. Although natural dunes erode during storms, they are basically a reservoir of sand which absorbs the energy of waves and surges which over-top the berms. Therefore, this unchecked development resulted in the destruction of the last natural line of defense against the waves and surges generated by storms.

The Dade County Project is one of many beach projects in Florida. Dade County has the highest population density in Florida, and its population is still increasing. It is interesting and important to note how recent has been the development of Miami Beach. There was almost no development prior to 1910. The Collins Bridge was opened on 12 June 1913, and the County Causeway on 17 February 1920. The 1920 census counted 644 residents living in Miami Beach, and the 1930 census counted 6494. Major growth occurred in the 1930s. For example, in 1936, 38 hotels, 110 apartment buildings, 320 houses and more than 1000 other buildings were constructed. In 1937, another 150 hotels with 9752 rooms and 508 apartment buildings with 6,120 units were opened. The Dade County Project is a joint project of the federal government and the Dade County Board of County Commissioners who are the local sponsors. The agreement between the United States of America and Dade County, was signed by the County on 12 October 1972.

Extensive, attractive, accessible beaches are of major social and economic importance to county residents. Much attention was, and is, given to environmental effects of the project, especially those related to dredging sand and placing it on the shore. There are linear hard limestone reefs offshore. Growing on them are hard corals, soft corals, and sponges. Monitoring, including post-construction monitoring, has been done by conservation groups, and by local, regional, state and federal agencies.

2. Coastal Zone Management Defined

2.1 The Importance of the Coastal Zone

The coastal regions of the world are amazing areas. The interface between land and sea, the coast is a unique geological, ecological, and biological domain of vital importance to an astounding array of terrestrial and aquatic life forms - including humankind.

The importance and value of the coastal zone cannot be underestimated. It is one of the most productive areas accessible to people. Fish and other seafood fulfill a significant portion of the dietary needs for millions of people around the world, while the industries of fisheries and aquaculture are commercial mainstays for thousands of coastal communities.

The coast also provides an important safety feature for residents living near the ocean. Many types of coasts provide a barrier from natural hazards emanating from the turbulent seas. Beaches, dunes, cliffs, and barrier islands all act as buffers against the high winds and waves associated with coastal storms.

The recreational aspect of the coastal zone is another factor for which we value the region. Stretches of beach and rocky cliffs along the Pacific and Atlantic Oceans and along the Gulf Coast provide numerous recreational opportunities for thousands of Americans. Boating, fishing, swimming, walking, beach-combing, and sun-bathing are among the numerous leisure activities in which our society revels.

Many of us go to the coast for the sheer beauty of it. There is something restorative and regenerative about the waves crashing and wind whistling. The aesthetic and scenic elements of the coastal zone make it invaluable as a source of inspiration and peace.

The coastal zone also provides a unique habitat for thousands of plant and animal species. The coastal ecosystem is made up of myriad interconnected subsystems whose functions cannot be duplicated elsewhere. For instance, estuaries, with their unique mix of fresh and saltwater, provide a nursery area for numerous species of fish. Likewise, coastal wetlands are home to a variety of birds, plants, and other biota, and also serve the important role of filtering impurities in the water coursing through them. These and other segments of the coastal ecosystem are precisely balanced, fragile areas susceptible to a variety of threats, including those posed by human interference in the natural system.

Despite its fragility, the coastal zone is amazingly resilient. The ecosystem as a whole is a dynamic and regenerative force; if left alone, natural mechanisms operate to maintain an equilibrium between all living things and the natural environment. There are limits, however, to the extent the coastal system can withstand external assaults to its integrity. Pressures emanating from the activities of people are particularly threatening.

There are many pressures exerted on the coastal zone every day. Some of these are part of the natural operation of coastal processes. Every day, winds and waves move material and affect the landscape. More dramatic action occurs with coastal storms, including hurricanes and northeasters, which can bring high winds and wave surge forceful enough to change the topography of the areas they hit, literally overnight. For instance, barrier islands are very unstable areas. Over time, in reaction to storms and the accumulative daily buffeting of winds and waves, the islands actually move; they are constantly migrating, usually landward. Inlets are another example of a coastal feature that is migratory in nature. Inlets can shift laterally, be closed entirely, and new inlets can be created during a particularly forceful storm.

Such alterations in the landscape are part of the natural processes in motion in the coastal region. Coastal areas are dynamic, yet adaptable. Changes in the natural environment are to be expected, and the region can recuperate when allowed to continue its evolutionary process. It is when additional external pressures are exerted on the coastal zone that the area cannot recuperate fully. Human interference with natural processes can alter natural dynamics.

Of course, people at the shore, both permanent residents and visitors, need to be housed, fed, and entertained. The pressures exerted by the presence of human beings at the coast emanates from these needs. Houses, hotels, condominiums, restaurants, gas stations, shopping malls, golf courses, piers, amusement parks, essentially any general development is spreading along all reaches of America's coastline. All these various development projects requires infrastructure - roads, bridges, sewers, etc., each of which can exert pressures on the environment or lead to various negative impacts. For instance, the increased area surfaced by impervious materials due to development projects and the infrastructure supporting them can cause problems with runoff into surrounding coastal waters.

People also need usable water, any many coastal communities are largely dependent on groundwater for their supply. However, there is a limit to the quantity of groundwater that can be withdrawn at a certain location within a certain time without adverse impacts. The water needed to serve projected population growth cannot exceed the gap between current withdrawals and this limit. The cumulative impact of groundwater usage can lead to changes to the water table, resulting in saltwater intrusion. Groundwater can also become polluted through the introduction of organic and inorganic contaminants associated with human settlement.

Human pressure exerted on the coastal region also involves the disposal of waste. We have been using the oceans and the coastal zone as dumping grounds for years, hoping the assimilative capacity of the ecosystem will take care of the problem. Medical waste washed up on the shores of the East Coast, for instance, has been known to close beaches for weeks. Barges filled with garbage have been unloading their cargo at sea for years, and not too far from the shoreline. While the recuperative quantities of the coastal region are high, over time the natural environment will not be able to withstand the pressure without serious alteration or degradation occurring. In other words, we are using the oceans and coasts as depositories for our wastes, and they are filling to capacity at a rapid rate.

The effects of human-induced pressures on the coastal zone can be far-reaching and long-lasting. Human activity can interfere with the natural processes of the coast and prevent the environment from maintaining the equilibrium so necessary to its continued vitality. Both marine and land environments are tightly woven systems in which all the parts are interrelated and dependent on one another. Destruction or degradation of one component can lead to impairment of other parts or the dysfunction of the ecosystem as a whole.

The cumulative impacts of human-induced pressures can be extremely significant in coastal regions. Until recently, cumulative impacts of development on the coastal ecosystems have not been regarded as a serious problem because human and development pressures have not for the most part overtaxed the assimilative capacities of natural systems. as the coastal population continues to grow, however, long-term cumulative impacts will become more evident. The adverse impact of a single project can sometimes be minimized to a certain extent. Considered together with other developments projects, however, the single project becomes part of a much larger ecological problem. As more and more projects are permitted in he coastal region, and more are concentrated in popular and economically profitable locations, the cumulative impacts will undoubtedly grow.

Areas which possess sensitive coastal resources (wetlands, fish, etc.) are particularly vulnerable to cumulative impacts. Areas of the coast experiencing rapid population growth are also especially prone to cumulative impacts. Population is an important gauge because size and composition of the population directly affect the amount and character of development in an area. changes in population and development patterns impose new impacts and demands upon natural and built systems in the area. In addition, population change increases the significance of natural processes such as barrier island migration, sea level rise, or coastal storms.

The coastal zone can be a hazardous area. Hurricanes and other coastal storms have been known to destroy entire communities in a matter of hours. People are displaced, homes and businesses are destroyed, infrastructure can be uprooted, and human lives can be lost. But why do these disasters occur? Because people have put themselves in the way of a natural force that cannot be diverted or stopped. The coastal zone is hazardous because humans have made it so. Coastal storms have no power to create thousands or even millions of dollars in damage to property if no property is within the storm's reach.

Of course, there are hazard mitigation practices which can lessen the impact of a storm on a coastal community. For instance, buildings can be designed and constructed to withstand all but the most forceful of winds and wave surge. Well planned and executed evacuation measures can reduce the risk to humans by getting them out of harm's way before a storm hits land. But the fact remains that coastal areas are hazardous only where there is something at risk in the area, something put there by people.

Many of our current public policies can exacerbate the pressures placed on the coastal zone. Without the intention to inflict harm, our regulatory and political structure nevertheless tends to encourage the exact type of behavior that endangers the fragile natural resources of the coastal area. The most obvious of these policies are those which encourage development in coastal communities. Such growth, which can actually increase the dangers to the environment, places more people and property at risk from coastal hazards.

For instance, infrastructure, a necessity for growth and development, is usually provided by various levels of government. Paved roads and highways, while ensuring safe transportation routes for local residents, also allow more people access to more coastal areas. Similarly, bridges can open formerly isolated areas such as barrier islands to numbers of people that may exceed the carrying capacity of that particular locale. Sewer systems and municipal wastewater treatment plants allow the density of coastal populations to increase dramatically. And the provision of public water supplies can deplete aquifer reservoirs at a faster rate than they can be replenished.

The availability of various types of hazard insurance is another form of encouragement for development in coastal areas. The availability of federal flood insurance in particular is frequently cited as a primary example of how hazardous coastal development is subsidized and how the wrong kind of incentives are created. Owners of property damaged by coastal storms and flooding are often allowed to rebuild in the same or equally hazardous locations. The damage-rebuild-damage cycle accounts for many damage claims, and there are no incentives for avoiding development in hazard-prone areas, although this regulatory situation seems to be gradually changing.

Coastal development subsidies are also provided in the form of tax expenditures, deductions, or other subsidies contained in federal and state tax codes. For instance, casualty loss deductions reimburse owners for damage to property that is not covered by insurance. Deductions are also allowed for property taxes on second homes, typical of coastal development.

People's activities have placed burdens on the natural resources of the coastal zone beyond their collective capacity to absorb the impact without adverse reaction. Human society is now using resources and producing wastes at rates that are not sustainable. It is our nation's desire for growth and our consumption habits that threaten the vitality, even the very existence, of a healthy, aesthetic, and productive coastal zone.

Although the presence of human beings has been the major causal factor in most of the environmental problems now being experienced in the coastal zone, not living there is not a realistic solution. I am not suggesting that all built structures be razed, all roads removed, and all people leave the coast. Instead, we as a nation must change our attitude as well as our behavior. What is required is a new way of thinking: humankind as a part of the system, not its master.

This new attitude could result in many innovative and complex solutions to the world's environmental problems; but one manifestation with large potential for actually changing human behavior and breaking out of the destructive growth cycle lies in the concept of sustainable development. Presently, sustainability is a foreign concept to our growth driven culture. We do not now view the earth and its resources as finites. Even renewable resources have the potential for becoming finite if used and managed with impropriety.

Sustainable development has become the catchword in the environmentally conscious nineties. There are many different definitions in current usage, no one of them accurately or fully embodying the two components and the relationship between these often dichotomous concepts. However, our generally accepted definition has emerged from the report *Our Common Future*, published by the World Commission on Environment and Development (commonly referred to as the Brundtland Report); sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The Brundtland Report elaborates on its definition by stating that sustainable development is "not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are made consistent with future as well as present needs."

Sustainable development does not mean no growth. It does mean not wasting resources; but most proponents of sustainable development realize that without some growth, communities would not be in a position to provide for their citizens a decent standard of living and engage in the newly required effort to improve the environment. Sustainable development does, however, demand a change in the content of growth, to make it less material and energy intensive.

While not every approach to sustainable development will necessarily encompass the same set of assumptions, some basic principles do emerge to guide our endeavor to reach development that is truly sustainable. All proponents of sustainable development emphasize that a greater knowledge and appreciation of, as well as respect for, the natural world is essential. To this end, education and consciousness raising about our environment must be first and foremost. Furthermore, the active and full participation of all the citizens in the community is crucial. This includes an awareness of the destructiveness of current over-consumptive lifestyles. Participation in grassroots organizations can really make a difference in our lifestyles and habits. We must then go further and become involved in the political structure that shapes much of the policy regarding growth and development at the state, national, and international levels.

We must engage in efficient resource use, reversing the degradation of renewable resources and implementing strategies for the sustainable use of land, water, and energy. Reducing waste generation, recycling wastes into productive activities, and finding safe ways of disposing of wastes that remain are essential elements in creating a healthy and habitable world. Polluters should pay for the costs of remediation, but it is even more important to prevent pollution and waste of resources in the first place.

Lastly, all human activity should be evaluated from its long-term environmental impact, not just from its short-term gain. The philosophical principle guiding sustainable development lies in its future orientation, without ignoring the needs of living people.

2.2 The Role of Government in the Coastal Zone

Each individual in our overly consumptive society must participate in the change of attitude necessary to achieve development that is truly sustainable. But in addition to the changes we must make in our daily habits and patterns of behavior, society as a collective body of individuals must change its attitude and actions as a whole. While we can speculate on a number of different methods of achieving this universal behavior modification, one method for which the institutional mechanisms are already in place is through government directive.

However, to achieve such an approach, we must overcome the strong aversion in our country to what is often viewed as overly intrusive government action, especially in the area of land use. Private property rights are deemed almost inviolate in the United States. However, much of the abuse we have inflicted on the natural environment has as its source the way that we use and manage our land and the attendant natural resources. This is especially true in the coastal zone, where development is taking place in inappropriate areas at an ever accelerating pace.

What land use regulation does take place in the United States falls mostly within the domain of local governments. This traditional view of land use regulation being a local prerogative in many cases is a suitable one, since the function of regulator is necessarily site-specific. However, due to the nature of the coast and the coastal ecosystem, local governments may not have the capacity in terms of financial resources, technical ability, or political willpower to fulfill the role of official protector and conservator of the coastal zone. Natural resources do not necessarily conform to humanity's artificial political boundary systems, and ecosystem limits often transcend local jurisdiction. Many coastal environmental problems are regional in scope, and local governments may not have the authority to deal with such wide-ranging issues. Furthermore, local governments may have too parochial an outlook to be effective at implementing the theory of sustainable development community-wide.

Due to a realization that local powers are in large part insufficient to effectively manage the coastal region, state and the federal governments have to some degree stepped in to fill the gap. Current federal and state programs are also found to be lacking. The traditional processes of government control and regulation have limited effectiveness, especially considering the long-term health and vitality of the coastal ecosystem.

What is needed now is a new and different set of values on which to base our government actions. Coastal zone management for the last two or three decades has focused on balancing economic development and the preservation of the environment. This balancing must take into account the sustainability of the economic development.

This new approach to government intervention based on the principles of sustainable development calls for an integrated program of coastal zone management. The system must be operative at all levels of government and involve all the participants in the coastal region. Many of the tools are already in place; the regulatory authority and financial resources are in existence, should we choose to direct them to the appropriate needs. What is missing is the wisdom, the will, and the political foresight to create a management system which will protect, enhance, and preserve our coastal zone for ourselves and for future generations.

2.3 Tools for Managing Coastal Erosion

Various options exist to reduce the erosion hazard to public and private buildings and infrastructure. These options include soft structural (e.g., beach nourishment) approaches, hard structural approaches (e.g., seawalls, revetments, groins, offshore breakwaters, etc.), building and land use restrictions (e.g., setback requirements), and relocation of existing structures from eroding shores. Both soft and hard structural solutions are categorized here under "shoreline engineering." It should be kept in mind that many developed coasts already are using both hard and/or soft forms of shoreline engineering.

2.3.1 Beach Nourishment

Beach nourishment involves excavation from one site and placing in another site large quantities of sand on an existing but retreating beach to advance the shoreline seaward. The material usually is placed on the beach at a slope steeper than the natural beach so there will be a period of perhaps several years during which profile equilibration will occur. In addition, the shoreline protuberance will induce additional components of longshore sediment transport away from the original location.

It has been shown that additional beach benefits from a beach nourishment project depend markedly on the quality of the sand placed. Ideally, for greatest benefit, the sand should be as coarse as or coarser than the native sand. However, knowledge about sediment transport does not include adequate information concerning the influence of grain-size distribution. The longevity of a beach nourishment project placed on a long uninterrupted shoreline varies directly with the square of the project length of shoreline and inversely with the 2.5 power of the representative wave height. If beach fill is placed downdrift of a littoral barrier or where the longshore sediment transport has been reduced otherwise, the loss rates will depend primarily on the supply deficit owing to the interruption. Projects so located should be considered as feeder beaches rather than nourishment projects.

Many examples of both successful and unsuccessful beach nourishment projects exist. Successful projects include Miami Beach, Florida, where 14 million cubic yards of sand was placed over a ten mile beach during a period 1976 to 1981 at a cost of $64 million. The first re-nourishment in 1987 placed 300,000 cubic yards, which amounts to a loss rate of less than 0.3 percent per year. The Inialantic Beach in Florida is regarded as an unsuccessful beach nourishment project. Approximately 500,000 cubic yards of sand was placed along two miles of beach. This is considered a relatively low density (~ 50 cubic yards per foot). Beach monitoring was conducted out to wading depth, so the true volumetric loss could not be ascertained. One year after project construction, little volume remained within the portions of the profile encompassed by the wading surveys.

In areas where material is placed near a sand sink, such as a deepened channel, terminal structures to stabilize the fill may be justified. Although knowledge of the performance of beach nourishment projects has improved over the past few decades, the capability to predict the loss rates associated with a beach nourishment projects are still probably no better than within about 30 percent. A great deal of this uncertainty is due to the lack of quantification of wave and sediment conditions and the lack of ability to forecast storms.

The following figure represents a simplified look at how beach re-nourishment is accomplished. Essentially one can think of beach re-nourishment as a large 'box' of sand being physically placed on top of the old beach. The high peak represents the new dune built on the beach landward of wave activity. Eventually this 'box' smoothes into an equilibrium state. The sand will move in and out with the tides and currents but the overall quantity of sand in the near-shore system has increased so the size of the beach will increase proportionately.

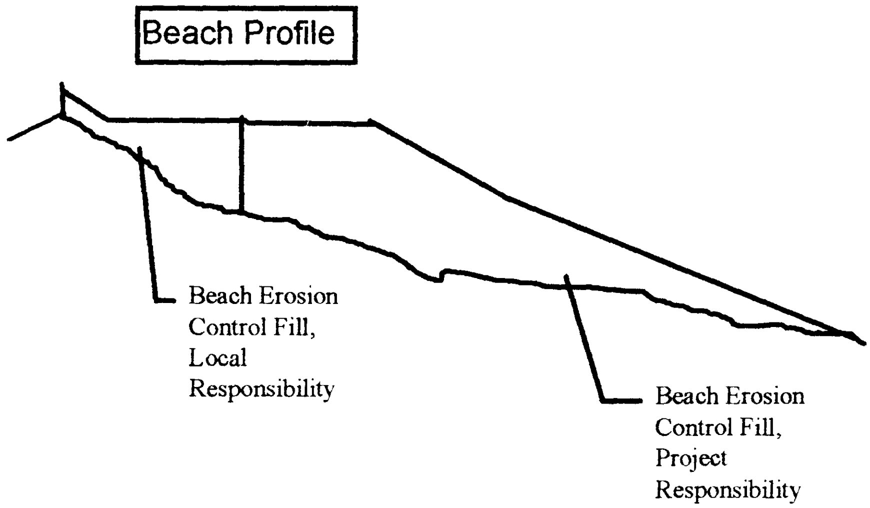

Figure 2. Typical beach profile section.

2.3.2 Groins

Groins are structures built perpendicular to the shore that may be constructed of timber, concrete, metal sheet piling, or rock. They may be built singly or in a series. Groins are intended to reduce longshore sediment transport; thus, when placed on an open coast, they widen the beach on the updrift side. Groins designed with heights that match the beach profile have less potential causing downdrift beach erosion.

Groins often have been used improperly in the past, and some states have prohibited their construction. Groins used with care, however, have the potential to stabilize beach fills. A type of adjustable groin has been used in Deerfield Beach, Florida, whose upper elevation may be maintained slightly above the sand level. In this way, the structures can be adjusted to ensure that they function primarily to stabilize material in place rather than trap material transport. A field of groins or groins placed as terminal structures might be particularly appropriate to retain material placed in a beach nourishment project. Additionally, a field of groins or a single long terminal structure may be suitable near the end of a littoral system such as adjacent to a channel entrance.

2.3.3 Seawalls and Revetments

Properly engineered seawalls and revetments can protect the land behind them without causing adverse effects to the fronting beaches. Seawalls normally are built on shorelines that are eroding. Often, however, the seawall is blamed for the additional erosion that occurs. This happens if they are not designed and constructed properly and can cause adverse impacts on adjacent property. Additionally, seawalls and revetments are expensive and require proper maintenance.

A survey of seventy technical papers and reports of the effects of seawalls on beaches followed by a more extensive study with an additional thirty references, led Kraus to conclude:

"It is concluded that beach change near seawalls, both in magnitude and variation, is similar to that on beaches without seawalls, if a sediment supply exists. Sediment volumes eroded by storms at beaches with and without seawalls are comparable, as are post-storm recovery rates. In addition, the shape of the beach profile after construction of a seawall is similar to the pre-construction shape if a sediment supply exists, showing the same number of bars with approximately the same volumes and relative locations. The form of the erosion response to storms at seawalls is typically different. Limited evidence indicates that the sub-aqueous nearshore profile on a sediment-deficient coast with seawalls does not become steeper indefinitely, but approaches an equilibrium configuration compatible with the coarser grained particles comprising the bottom sediment."[1]

As pointed out by Dean, the only principle that is definitely established is the one of "sediment conservation."[2] Coastal armoring neither adds to nor removes sand from the sediment system but may be responsible for the redistribution of sand and can prevent sand from entering the system. Although armoring can cause additional localized scour during storms, both in front of and at the ends of the armoring, there are no factual data to support claims that armoring causes the profile to become steeper, increased longshore transport, transport of sand to a substantial distance offshore, or delayed post-storm recovery. Low-profile seawalls or dikes can be used to retain a beach or fillet of sand above the normal beach profile level. Such structures are referred to as perched beaches and may exist as single-level or terraced structures.

2.3.4 Offshore Breakwaters

Offshore or detached breakwaters typically are constructed from rock or concrete armor units and protect the shoreline by reducing wave energy reaching it. They also promote sediment deposition leeward of the structures. Most offshore breakwaters built for shore protection are

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[1] Dean, 1988.
[2] Dean, 1983.

segmented and detached; thus, they provide substantial protection to the shoreline without completely stopping longshore sand transport. They do not deflect and relocate currents, like breakwaters that project from the land. Unlike seawalls, revetments, or bulkheads, breakwaters aid in the retention of the beach because they reduce wave energy. A main disadvantage is that they are more expensive to build than land-based structures.

Segmented, detached breakwaters have been used successfully to protect shorelines from erosion in many countries such as Japan, Spain, Italy, and Israel. The use of these structures in the United States has been limited to a few sites in Massachusetts, Ohio, Pennsylvania, Virginia, and Hawaii. Submerged breakwaters, or artificial reefs, have been used in many parts of the world, notably in Italy but recently in Florida. They may be composed of sunken barges or ships or any heavy objects that break up wave action. The costs can be much less than for breakwaters that project above the water surface because they do not have to absorb the full wave impact, but merely cause storm waves to break and spill their energy in turbulence

2.3.5 Sand Bypassing

Inlets, navigation channels, and harbor entrances all interrupt the natural flow of sediment transport along the shoreline. The interrupted flow of sand is diverted either offshore in ebb tide shoals, into bays or lagoons in flood tide shoals, or in navigation channels. They generally cause shoaling and downdrift migration of channels, which require frequent dredging in order to maintain safe navigation. As a result, erosion occurs downdrift of the interrupted coastline. Sand bypassing, by either a fixed or floating pumping system, restores the natural flow of sand to the downdrift shorelines and reduces the need for channel dredging. Successful operations of this type exist in many countries such as Australia, Japan, and South Africa. In Florida the use of two fixed bypassing plants for a period of 30 years suggests the feasibility of such systems to alleviate human-induced erosion downdrift from inlet control structures.

2.3.6 Dune Building

Natural sand dunes are formed by winds blowing onshore over the beach, transporting sand landward. Grass and sometimes bushes grow on sand dunes, creating a barrier against sea attack. The dunes provide a reservoir of beach sand during severe storms and thus help prevent flood and wave damage to adjacent property. In areas where substantial dunes exist, the post-storm beach width can be greater than the pre-storm width.

Attempts have been made to mimic nature by promoting the formation of artificial dunes. Artificial dunes have been created in many countries around the world, as well as in the United States. States where large-scale dune construction has occurred include North Carolina, Texas, Florida, and New Jersey.

3. Factors That Determine Success of a Beach Project

This chapter examines the following factors that affect the success of a coastal erosion program.

a) dependency on tourism
b) growth of local population
c) demand for storm and flood protection
d) economic feasibility and cost effectiveness
e) magnitude of erosion-causing wave energy
f) size of program fits with natural boundaries
g) support from the federal government

3.1 Dependency on Tourism

The more the local economy is dependent on beach related tourism the more apt a beach project is apt to meet the goals established for the project. The community has a vested interest in the beach. If the beach were to disappear, so too would the community so all cost effective measures would have a chance for success. Failure would mean relocating entire communities.

3.2 Growth of Local Population

The growth of the local population insures that the tax revenue base will be growing. This provides for future security of money available to maintain a project. It also has the extra advantage of being able to do more research investing in having a more durable project in the future.

3.3 Demand for Storm and Flood Protection

Most environmental problems happen as a result of a crisis. A gradual depletion of a resource is not as noticeable as an instantaneous one. To use an old analogy (although cruel to the frog it illustrates the point nicely): placing a live frog in a pot of boiling water will cause the frog to jump from the pot to safety, placing a frog in the pot and then boiling the water with the frog in the pot causes the frog to die because he does not sense the gradual change. People respond to catastrophe. If a region is historically decimated by hurricanes then it is more likely to invest in storm protection measures. Re-nourishing a beach is a cost effective storm protection measure.

3.4 Economic Feasibility and Cost Effectiveness

Other factors listed here factor into cost effectiveness but in general if investing in redevelopment of a beach has little to no return, then it can not be seen as successful. On the other side of the equation is how much money a local community can allocate to support a beach project. This would lead us to believe that the more money a community can allocate, the greater the potential success of a beach project.

3.5 Magnitude of Erosion-Causing Wave Energy

The larger the magnitude of erosion the less durable a project will be. Success of a beach project can be determine partially by the length of time between re-nourishings. If the sand washes away within a year beach nourishment is not a good idea; other beach erosion control measures would be required (seawalls, etc. see Chapter 2).

3.6 Relationship Between Project Boundaries and Natural Boundaries

Environmental statutes and regulations are promulgated at both the state and federal levels. In addition, local governments may also pass ordinances which address environmental concerns. This combination of authorities and institutions can often lead to confusion when conflicting policies and duplicative or inconsistent permit requirements exist. Furthermore, some regional environmental problems may not be addressed at all. Federal and state programs may be too broad in scope to deal with an area's particular concerns, while local government solutions may only be able to solve a portion of the problem. The following is an attempt to describe some of the drawbacks that might become apparent, and which regional management attempts to address, when each of the traditional levels of government attempt to regulate natural resources.

3.6.1 Federal Policy

The first drawback involves federal policy, which is often too broad to adequately protect the environmental resources of certain areas. Statutes such as the Clean Water Act and the National Environmental Policy Act must necessarily establish broad goals and standards applicable nationwide. Smaller areas on the regional scale, however, frequently require specific environmental management strategies regulating activities such as land development and pollution discharge in order to preserve their sensitive natural systems. The site-specific environmental necessities of certain areas are often not addressed in federal legislation.

Furthermore, federal environmental policies are not designed to mitigate multi-jurisdictional conflicts or address regional issues. Managing wide areas requires cooperation among all levels of government. Although federal policies can mandate state and local compliance with environmental standards, they often do not establish a basis for intergovernmental cooperation. Most federal policies do not mitigate conflicts between municipal, county, and state governments regarding authority over and responsibility for management planning. Rather, these policies frequently act as enforcement agents by concentrating more on delegating responsibility to the states than on working collectively to address regional issues.

3.6.2 State Policy

While states are given much authority to carry out federal mandates and programs of their own, there are often problems associated with natural resource management at the state level. State environmental agencies are usually the parties responsible for environmental quality within the state. State agencies may be subject to broad federal standards; but it is the states, not the federal government, which are responsible for creating implementation plans and drafting regulations.

As with federal environmental statues and regulations, state standards are intended to address large areas and therefore cannot be tailored to meet the needs of particularly sensitive areas.

3.6.3 Local Policy

Although state agencies administer most environmental regulations, local governments play an important role in natural resources protection. Many state regulations are implemented and enforced at the local level. Through the police-power and state-enabling legislation, local governments are responsible for land use planning, zoning, and subdivision regulations. There are, however, several limitations to natural resource protection at the local level.

One such limitation lies in the fact that natural ecosystems transcend local boundaries. Local political borders do not correspond to natural ecosystems, and natural resource management plans are often developed around jurisdictional boundaries without fully incorporating the natural systems that are to be protected. This problem is especially true if land use management is required to protect resources, as the regulation of land use is a local domain. For example, through their land use practices, all localities within a watershed affect the water quality for all users of that watershed. Uncoordinated efforts to improve water quality by individual localities through land use regulations may be hindered as a result of activities in other jurisdictions, whose land use laws may not be as stringent.

In addition, local governance is largely fragmented among numerous counties and municipalities. Activities or problems in one jurisdiction, such as non-point source pollution, may affect other localities. Traditionally there is a lack of framework for dealing with regional issues or problems and there are generally no incentives for protecting resources of regional significance.

Within localities, authority may be fragmented among various agencies, special districts, or service districts. For example, programs and regulations affecting the environment, planning, housing, and infrastructure may be carrier out by independent agencies. As a result, the local permit process is also fragmented, and there is generally no coordination between local and state or federal permit processes.

A final drawback is that local governments may have taken provincial or parochial outlooks. The regulation of land and natural resources is a political decision, and local decisions tend to reflect local political influences which often do not take into account greater-than-local concerns. All too often there is no reason for localities to consider impacts beyond their border or outside of their jurisdiction. Economic development and the pressure to create jobs and increase the tax base may take precedence over other wider community goals. As a result, some local governments may be pro-development at any cost, although competition for economic development among localities can substantially reduce any benefits. An urban and rural dichotomy may be a problem as well, as rural residents may resent conservation efforts that are seen as deterring growth.

3.7 Federal Government Support

The local sponsor of the beach program must make sure that the project design and local conditions (public beach access, etc.) are consistent with the federal government requirements to receive federal support.

4. Case Study of Dade County Florida

Chapter 3 outlines seven different aspects that influence the success of a beach project. This chapter will illustrate the application of these aspects to a particular case, Dade County, Florida. This chapter discusses: the region's dependency on tourism (Section 3.1), the growth of the local population (Section 3.2), the demand for storm and flood protection (Section 3.3), and the magnitude of erosion-causing wave energy (Section 3.5). Chapter 5 examines the factors that determine a community's likelihood of receiving federal monetary support for local coastal erosion management (Section 3.7). Chapter 6 examines the economic feasibility and cost effectiveness of the Dade County project (Section 3.4). Chapter 7 demonstrates problems with the project because of differences between the natural boundaries and the project boundaries (Section 3.6).

This chapter is an examination of the Dade County beach erosion control project. Dade County contains the city of Miami and the town of Miami Beach. The beach project has been heralded as perhaps the greatest triumph in managing coastal erosion. There are, however, problems with the work done in Dade County. This project is used as an example to demonstrate coastal zone management to prevent coastal erosion. There are many factors that can be seen as intrinsic only to the Miami area. The state's dependence on beach related tourism, the proximity of such a large urban population, a concentration of wealth in the State in the region, etc..

The reader will understand how and why Dade County's beaches were rebuilt, problems with the design of the beach, and also develop an understanding of the problems that face coastal communities in the future with the changing role of the federal government.

Dade County is used as the case study because Dade County has one of the largest and most successful beach erosion control programs in the nation. At present, there are 15.5 miles of restored beach in Dade County, representing virtually all the major tourist and resident recreational beaches in the county.

The success of the County program results primarily from two factors. The first is a high proportion of tourism-oriented commercial development along Dade County's major beaches. The importance of maintaining a viable recreational beach is crucial to local tourism, and will become more important as other tourist centers within the state increasingly compete for the tourism market. In addition, the storm and flood protection provided by these projects will prevent serious damage to beachfront tourism industry infrastructure (hotels and attractions) in the event of a major storm. Because of this, restoring and maintaining our beaches provides an extremely high cost benefit ratio to Dade County, despite the high cost of these activities. In addition to the direct economic benefits attributable to the project, the presence of a viable beach again has stimulated extensive redevelopment and improvement of areas directly adjacent to the restored beaches in South Beach, the Art Deco district, Sunny Isles and many other restored beach areas.

A second major factor in project durability is the relatively mild wave climate in southeast Florida. These conditions exist primarily due to the proximity of the Bahaman Banks, which provide protection from the most severe storm waves generated in the open ocean. As a result, less wave energy strikes south Florida, less sand is eroded, and overall long-term costs of maintaining the beach are reduced. Almost all of the most successful projects on the Atlantic cost are located in southeast Florida.

4.1 Historical Overview of Dade County

Tourism is a vital part of many coastal economies. Because of the proximity of the population to the shore and mankind's need for sanctuary, tourism is often an important factor in the decline of coastal systems, such as beaches. While this is true throughout the world, the

Florida coastline, from Boca Raton to Miami, offers an excellent example of the conflict which may exist between the natural, political, social and economic systems.

Florida's tropical climate and broad sandy beaches have made it a popular vacation destination for tourists from America and around the world. In 1972, over 25 million tourists visited the state. Coupled with the large beach going population in Florida, this made for an estimated 270 million beach visits that year.[3] Those visitors may have been unaware that the beaches which had drawn them to Florida were not only being lost to the sea, but not natural to begin with. In 1989, tourism provided $8 billion in beach related sales, $500 million in beach related sales tax collections and generated 320,000 beach related jobs with a payroll of $1.9 billion.[4] By 1995, beach generated income from sales is expected to increase to $50 billion and provide almost $2 billion in beach-related sales taxes.[5] This revenue generation is based upon the fact that more than 75% of Florida's population lives in coastal counties, and over 80% of the state's growing population growth during the last decade has been concentrated in coastal areas.[6] Among the most populous of this areas is located between the cities of Boca Raton and Miami.

Development of the coastline for human use has interrupted the natural equilibrium and inhibits replenishment of beaches, thereby speeding beach erosion. This condition leads to ecological, economic, social and political stresses. What steps can, or ought to, be taken to diminish these stresses, given that significant development has already occurred. What lessons can be learned from the steps already taken in the coastal region from Miami to Boca Raton to prevent this condition from becoming critical in other areas.

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[3] Florida Department of Commerce's: Office of Coastal Zone Management, 1972.
[4] Task Force for Beach Management Funding, 1990.
[5] Florida Department of Natural Resources, 1989.
[6] Florida Office of Coastal Management, 1989.

An initial assumption being made is that significant development has taken place, and that this must be considered in any solution. There are other attributes about this particular situation that we must note before going further. Florida is economically dependent upon tourism. Tourism is dependent upon "healthy" beaches. Healthy meaning abundant from the human perspective. Developments built on top of beaches are at risk due to beach erosion. Efforts to protect developments have made matters worse. Sand used for beach nourishment is a finite resource. Development has the possibility of endangering coastal habitats and creatures.

The importance of tourism to the economy of Florida makes tourism of crucial importance in the politics of Florida. Beach erosion, however, has not been the only threat to Florida's precious tourism economy. The oil crisis of the early 1970s reduced nonessential travel across the board which hurt tourist markets. A series of cold winters in Florida in the 1970s further hampered the tourist-based economy. In 1976, Miami Beach had its coldest winter on record, complete with snow. That same year, the hotels that were managing to hang on were further crippled by a hotel workers union strike. By December 1977, the beach's largest hotel was sold at auction in federal Bankruptcy Court. During 1977 Miami residents were considering legalizing gambling in the area as a way of revitalizing the crumbling resort area. Yet throughout these social and political problems, the very foundation of the tourist economy was literally washing out from under them.

Miami Beach, and much of the eastern Florida coastline, was receding. This in and of itself is not a problem. Beaches erode only to have their sands deposited somewhere else, forming new beaches. Sands and sediment upstream in the system often are deposited in their place. Human beings, in an effort to enjoy these beaches and natural systems, have interrupted the natural equilibrium. Hotels, condominiums and commercial development have been built close to, or on top of, beaches in an effort to draw tourists. As the beaches eroded, a succession of seawalls and bulkheads were built to protect the property. Furthermore, jetties built to protect inlets and waterways, which humans require for navigation, disrupt flow and trap sediments. These prevent sediments from reaching downstream beaches and interrupt the replenishment cycle, often speeding up the longshore currents. In the mid 1970s it became evident that sand was being lost faster than before and virtually no beach was going to be left.

At this point the United States Army Corps of Engineers (COE) reminded the community of a suggestion they had originally made nine years earlier to the Miami City Council: rebuild the beaches. When they brought this idea up in 1967, residents balked at the costs; an estimated $35 million for a beach seven miles long and three hundred feet wide. The plan might have been accepted, however, if it had not been staunchly opposed by the hotel owners. They blocked measures to restore the narrow sandy beach that was eroded by the natural ocean currents, and the intrusion of concrete bulkheads, and canopied hotel cabanas because they did not want the public to share a widened beach with guests who were paying $100 a day. Indeed public access was a major condition of the Corps of Engineers permitting such a replenishment. The 1975 revision of the Coastal Zone Management Act requires that any community receiving federal money for beach management follow the provisions for providing public access.

The debate was far from over with the initial $60 million, ten mile nourishment. Replenishment, by its very nature, is a recurring process which must be continually revisited over the years. Nourished beaches are not permanent and, once started, beach nourishment quickly becomes a frustrating cycle. When replenishment began in 1977, sand from offshore borrow sites was deposited on the beaches. In the Miami system, only 10-15% of the sand lost to sea actually is deposited back in the areas from which the sand for replenishment is gathered. The rest is lost to areas further south, such as the beaches in the Florida Keys and the Bahamas. The result is that the sand in the initial borrow areas used for nourishment is a finite resource. Nourishment was repeated in 1982 and 1989. It is estimated that after the next nourishment project in the mid to late 1990s, no sand will be left for another similar replenishment project. It is evident that a new tactic is necessary, which may provide insight for projects in other regions.

4.2 Physical and Technical Aspects

Longshore sediment transport is defined as the movement of sand in a direction parallel to the beach and is primarily dependent upon the incident wave height and wave angle to the shoreline. The transport is southerly in direction between Boca Raton and Miami and is on the order of 120,00 - 175,000 cubic yards of sediment per year. Because sediment transport is directly dependent on the local wave climate, there tend to be seasonal variations in the transport, as well as a few episodic events that account for a great deal of the transport in any particular year.

In the vicinity of tidal inlets, longshore sediment transport is combined with the transport of sediment due to tidal currents. Sand which makes up this transport moves into the inlet and is deposited on the inner or outer shoals, or naturally bypasses the inlet as part of the longshore transport. This movement maintains a quasi-equilibrium state of the shoreline. The migration and relatively shallow depths of natural inlets pose a serious navigation hazard and are therefore modified with the construction of jetties (training an inlet) and the dredging of channels. The dredging of the channels has caused problems as the majority of this removed sand has been dumped out at sea, out of reach of the longshore sediment transport along the coast. The addition of jetties changes the sediment transport. The placement of a littoral barrier (jetty) across the longshore transport induces an anti-symmetric erosion about the barrier. As sand builds up on the upshore side of the barrier an equal amounts of sand is eroded from the downshore side. The presence of the jetties along an inlet increases the flow of water through the inlet. These increased currents push the ebb and flood shoals further away from the inlet and thereby removing the natural ability of the coastline to allow sediment to bypass the inlet. Much of the sand that passes into the increased tidal currents at the inlet is therefore jetted out to sea and lost to the downdrift shoreline which increases erosion along the downdrift shore.

4.3 Human Intervention

There are five inlets along this shoreline region, all of which have been trained with the addition of jetties and/or shoreline revetments. Each of these inlets is responsible, in its human-induced state, for the loss of sediment to the neighboring shorelines.

Boca Raton Inlet: The addition of jetties has caused severe erosion along the southern shoreline. However, since 1980 when a weir section was place in the upstream jetty, 1.1 million cubic yards of sand has been manually (by dredge) bypassed to the southern shore which has slowed the erosion to almost naturally occurring levels.

Hillsboro Inlet: The training of this inlet has not induced much additional erosion due to an offshore reef which greatly reduces the wave energy near Hillsboro. Since 1966, 2.2 million cubic yards of sand (not including bypassing) has been removed from the inlet (in order to keep the inlet navigable). Only 60-65 percent of which has been placed on the adjacent beaches.

Port Everglades Entrance: This is an artificial inlet which has two stone jetties as well as two stone breakwaters. Since 1931, 8 million cubic yards of sand has been dredged with only 3.2 million cubic yards placed on the beaches.

Bakers Haulover: The only inlet of the five that is primarily stable with respect to erosion. This is an artificial inlet that has had all dredged sand (2.7 million cubic yards) placed on the beaches and does not show any increased erosion either upshore or downshore. As the sand has built up in the inlet and along the upstream shore, it has all been bypassed to the downstream shore. This process mimics (fairly successfully) the natural longshore transport and reduces human-induced erosion while leaving the natural erosion rates at their pre-training levels.

Government Cut: This is the entrance channel to Miami Harbor. It has been continually dredged and widened, most of the sediment removed since construction has gone into the creation of Fisher Island, a semi-artificial island inside the harbor region.

There have been numerous beach nourishment projects along this section of the east coast of Florida. (These do not include annual bypass dredging operations). These are covered from north to south.

Delray Beach was first nourished in 1973 with 1.6 million cubic yards of sand placed on the shoreline. In 1978, another 0.7 million cu. yards were added and again in 1984 1.3 million cubic yards were pumped on shore. In 1992, the most recent re-nourishment project added just over 1 million cubic yards of sand. All of this sand was obtained from offshore borrow sites.

At Boca Raton Inlet in 1985, 0.2 million cubic yards were removed from the ebb tidal shoals and placed on the downdrift beach of the inlet. In 1972, 0.4 million cubic yards of sand was dredged from offshore sites one mile offshore and pumped onto Hillsboro Beach. Just south at Pompano Beach in 1970, 1.1 million cubic yards was removed for nourishment from three offshore borrow sites. In 1983, another 1.9 million was dredged from offshore to nourish 5.3 miles of Pompano Beach.

In 1971 the Hollywood - Hallandale beach area was nourished with 0.4 million cubic yards of sand. In 1979, a five year project removed 2.1 million cubic yards of sand from seven different offshore sites and placed it up on the beaches. The original plan had called for the sand to be trucked in from onshore, but suitable offshore sites were found and utilized.

Miami Beach. the initial nourishment of this shoreline was started in July 1975 with the placement of 1.6 million cubic yards of sand along the northern end of Miami Beach. Over the next six years, five more phases were completed, adding 12.3 million cubic yards of sand along the shoreline. A re-nourishing project was completed in 1988 which added 16.5 million cubic yards of sand. All of the sand currently placed along Miami beach has been removed from offshore borrow sites.

An untouched shoreline lives in a cyclical state of equilibrium. As the shoreline is modified by human constructs, this equilibrium is lost and the shoreline spends all of its energy trying to return to that state. The training and dredging of the five inlets between Boca Raton and Miami has resulted in the loss of sand to the surrounding shoreline. The increased tidal currents at the inlets now jets sand out of the reach of the longshore currents and therefore out of the longshore sediment transport.

The nourishing of these beaches has greatly reduced the erosion along this stretch of the coast by replenishing sand that has been lost to the system from both natural and human-induced processes. The added beach width also helps prevent serious erosion damage during storms by providing a buffer zone. The problem occurs when you look at the amount of sand that has been removed from offshore sites to provide the beaches. The nourishing of the beaches of the two southern east coast counties has accounted for the removal of 41.1 million cubic yards of sand from offshore sites. Due to the offshore location of these sites, they are not capable of diverting the longshore sediment transport and refilling to their original (pre-nourishment) state. Meanwhile, the longshore sediment transport continues to move sand along the coast and to induce natural erosion of the beaches. Coastal processes also smooth out the shoreline, increasing erosion at the nourishment projects. Southern Florida is now facing the dilemma that the erosion is not stopping or being reduced, and the method (nourishment) that has been the most effective at increasing the beaches without creating increased erosion elsewhere, is becoming less feasible. This is because the offshore borrow sites that contain suitable sediment quality and grain size are rapidly being depleted while the sites have no natural process for refilling within the temporal boundaries that we need.

A policy analysis of the Miami Beach erosion problem requires an understanding of the different players and their common and conflicting needs. The political process is molded by these groups or organizations and seeks a satisfactory compromise. It is unrealistic to believe that a "solution" to the problem which does not account for these needs in one way or another can be implemented.

Tourism is big business throughout the United States. Miami's economic well-being depends upon these tourists, both domestic and foreign. It is the demand from tourists which has driven the development of Miami Beach. These tourists desire hotels and resorts right at the beach, but they also demand a healthy beach. It is the demand from tourists which has driven the development of Miami Beach. It is this demand for waterfront resorts which has created a problem. A retreating beach in itself is not a problem. When the beach retreats to a hotel's steps, it then becomes a problem. The desire for beachfront vacation property and a healthy beach is not consistent with the way beaches are formed, since waterfront property ownership tends to lead to an unhealthy beach. Tourists require easy access to these beaches and don't want to pay a premium for it. Needs vary, depending upon the type of tourist. For this reason it is difficult to assess tourist desires as a single set of values.

The residents of the affected areas have a variety of conflicting needs. They want to be employed, which implies that their well-being is tied to the tourist industry. At the same time, they have an interest in maintaining free access to the waterfront for themselves. Paying to maintain beaches that were once free is not easy to accept, particularly when the beach is one's own backyard. Along similar lines, owners of waterfront property would like to restrict access to their beaches. While many residents rely on tourists for their income, they do not want to see the beaches that they enjoy overrun with tourists. This has become increasingly important with rising population. This brings up an important policy issue. Who owns the new beach? This question was answered during 1987's project by requiring the mean high water line of ownership to be determined prior to beach nourishment. The authority for this decision comes from the Florida Constitution, article X, section 1. Any beach property existing as a result of the restoration would then be in the public domain, which implied public access. This sparked great controversy in 1987, and it is likely that similar concerns would exist today. Florida property owners are already restricted to some extent by Florida common-law. For example, if the recreational public use of a sandy beach area adjacent to the mean high tide mark has been "ancient, reasonable, without interruption and free from dispute, such use, as a matter of custom, should not be interfered with by the owner" according to the Florida Supreme Court in a 1974 case.

Residents are also very concerned about property values. If beach retreat is permitted, property values are likely to decrease due to the potential for loss of property and reduced tourist revenue. At the same time, residents do not want to see action taken which will significantly impact traffic in their communities or create unsightly work areas for long periods of time.

Developers and owners of resorts are very concerned about the outcome of these debates. A policy of permitting beach retreat implies moving or destroying existing structures. Developers would also like to have continued access to property for development. Clearly, this group has a strong interest in both beach replenishment as well as avoiding barriers to beach front construction. Developers as well as hotel owners in the area can put up their own money towards whichever solution that they feel is more desirable for their purposes, and alter the cost-benefit ratio in its favor, thus allowing the COE to select it. All the state can do to prevent a solution from progressing in this manner is to deny permits, but this is a difficult move politically. Among these groups, the National Association of Realtors and Home Owners is the largest and most significant lobby. They would like to preserve the beach and will financially back the option that they feel will best help their businesses.

State and local governments have a variety of concerns. The state and local government is not a single entity, but a variety of entities, each with separate agendas and concerns as well as jurisdiction. Elected officials have the need to be reelected, and this requires balancing the needs of many powerful lobbies. State and local governments also have limited budgets with which to work and are concerned with economics. They seek an economical solution and a continued source of tax revenues. They are, in many respects, being forced to make a choice between jobs and the environment which is responsible for supporting those jobs. They must make decisions which will make a positive short term impact, but have which potential for long term success. They must bolster the economy without destroying the resource which drives it. The government must make its decisions in the face of much uncertainty regarding the environmental impact of different choices for the future of Miami Beach.

Economic assessment is also complicated by the interdependency between the environment, real estate values and the tourist economy. It is difficult to estimate the long term effects and costs of different alternatives. Spending more today may assure a longer term solution but require taxation in the short term, which is politically difficult. Spending less today may gain only a slight respite by simply delaying the same set of problems and decisions until later, but the problems may be complicated by further degradation and high populations and development. State and local governments may also have an incentive to do something and set a precedent before the federal government steps in with a more rigorous coastal zone management program.

Many of the policies regarding the coastline in Florida have grown out of the public trust doctrine. This doctrine holds certain lands as public lands to be held by the Florida Board of Trustees. Among these are traditional public trust concerns such as navigation and fishing.

Beyond these issues, Florida extends its public trust protection to other uses such as "bathing" and "other useful purposes". This type of language has been used by Florida courts to allow the state jurisdiction over beaches.

At the state and local level, storms serve as a catalyst in the policy process. A storm serves as a reminder to the local population that their town is susceptible to the sea. Over time, people tend to forget the tenuous position they put themselves in living so close to the sea. After a storm, people can then see damage incurred by the past storm and are capable of seeing how much potential damage a storm can bring about. A local municipality or county will then write to the COE asking them to look into potential solutions for their susceptibility to storm and beach erosion.

The Department of Natural Resources (DNR) is Florida's major conservation agency, directing programs in land conservation and reclamation, recreational lands, animal and plant protection, and saltwater fisheries protection.[7] DNR manages Florida's natural resources, recreation areas, aquatic preserves, state parks and wilderness areas, environmentally endangered lands, recreation trails, shoreline use and protection, beach nourishment, erosion control projects, assurances of adequate beach access, and establishment of coastal construction control lines; conservation and management of marine fishery resources; mineral resources management and geological survey; and oil and gas exploration and production regulation.

DNR is headed by the Governor and Cabinet and administered by an Executive Director appointed by the Governor and Cabinet. DNR is made up of many divisions, including: Division of Beaches and Shores; Division of Recreation and Parks; Division of Resource Management; Division of Marine Resources; and Division of State Lands. The Institute of Marine Research

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[7]Christie, 1989.

within the Division of Marine Resources conducts research necessary for management of Florida's state waters. DNR is also the home of the Marine Fisheries Commission.

When beach erosion problems were faced in 1986, the DNR was given the task of determining which beaches were critically eroding and needed Beach Management Trust Funds for beach restoration and re-nourishment. They determined which type of alternative (restoration, armoring or retreat) would be used in different areas. The state was divided into seven beach management districts for which alternatives were studied. A similar approach is likely to be used in the 1990s.

The Department of Commerce has within it the Division of Economic Development and the Division of Tourism. This department has an agenda which includes stimulating and promoting development in the state. It is a powerful force in the state government which heavily influences the economic and physical development of Florida.

The DER is headed by a secretary appointed by the Governor, which implies that it is a highly political body. The Florida Coastal Zone Management Act of 1978 designated the DER as the lead agency for coastal zone management in the state. It authorized the DER to create a plan for the Florida Coastal Management Program. This program, approved in 1981, involves sixteen state agencies with DER, DNR and Department of Community Affairs as being responsible for the majority of the operations.

A variety of federal government agencies have interests in decision regarding Miami Beach. The first of these is the Army Corps of Engineers (COE). They have performed the majority of the projects in the Miami Beach area, and would like to continue to do work in this area to justify their existence and increase their revenues. They do not have to be contracted to perform the work and will bid to perform the replenishment project, or any other coast engineering project. It is interesting to note that the COE performs the dredging work to keep inlets and channels open, and this dredging has added to today's dilemma. Millions of cubic yards of sand which could have been used in beach replenishment projects have bee disposed of far out to sea, outside of the natural replenishment system. COE regulations require that they use the "least cost" disposal method, but it is difficult to determine what is least cost and what to account for.

The COE responds to requests from local governments to study coastal erosion problems. The Corps has a series of observations it makes to see if a full study is warranted. If the Corps deems it necessary for a further look, a Corps project will begin and funding will be sought. Currently, the policy of cost sharing is employed. This means that the local government must put up a significant dollar amount for the project and the cost of the project will be shared with the federal government.

The federal Coastal Zone Management program has an agenda for the coastal zone which may be at odds with that of the local government. The federal system has a broader outlook with an interest in setting precedents for the country and preventing decisions in one area from having significant negative impacts in another. In 1972, the federal Coastal Zone Management Act was passed which established the program to "preserve, protect, develop and where possible, to restore or enhance, the resources of the Nation's coastal zone". However, Lawton Chiles, current governor of Florida and former US Senator, was instrumental in the passage of this act, which implies that he felt it was in the best interest of the state.

The Environmental Protection Agency implements programs regarding wildlife and other environmental considerations. Development projects are required to submit environmental impact statements which are then reviewed to ensure that they meet existing federal regulations.

The Office of Management and Budget establishes funding for the federal agencies involved. The Environmental Protection Agency must remain vigilant to its mission statement and the Endangered Species Act. Projects must be approved by the US Army Corps of Engineers and meet their one to one cost benefit ratio unless the project maintains navigable waters. NOAA and the National Research Council hold an annual symposium on sea turtle biology and conservation.

The Department of Commerce has an interest in implementing the Buy American Act, which placed restrictions upon the use of foreign goods by a federal or state agency. This had implications with regard to the use of Bahamian sand. In 1987, this law was amended to allow such a project to proceed.

Some environmental lobbyists are of the opinion that allowing beach retreat is the ideal answer, and that allowing natural cycles to work is desirable over interfering. Many of the environmental concerns which are being raised in Miami are complicated by the fact that these beaches are not really natural. The fact that there may not be any sand left for the ecosystem if nourishment were not permitted is not always understood by environmentalists. Other environmentalists point out that the retreating beach has exposed rocks and structure which now provides a habitat for some creatures, and they question whether we should interfere with this habitat. It is not hard to see that it is difficult to estimate the full environmental impact of any option. Some environmentalists are concerned about saving the "natural" coast as a principle, rather than any particular animal or habitat. They would prefer to visit a quiet beach sanctuary than a bustling beach tourist town.

Overall, environmental groups have yet to fully mobilize an effort in support of one particular stance or alternative. Mostly, they are not organized or focused on environmental problems in Dade and Broward Counties beyond a level of concern. Once a proposal is made, there might be strong objection by groups like the Florida Audubon Society. However, until that time, most of the concern for the environment that has an impact on the outcome of the search for a solution is raised by the scientists involved in evaluating options, either from the COE or the State Department of Environmental Protection.

As would be expected, some conflicts arise due to the large number of players involved in this drawn out political process. Having an understanding of the participants, their perceived responsibilities and authority is necessary to comprehend the policy making process for the coastal zone, and the beach erosion - replenishment issue.

Federal and State coastal zone management plans and interpretations often conflict. For example, state and federal agencies often take differing stances on the definition of the term "coastal zone" depending on the groups involved and their interests. The COE often finds itself in conflict with local coastal zone management over issues such as ocean dumping and dredging when the local coastal zone management definition would constrain the COE's authority.

The major opposition to beach replenishment in 1967, the time that the idea was first suggested, had nothing to do with environmental issues. While environmental issues have become front page news recently, this was not the case in the 1970s. In fact, when the National Coastal Zone Management Act was passed in 1972 the *New York Times* reported its passage with one sentence in its daily "Washington: For the Record." Clearly this was not considered a major news item of the day. Concern for other creatures which inhabit the coast has become a more popular source of opposition to development. During the 1980s, with growing environmental awareness throughout the country, and a sense that the federal government had little interest in protecting natural ecosystems, environmentalism grew rapidly. Membership in nation environmental organizations increased sevenfold from 1983 to 1989.[8]

In 1986, Florida environmentalists were concerned that this project in particular had the possibility of causing irreparable harm to an ecosystem, namely limestone reefs near shore, which would be smothered by increasing sediment erosion. By May 1987, the environmentalists had enlisted the support of the federal Environmental Protection Agency which urged the COE to reject

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[8] Rosenbaum, 1989.

the proposal in order to protect the reefs.[9] This was a particularly significant move as the EPA has no official jurisdiction over such beach replenishment projects, according to the Office of Coastal Zone Management.[10] This was not only a more to protect environmentally sensitive reefs, but also to assert the agency's place in coastal planning. Since the National Environmental Policy Act was passed in 1969, projects accepting federal funds (as most replenishment projects do) have been required to file environmental impact statements showing that they considered the environmental impact in their planning, but the EPA has only had the authority to make such recommendations. With the Boca Raton replenishment, the EPA and environmental lobbyists were able to do more that that. Nearly a year later, despite having had the permits for almost the entire time, the project was still not underway. In May of 1988 they had the permits from the Corps of Engineers and the state Department of Environmental Regulation. They had the approval of the governor and were awaiting approval of the DER secretary. They did not yet have the EPA's blessing, but did have a lawsuit brought by twelve environmental action groups to bar the nourishment.

Boca Raton is hardly the only community facing environmental opposition to replenishment these days. While communities seem increasingly ready to pay the millions it takes for one of these projects since it has been shown that the outlay can be recouped in tourist tax dollars, environmentalists now offer resistance. Issues other than reef damage exist. There is great concern over the fate of three species of sea turtles which nest on these beaches, one of which is classified as an endangered species. A variety of problems and potential problems plague these creatures. Rapid development of the beach front has diminished the ability of newly hatched turtles to find their way to the ocean. Replenishment also impacts the turtles. With offshore sources drying up, sand from other regions may be imported. This sand, being whiter, may result in a

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[9] Loftis, 1987.

[10] Ditton and Stephens, 1976.

cooler temperature. The sex of newly hatched turtles is dependent upon temperature. Some studies have implied that should replenishment with the cooler sand proceed, a significantly greater number of males would result.

As the environmentalists have become more vocal, so have the proponents of coastal engineering. In letters to the *Miami Herald,* presentations in town meetings and advertising campaigns, the engineers promote not only replenishment, but seawalls and revetments as well.[11] Hurricane activity has been taking its toll, and the engineering firms are taking full advantage of that situation to promote all three of these alternatives as the only way to save property from eventual destruction.

At the same time, politicians at all levels, some of whom have been in one office or another since the Corps first presented the replenishment plan in 1967, are happily taking credit for the revitalization of the area. Tourism is back up, hotel development is on the rise. In fact, Miami's nourishment projects have more than paid for themselves in increased tax revenue, at least in the monetary sense. The question is, how may more times can they afford to do this, especially now that the traditional offshore sand borrow areas are gone?

4.4 Options

The question of beach replenishment has recently gone beyond the scope of economic feasibility. Through previously believed that the replenishing sand would be eroded from the beach and restored to the offshore bar from which it came, it was discovered soon after the first replenishment project that this was not at all the case. As the beaches of Dade and Broward counties undergo repeated nourishment, the sand supply has shrunk to a level which can support only one more major replenishment of the beaches in each county, which will be completed by the

[11] Miami Herald, 1987.

end of 1997. As the inevitable exhaustion of the current borrow areas approaches, one of two actions must be taken. Either a new source of sand must be identified and brought on-line to supply the beaches, or the system as a whole must be reevaluated and a non-nourishment course of action taken.

Shortly after the time of the initial Miami Beach nourishment in 1977, the Florida Department of Natural Resources and the Minerals Management Service have been seeking alternate sand sources. At this point in time, the most probable option includes sand from island ridges in central Florida and sand imported from sand fields off of the Bahamas (Flynn, 1994). Other sources considered in the past include sand diverted from man-made inlets to the Intracoastal Waterway and sand from the mines of Florida concrete firms. None of the options available share the same level of convenience or cost-effectiveness as the initial offshore bar supply.

The sand from the central Florida ridges is quite similar to the sand which had washed from the Dade and Broward shoreline decades ago. Because of the similarities, sand from these sources is expected to function well within the system in terms of compatibility with geological and biological components within the system. However, the problems which arise when evaluating this option are those of logistics.

The movement of appropriate amounts of sand from central Florida to the eastern coast would involve large numbers of either barge and tug combinations or trucks. In addition to the costs incurred to operate these vehicles, additional expenses would arise through the extensive modifications to either the waterways or the roads in the area required to support the increase in traffic. These expenses could be expected to bring the total operating costs to a level two to three times those incurred when replenishing a similar area by the current method.[12] Aside from the compatibility of the sand with the Miami area beach system, another key benefit to this method

[12] Zaneski, 1993.

would be the impact on the economies of inland areas. Populations in these areas have traditionally been opposed to the magnitude of state and federal money that is derived from their taxes yet used in areas, such as beach and shore replenishment projects, that do not directly affect them. This opposition may turn into support to beach preservation planners if the project will create jobs and otherwise divert spending inland.

The sand under consideration for import from the Bahamas represents a very attractive option for restoring Miami Beach. The fine, white sand is considered by many to be ideal for recreational purposes, the same reason the beaches are currently being nourished. The costs of shipping the sand about fifty miles from the Bahamas is expected to be more than offset by the reduced processing costs of the higher quality sand, keeping total project costs at or below previous levels.[13] However, the Bahamian sand presents a different set of challenges for the beach nourishment projects to address. The fact that the sand, and its living inhabitants, would be imported raises concerns in areas ranging from federal importation laws to endangered species protection to the 1993 Buy American Act.

Until recently, the protectionistic policy of the United States, particularly that of the Buy America Act, has prevented the imported sand from being used for any government funded programs. In 1987, the act was amended to allow the use of the sand provided it was more cost effective than any American source of sand. Unfortunately, the fact remains that as long as there is sand available in the current offshore borrow areas, that sand will remain more cost effective, and the Bahamian sand will not be used until these resources are exhausted. Another significant political factor which has arisen with the possibility of the importation of sand is the debate over the environmental impact at the mining sites in the Bahamas. With this debate comes the

[13] Zaneski, 1993.

additional questions of ownership of the mining rights to these sites, and should the United States be able to exploit these rights, especially since they are most likely held by a developing country.[14]

The performance of the imported sand in the Miami area beach system is also not entirely understood. The white sand in the Bahamas is aragonite, a crushed coral rock with the same calcium carbonate composition as limestone. It is much finer and more uniform than the quartz based sand dredged off of Florida. These qualities imply that the sand would not need as much sifting as that currently used, and that the more durable limestone based sand would last longer, requiring less replenishment efforts. It is expected that these traits would have the effect of keeping the total costs of this option at the current level.[15]

These same traits which seem beneficial to the projects may prove detrimental to other aspects of the system as a whole. The limestone composition sand, when on shore in the more sever Florida climate with its greater wave energy, may be ground down and tightly packed into a concrete-like substance. This may create erosion problems consistent with shoreline hardening as well as making the beach unattractive to tourists. Similarly, when used on beaches in more arid climates, aragonite has a tendency to dissolve and precipitate to produce "beach rock". If current global warming trends continue, changing the Miami weather patterns such that there is more evaporation and precipitation, the problems arising from this form of hardening may be exacerbated.

Other questions about the compatibility of aragonite focus on the living components of the system. Although the Bahamian sand will not be subject to as much silting as the Florida sand, the fineness of the gains may already be small enough to smother many corals. There is also some concern that the lower temperature of the white sand at the levels of sea turtle egg incubation may

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[14] Parkinson, 1994.
[15] Shannon, 1984.

disrupt the populations of several endangered and protected species. The topic of introducing alien species into the Miami system from the Bahamian borrow area has also surfaced.

The amendment to the Buy American Act has provided the needed spark for more serious consideration of the imported sand for use in the region, and the above issues are currently under investigation. A small private replenishment at Fisher Island using Bahamian aragonite has proven to be a success, alleviating doubts about the performance of the sand. Studies have shown that the sand currently on Miami Beach may be above the optional temperature for turtle egg incubation, and the reduced temperature of the aragonite may help the turtle populations. Still other studies have determined that both the Miami area and the Bahamas are contained within one of the largest and calmest open ecosystems in the world. Thus the chances of introducing an alien species are very small, and even if such species were introduced, they would quickly become assimilated by the existing system in Miami.[16]

There is still much to be established regarding the use of aragonite in Miami, but as time passes, and the sand supply of the existing borrow areas dwindle, it is quickly becoming an attractive option both economically and ecologically.

Due to the costs involved with a commitment to keep the nourishment projects operating in the Miami Beach - Boca Raton areas, it may be time for the planners to step back and reevaluate this approach to preserving the beaches. Depending on the political, economic, environmental, and social impacts on the area, it may be more beneficial to examine the problem from a different perspective such as hardening the shores, adding current altering structures, or relocating buildings and letting nature take its course. All of these would have significant impact on the system. Selecting a solution of this nature would also represent a shifting of value from the beaches to the

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[16] Flynn, 1994.

structures built on them as these methods will protect the structures at the expense of the beaches and shoreline.

Hardening and other shore armoring methods are currently frowned upon by Florida legislation. Poorly planned and excessive hard structures built in the past are considered the main source of the problems currently facing Miami beach and the surrounding areas. These methods were used before Coastal Zone Management was in effect in Florida, and were generally proposed by civil, not coastal engineers.

Miami Beach probably had a chance to make the environmentally correct move back in 1972. With many of the hotels bankrupt and tourism severely hurting, it would have been feasible and perhaps considerably cheaper to buy the suffering businesses and let the sea reclaim the beach. This would have been politically difficult then, and even more so now that development has continued. We must find solutions within the realities of both our natural and political systems. With enormous costs increasing each year, and growing concern over tampering with systems we do not fully understand (such as the running out of what was thought a limitless supply of sand), the question remains: what options are there for Florida and other eroding coastal zones?

4.5 Dade County Project Conclusions

The option decided upon for the replenishment of the beaches in the Miami - Boca Raton area must be chosen using a method of valuing the various components of the system. Care must also be taken to ensure that an eye is kept towards the future with respect to the duration and repeatability of the solution, the reaction to the solution by various groups and agencies involved, and the possible future shifting of values. It is assumed that legislation will closely respond to the values prevailing at the time and allow the adoption of any technically feasible solution.

The system currently dominant in Miami places the highest value on the existence of beaches as a source of revenue. There are also strong sentiments arising which desire a preservation or restoration of the native ecological system. Unless alternate methods can be shown to be as cost effective in keeping sand in the system, and thus a beach in Miami, a policy which involves replenishment will undoubtedly continue. The question remaining at this time is where will the sand come from to support such a policy.

Of the available sources of sand, the source which seems to be most readily available, and have the least impact on the social and economic components of the system would be the aragonite sand from the Bahamas. Much interest has been shown in this sand since the Buy American Act was amended to allow for its use, as working groups which involve many of the key organizations are currently meeting to address the compatibility issues.

The benefits of using sand from the inland ridges lie in the retaining of money within the Florida economy, and the creation of jobs and spending of money in the poorer inland regions of the state. The people of these regions, traditionally against the amounts of money spent on coastal area projects despite indirectly benefiting from such spending, will no longer feel anger towards the temporary beach replenishment solutions.

Hard and soft armoring of the coast is frowned upon by both the state of Florida and the Coastal Zone Management community. However, if the value system is changed so that preserving seaside structures is considered of more importance than preserving beaches, such methods may be implemented. Such a switch in emphasis will only be made as a result of a refocusing of the Miami region economic base off of beach recreation, perhaps towards gambling or other revenue sources. It can be expected that tourism would steadily drop otherwise, just as it did in the mid seventies when the original beach disappeared.

As an armoring system will not introduce new sand into the system, and will allow the existing sand to be removed at an accelerated rate, it is only with a complete disregard (or devaluation) for the Miami area beaches and adjacent ecosystems that such a policy would be implemented. Similarly, since an armoring system will increase the rates of beach erosion, a combination of nourishment and armoring strategies would be less effective than simply replenishing the sand.

The size of the metropolitan Miami area, and the extent of development which is close to the beach, created a political and economic system where a do nothing alternative is not feasible at this point. The costs of relocating the people and businesses affected by this type of policy would be astronomical. However, development and zoning planning commissions can use the current situation as an example to create policies of setback regions for new development.

Politically, any policy implemented must take into account the concerns of residents and the tourist industry as well as anticipating issues that may be raised by environmental groups. The policy that would benefit each group the most would be one that included extensive monitoring of the ecosystems and education of the resident and nonresident beach users to make all interested parties aware of the costs involved and the sacrifices made to allow them to enjoy the beach environment.

5. Introduction to Statistical Analysis of Dade County

This chapter is a statistical analysis of the factors that determine a community's likelihood of receiving federal monetary support for local coastal erosion management. It examines the relationship between distribution of federal funds for the purpose of managing coastal erosion along the eastern coast of the State of Florida and the statistical analysis examines forty two east coast towns in Florida. Physical, economic and political data are used to explain why a particular community receives federal funding and how substantial a federal contribution is received.

5.1 Statistical Example of Wealth

This section examines the relationship between distribution of federal funds for the purpose of managing coastal erosion along the eastern coast of the State of Florida and the statistical analysis examines forty two east coast towns in Florida. Physical, economic and political data are used to explain why a particular community receives federal funding and how substantial a federal contribution is received.

Florida, because of its geography, is susceptible to significant storm activity. This storm activity causes erosion along the shoreline which is detrimental to coastal communities. The State of Florida in conjunction with the federal government attempts to effectively manage the coastline of Florida. The primary way in which this management takes place is by funding erosion prevention programs.

Initially only hard structures - groins and jetties - were used to maintain the navigability of inlets and the position of the shoreline. Beaches along the Atlantic Coast naturally recede. Since Americans have decided to live in such proximity of the sea, government has attempted to intervene on their behalf with nature. Currently the erosion prevention method used is by placing sand on the eroding beach. This technique is reversible in that over time the sand will disappear and you will be back to square one. It does, however, prove to be an expensive although effective tool for coastal erosion management.

Federal funding is distributed on a cost-sharing basis. This means that the local sponsor (county or municipality) must contribute a portion of the funding needed for an approved project. Currently the federal contribution is fifty percent for non-public property and sixty percent for coastline of public lands.

There has not been work done, that can be found, on this specific topic. The Army Corps of Engineers examines the amount of potential storm erosion damage. This is factored into their benefit-cost ratio which motivates initial startup of a county project.

5.2 Review of the Statistical Test Performed

There are three types of variables defined in this analysis: physical, economic and political. The physical variables are the length of coastline for each community, the erosion rate for each community, the population of each community, and the amount of sand lost per year for erosion - defined as the product of the rate erosion and the coastal length affected for each town. The economic variables are the average household income for each community and the aggregate wealth per community - defined as the product of the population and average income.

The amount of federal funding should be a function of physical need. Physical need is defined as a function of erosion and length of shoreline. A community which has a high erosion rate should receive more money to protect its coastline. Also a community with a long shoreline should, proportionately, receive more funding than a community with a comparable erosion rate but shorter span of beach.

It has been determined, through the following analysis, that wealth of a community is highly correlated with the amount of federal funding contributed. The federal program is based upon a cost-sharing system where, currently, the local sponsor - the community or county, contributes half of the money needed for the execution of a project. This would lead one to believe that communities with a larger tax base would be better positioned to receive a larger segment of federal moneys.

Prior to this analysis the belief of the author was that there was a potential for political influence in funding. It became a difficult task to effectively model political influence and characteristics of a town in Congress. The largest hurdle was mapping each town to its Congressional District. Florida has been redistricted many times since the 1970s. The number of Congressional seats has almost doubled over the past twenty years. This is in response to the population explosion that is underway in Florida.

Incumbency, it is believed, has a strong effect on who gets elected to Congress. If a Congressional District migrates or changes, an area not once included in a strong incumbent's district may find itself becoming part of the constituency of a strong incumbent. This makes the amount of influence a particular community has on a Congressmen difficult to chart. Attempts to develop a legitimate way to model incumbency proved too cumbersome and to be done correctly and would require research not particularly pertinent here. Future work could be done to analyze the influence Florida towns have in Congress as redistricting occurs.

The only political variable used in this analysis is party affiliation of each Congressman over the past twenty years. The number represents the percentage of time a town's Congressman was a Democrat. The major urban areas - Jacksonville and Miami - proved to be the only areas which remained Democratic over the twenty year time period examined.

5.3 Data - Description and Sources of Variables

The data set employed in this analysis was developed by the author by accumulating census data, Army Corps data, and data developed by the author.

5.4 Observations

The points of interest, observations in the data set, are coastal towns in eastern Florida which have a significant population (greater than 2500 persons). Independent areas with populations smaller than 2500 persons are included in neighboring communities.

5.5 The Dependent Variable

5.5.1 Federal Funding

The amount of federal money in 1989 dollars contributed to the establishment of coastline erosion prevention is the dependent variable. This data has been obtained from the Coast of Florida Study, which is an ongoing study by the Army Corps of Engineers, Jacksonville, Florida on the State of Florida as a physical not political unit of study. Traditionally the Corps will examine only one county at a time. This leads the Corps to ignore effects work in one county has on another. The Coast of Florida Study is an attempt to understand these effects. The Army Corps of Engineers serves as the federal body which determines the size and scope of beach projects.

5.6 The Independent Variables

5.6.1 Historical Erosion Rate

This is the amount, in feet, that a community's coastline has moved per year over the past fifty years. Shoreline position data has been taken at multiple positions along the coastline. This is an average erosion rate per community. This data comes from both the Coast of Florida Study and the General Design Memorandum of each county project. A large portion of this data was calculated by the author.

5.6.2 Population

Population of each coastal community as of the 1990 census.

5.6.3 Length of Coastline

The length in feet of coastline (or beach) that is in a community's jurisdiction. This data comes from both the Coast of Florida Study and the General Design Memorandum for each county project.

5.6.4 Income

Average household income of each coastal community as of the 1990 census. The unit of measure is 1989 dollars.

5.6.5 Party Affiliation

The assumption is made that the US Senators from the State of Florida have the interests of the entire state, so concentration is only on the House. This is a measure of how often a Democrat has represented a particular community from 1974-1994. If a Democrat has held the seat whose district includes the town in question for the entire span of time then this value would be 1.00. If a Democrat has held the seat whose district includes the town in question for sixty percent of the time then this value would be 0.60. The values for party affiliation were developed by the author from publicly available information.

5.6.6 Wealth

This is the product of population and income. This is an attempt at measuring economic might. It can be thought of as being proportional to the amount of money available for a community to sponsor beach erosion control projects.

5.6.7 Sand

The product of the historical erosion rate and the length of coastline. This can be thought of as a volume of sand. Although two dimensional - a longshore distance and a recession distance, the depth of water along the Florida eastern coast is approximately the same, so this value is proportional to the volume of sand eroded in a year by a factor of the depth of the coastal profile.

5.7 Estimation - Specification of the Statistical Model

It has been determined by the statistical analysis employed in this section that federal funding is not a function of one particular factor. Instead it is a combination of several factors. A full explanation of the model is included at the end of the following results section.

5.8 Results of the Statistical Model

The following section is an examination of the bi-variate relationships of the seven variables and their influence on federal spending. Scatter plots of the data are included to facilitate a better understanding of the data for the reader.

Errors are large for both the intercepts and the coefficients of the following regression lines because of the wide variation in federal funding with respect to the small number of observations. One possibility would be to use a log scale for the independent axis but much of the variation is due to Miami Beach. It could be suggested that Miami Beach be eliminated from the analysis, but Miami Beach represents the reason for much of the surrounding beach erosion control work.

Without its inclusion the analysis would not be complete. A major motivation was to see if the size of the Miami Beach project could effectively be explained by the factors reviewed in this analysis.

5.8.1 Modeling Federal Spending as a Function of Erosion

Federal Spending = 7,193,629 - 4,293,759(Erosion)

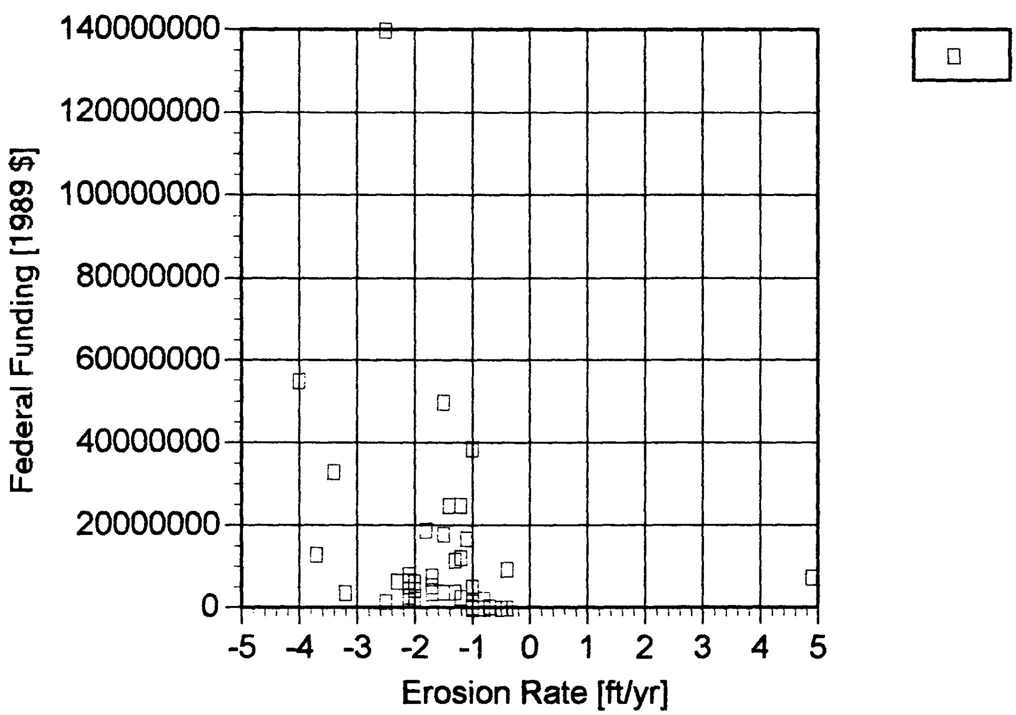
Intercept Error 5,665,375

T value 1.270 Prob > |T| 0.2113

Erosion Coefficient Error 2,801,985

T value -1.532 Prob > |T| 0.1331

R squared 0.0542 Adjusted R squared 0.0311



Erosion appears to explain somewhere between 3 and 5 percent of the variance of federal funds.

The relationship between erosion rate and funding is negative because erosion is defined as loss of sand, thus negative, therefore larger erosion rates are negative. Erosion will therefore be included in the final model.

The intercepts of the bi-variate regressions represent the amount of funding provided when the dependent variable is zero. This is a monetary offset that can be seen as intrinsic to Florida.

5.8.2 Modeling Federal Spending as a Function of Population

Federal Spending = 3,342,778 + 392.85(Population)

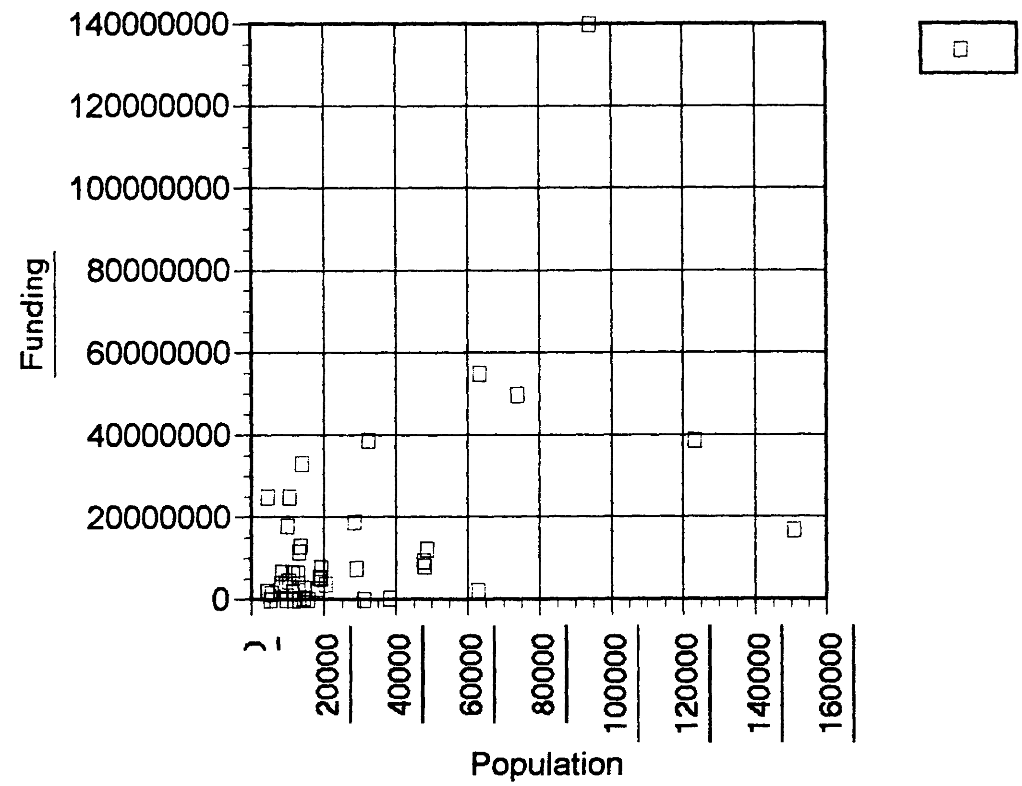
Intercept Error 4,157,997

T value 0.804 Prob > |T| 0.4261

Population Coefficient Error 100.5

T value 3.908 Prob > |T| 0.0003

R squared 0.2714 Adjusted R squared 0.2536



Population appears to account for approximately one quarter of the variance in funding. This makes intuitive sense: the larger the population the larger the number of people affected; therefore, the larger the government response. Population plays an important role in the final model.

5.8.3 Modeling Federal Spending as a Function of Length of Coastline

Federal Spending = 13618482 + 8.53(Length)

Intercept Error 5,917,120

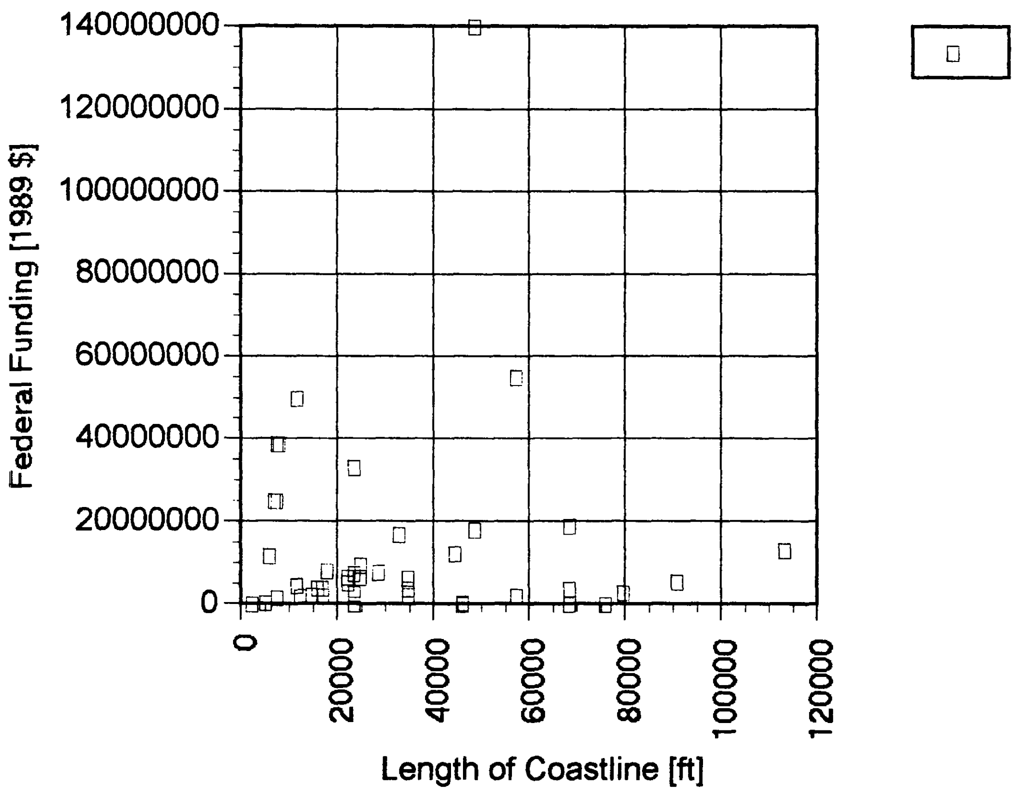
T value 2.302 Prob > |T| 0.0265

Length Coefficient Error 142.94

T value 0.060 Prob > |T| 0.9527

R squared 0.0001 Adjusted R squared -0.0243

Error in coefficient much too large to draw any statistical inference.



The length of coastline does not appear to have any significant correlation with the amount of funding and therefore will not be included in the final model.

5.8.4 Modeling Federal Spending as a Function of Income

Federal Spending = 21756922 - 183.24(Income)

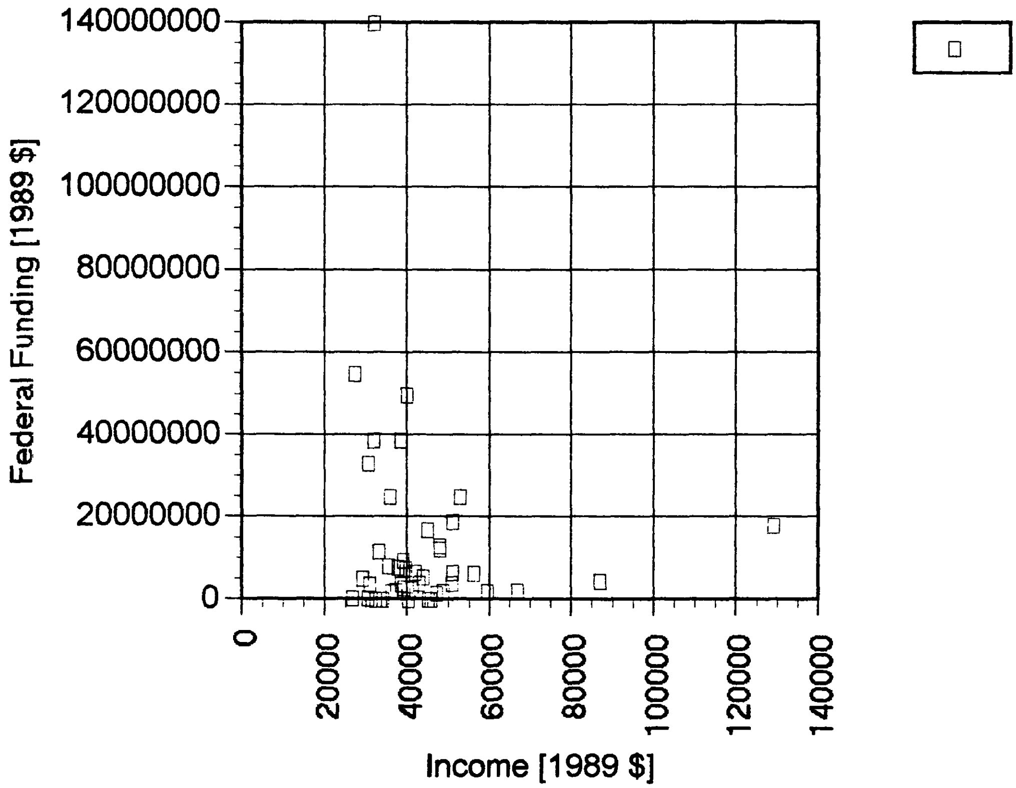
Intercept Error 9,876,225

T value 2.203   Prob > |T| 0.0333

Income Coefficient Error 213.66

T value -0.858   Prob > |T| 0.3961

R squared   0.0176   Adjusted R squared   -0.0063



Average income of a community does not appear to correlate with the amount of federal funding. This fact is in response to the small variation in income. Essentially the average income is $40,000. Income by itself will not be included as part of the final analysis.

5.8.5 Modeling Federal Spending as a Function of Political Party

Federal Spending = 4,133,113 + 16,923,927(Degree Democrat)

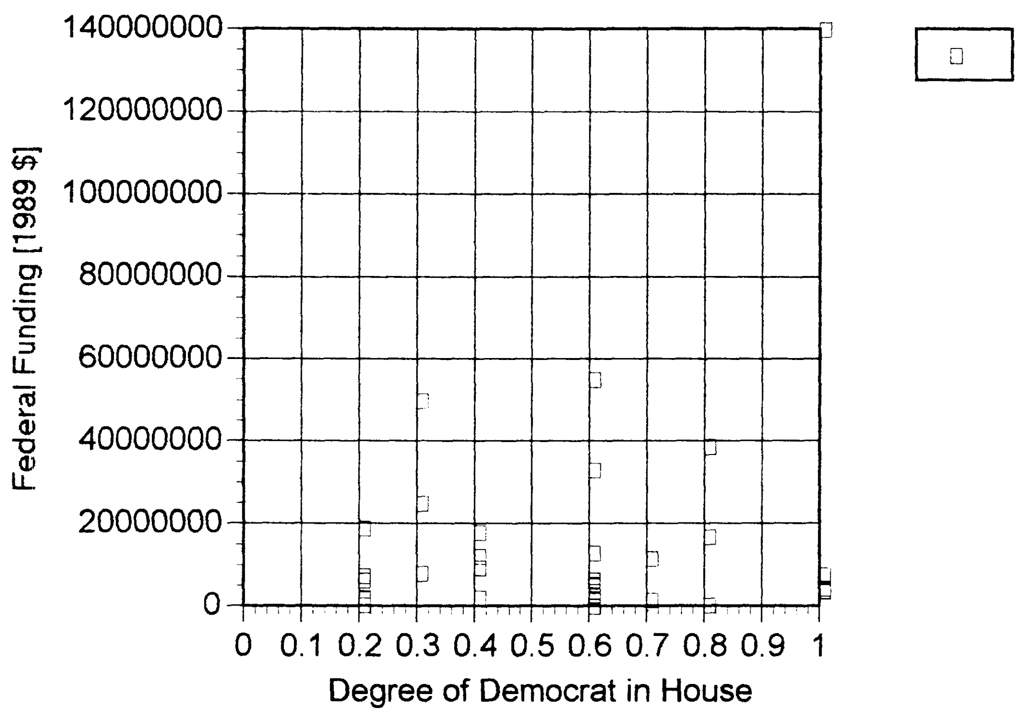
Intercept Error 9,303,698

T value 0.444 Prob > |T| 0.6592

Party Coefficient Error 14,840,430

T value 1.140 Prob > |T| 0.2607

R squared 0.0307 Adjusted R squared 0.0071



The party affiliation of each town's representative in Congress appears to explain 1 - 3 percent of the variation in federal funding and will be included in the final model.

5.8.6 Modeling Federal Spending as a Function of Wealth

Federal Spending = 6,422,486 + 0.00692(Wealth)

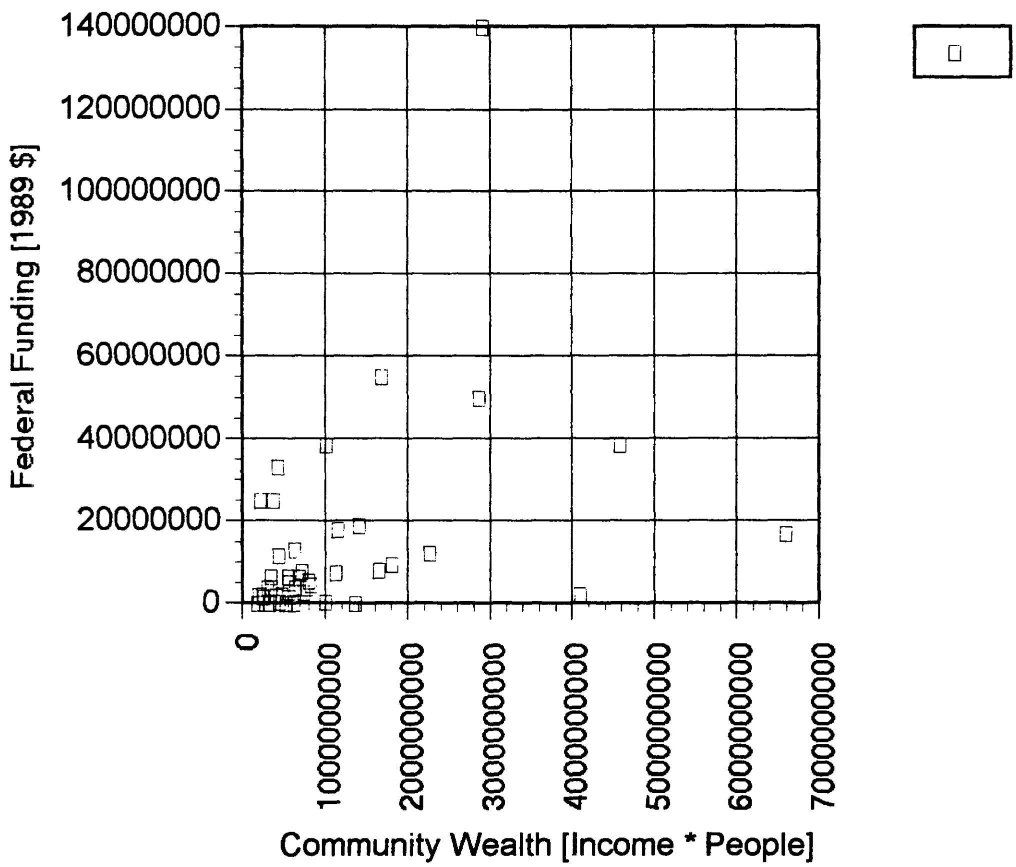
Intercept Error 4,469,395

T value 1.437   Prob > |T| 0.1583

Wealth Coefficient Error 0.00265

T value 2.608   Prob > |T| 0.0126

R squared   0.1423 Adjusted R squared   0.1214



Wealth appears to explain 12 - 14 percent of the variation in funding and therefore will be included in the final model.

5.8.7 Modeling Federal Spending as a Function of Sand

Federal Spending = 11,015,386 - 48.82(Sand)

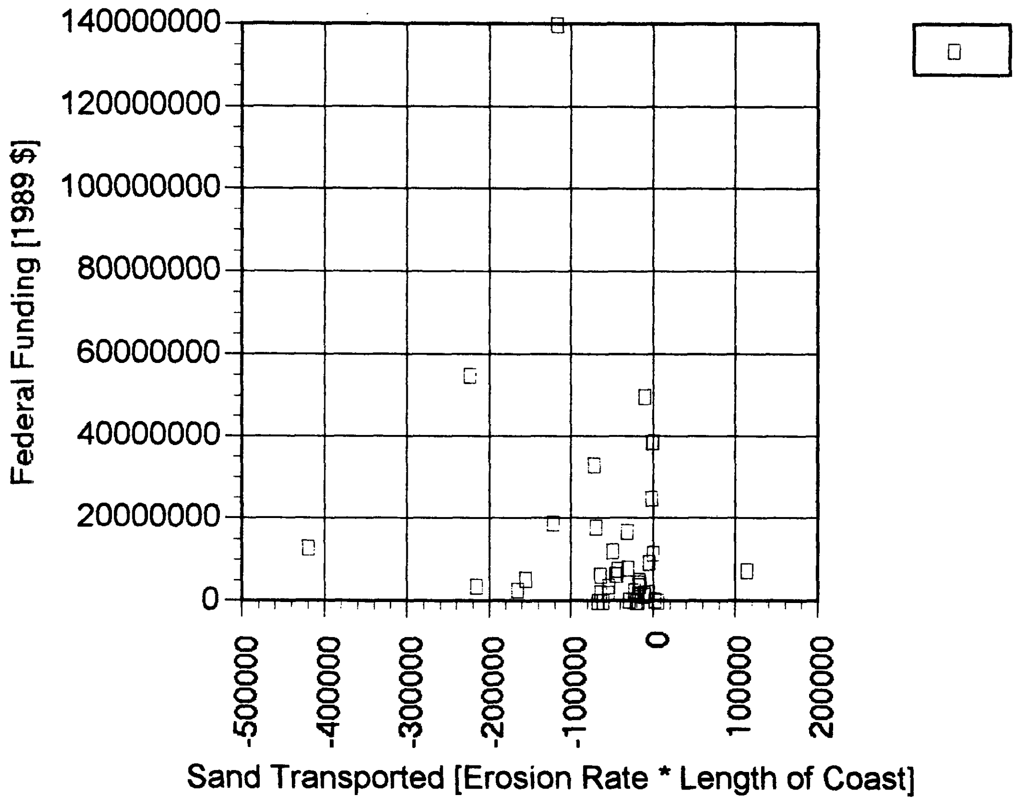
Intercept Error 4,496,969

T value 2.450 Prob > |T| 0.0187

Sand Coefficient Error 44.25

T value -1.096 Prob > |T| 0.2793

R squared 0.0285 Adjusted R squared 0.0048



The amount of sand transported each year contributes somewhere between one half of one percent and three percent of the variation and will be included in the final model. The erosion rate probably drives this number but it will still be included for completeness.

5.9 Statistical Model Applied

Federal Funding = Erosion + Population + Party + Wealth + Sand

5.9.1 Model Used to Represent Federal Spending (M Model)

Federal Spending = -2987360 -3377530(Erosion) + 1393.9(Population) + 2688046(Party) - 0.025(Wealth) + 0.12(Sand)

Intercept Error 7680093.7

T value -0.389 Prob > |T| 0.6995

Erosion Coefficient Error 3025002.28

T value -1.117 Prob > |T| 0.2714

Population Coefficient Error 314.89

T value 4.395 Prob > |T| 0.0001

Party Coefficient Error 11881754.9

T value 0.226 Prob > |T| 0.8223

Wealth Coefficient Error 0.00765

T value -3.279 Prob > |T| 0.0023

Sand Coefficient Error 45.88

T value 0.003 Prob > |T| 0.9979

R squared 0.4872 Adjusted R squared 0.4179

F Value for Model 7.030 Prob > |F| 0.0001

5.9.2 Full Statistical Model (F Model)

Federal Funding = Erosion + Population + Length + Income + Party + Wealth + Sand

Federal Spending = -17,870,454 - 1,084,397(Erosion) + 2016.6(Population) - 5.9(Length)

+ 504(Income) + 436777(Dem) - 0.04(Wealth) - 65.5(Sand)

Intercept Error 12,705,378.5

T value -1.407 Prob > |T| 0.1684

Erosion Coefficient Error 3,610,286.8

T value -0.300 Prob > |T| 0.7657

Population Coefficient Error 401.13

T value 5.027 Prob > |T| 0.0001

Length Coefficient Error 223.38

T value -0.877 Prob > |T| 0.3864

Income Coefficient Error 208.15

T value 2.423 Prob > |T| 0.0207

Party Coefficient Error 11,308,663

T value 0.039 Prob > |T| 0.9694

Wealth Coefficient Error 0.00968

T value -4.164 Prob > |T| 0.0002

Sand Coefficient Error 91.03

T value -0.719 Prob > |T| 0.4767

R squared 0.5661 Adjusted R squared 0.4793

F Value for Model 6.523 Prob > |F| 0.0001

5.10 Substantive Discussion of Statistical Model Results

The two models of federal funding are listed statistically above. Examining both models we can say that the M model describes federal funding with a greater degree of confidence, the F value is higher, but they both explain the variance quite well, Prob > |F| is 0.0001 for both. The R squared for the F model is higher explaining around 53% of the variance compared with 45% of the variance explained by the M model. So it seems that the F model explains more of the variance.

Both intercepts are negative meaning that there is an initial criteria to be met by a community to receive funding, i.e. not every town receives funding. This makes sense because there are data points that have zero funding. Erosion is negatively correlated in both models with it contributing more to funding in the M model. Wealth and Population (Population is a factor of wealth) seem to explain the most variance. This would lead us to believe that those with money receive more federal funding. This notion was addressed earlier in the bi-variate explanation.

5.11 Conclusion of the Statistical Model

Florida is a separate case in America because of its extreme coastal nature. Most counties have a coastal component, and half of the counties in Florida have their population centers in close proximity with the sea. The major contributors to federal funding are wealth of a particular community, and erosion, with wealth being the primary contributor. The political model of Florida is not robust enough in explaining the contribution of political influence. Federal funding does not seem to be affected much by the party in power.

6. Economics and the Cost-Benefit Ratio

This chapter is a description of the development of the cost-benefit ratio for the Dade County Beach Erosion Control Project.

Beach re-nourishment projects can be viewed as a response to increased development. The beach erodes at a natural rate. This rate is influenced by the amount of sand that can be moved. Development removes sand from the near-shore in attempts to make stable land. With the reduction of the total amount of sand, erosion increases and may become unstable. Coastal communities rely on their beaches to attract tourists. The larger and more attractive a beach is the larger the influx of tourists into the region, thus the larger the revenues as a result of tourism.

This section looks at southeastern Florida, specifically Dade County. The socio-economic situation that exists in Dade County is unique. This uniqueness will not be discussed in this paper. This paper will focus on the economics of beach re-nourishment in Dade County. It can be seen as a large scale example of American coastal zone management policies.

6.1 The Market System Effects

Now that we have established the impetus for all of this concern over sand and the movement of sand we can look at the economics that drive the problem.

An examination of the costs and benefits associated with beach re-nourishment in the region.

Project	Total Cost	Federal Share	State Share	County Share
Dade County Erosion Project	56.890	33.000	14.790	9.100
Key Biscayne Beach Restoration	2.700	1.000	.529	1.172
Haulover Jetty Improvements	3.000	2.100	.590	.310
Dade County Project - 1st Re-nourishment	5.000	3.715	1.714	.571
Sunny Isles Beach Restoration	19.350	8.925	7.818	2.606
Bal Harbour Beach Nourishment	4.600	2.305	1.726	.572
Dade County Beach Vegetation	3.700		2.500	1.000
Totals (in millions of dollars)	96.240	51.045	29.656	14.769

The Corps's estimate of average annual benefits were :

$18 million - Total,
$1.64 million - Recreation,
$0.9 million - Prevention of damage to existing erosion control structures,
$0.5 million - Hurricane protection,
$0.2 million - Enhancement of property values,
$2.77 million - Average annual cost.

The benefit to cost ratio was projected to be 5.9. The resulting ratio was 6.5 (post project).[17] About 15.5 million cu yd of fill were placed (including all advance re-nourishment and the Sunny Isle extension). Erosion of the fill has been less than expected, decreasing re-nourishment needs. About 680,000 cu yd have been used to re-nourish four eroding sections, which is less than 5 percent of the original placement. Due to the wide beach resulting from the design and advance re-nourishment placed at the time of the original fill, there has been no dune erosion.

The critical number is the benefit to cost ratio. A project can not be funded if the ratio is not above 1. This means in short that the calculated benefits outweigh the calculated costs. Costs are computed as a function of land and property damage. No external or environmental costs are computed. Benefits are purely a function of the real-estate market, size of the beach (recreation use benefits), and storm damage from storm damage modeling based on historical data.

[17] General Design Memorandum, 1977.

6.2 Estimated Benefits (pre-project)

Type of Benefits	Public	Private	Total
Erosion control benefits			
Damage to development benefits			
Seawalls	$106,000	$494,000	$600,000
Groins		$328,000	$328,000
Recreation			
Increased use benefits	$6,875,000		$6,875,000
Overcrowding benefits	$7,500,000		$7,500,000
Land enhancement	$107,000	$178,000	$285,000
Hurricane surge protection benefits	$520,000		$520,000
Total	$15,108,000	$1,000,000	$16,108,000

6.3 Externalities and Problems with the Market

The costs and benefits are calculated in dollar values. The main way to develop these dollar values are to look at the impacts to real estate and tourism. There are problems with this that are common to environmental economics.

The first difficulty is the cost of the sand source. There is never a calculation of the cost of removing that sand to the local environment. Currently experiments are going on with new sand types from the Bahamas. Since the Bahamas are outside of the country, the impact on those islands are never developed.

The problem of turbulence is never addressed. When dredging is going on, sand gets stirred up and turbulent mixing of the sand in the near-shore occurs. This has a significant impact on coral reefs and life that depends on them. Instead of the clear water organisms are used to, there is an acute change in the amount of sand stirred up.

At the time of the design and implementation of the Dade County plan a regional approach was not used. Sand and effects gained or lost as a result in the local environment are not accounted for. How the project affects the towns that border the project can show significant benefit or costs. Sand can move down-shore or up-shore and be placed on beaches not part of the project. The stability of the beach is a function of the change in the width of the beach. At the end of the project there is a large differential in beach width. Usually there is an attempt to "taper" the beach to meet the next community, but this is at the cost of having a narrower beach than initially designed in the project area.

6.4 Capturing the Externalities

There is a need to address dollars as units but most of this can be achieved by addressing the other problems with using the market in this example. The costs of removing sand from its current location should be factored in. That impact needs to be realized and quantified. The stirring problem is also contained to the local sand source environment and could be quantified and made a part of the cost of removing sand.

The regional approach is the simplest way to alleviate many of the problems noted above. If the design boundaries fall more in line with the natural boundaries of inlets, channels, and regional currents, then the boundary effects are minimized because the area beyond the boundary is not similar enough to feel the effects of the region within the boundary.

6.5 Policy Recommendation

Currently the Army Corps of Engineers is adapting a regional approach to coastal zone management and beach redevelopment. This should be continued and broadened. Also studies of effects of prior projects should receive a regional analysis to see if they can be improved. A regional approach eliminates almost all of the order of magnitude problems that are a result of designing on too small of a scale.

7. Engineering a Beach

This chapter explores the boundary problem of designing a beach re-nourishment project. The natural boundaries must be taken into consideration in the determination to go forward with a project and where a project beach begins and ends.

The beaches along the county boundary between Dade and Broward Counties are highly unstable. This is a problem because the federal government has invested money to stabilize the beaches and protect them from storms. Not all of the towns along the coast of Dade and Broward Counties contribute to the funding of the protection program.

I argue that if enough foresight existed on the part of the initial planners of the project (the Corps of Engineers), the instability would not exist. When dealing with natural systems, the definition of the boundaries of the system are critical. In this case, the political boundaries (county and town lines) are much smaller than the physical, natural boundaries. This allows for political interference in the effective maintenance of the natural system.

7.1 Statement of Scope

Erosion along the shorelines of Broward and Dade Counties in Florida was modeled mathematically using a computer simulation developed by the US Army Corps of Engineers. The work included modeling based on what the shoreline looked like in 1967 and what it looked like in 1973. In 1972 the Corps of Engineers authorized construction of a larger beach in Dade and Broward counties. Mathematical representations of the shoreline in 1967 represent what the coastline looked like before the beach was rebuilt - before sand was pumped in from offshore to increase the size of the beach. The 1973 shoreline will represent what the beach looked like after Corps of Engineers intervention.

Analysis of the results of the shoreline modeling will be used at a later date to evaluate the policy choices made in the initial design of the shoreline protection project. This report describes only mathematical modeling. The policy analysis will be a future project beyond the scope of this work.

7.2 Basic Assumptions of Shoreline Change Modeling

The first and most basic assumption of shoreline change modeling is that the beach profile moves landward and seaward while retaining the same shape. Therefore, any point on the profile is sufficient to specify the horizontal location of the profile with respect to a baseline, and one contour line can be used to describe change in the beach plan shape and volume as the beach erodes and accretes. This contour line is taken as the shoreline, and the model is therefore referred to as the shoreline change or shoreline response model. Sometimes the terminology on-line model, a shortening of the phrase on-contour line model, is used with reference to the single contour line.

A second geometrical-type assumption is that sand is transported alongshore between two well-defined limited elevations on the profile. The shoreward limit is located at the top of the active berm, and the seaward limit is located where no significant depth change occurs, the so-called depth of profile closure. Determination of the top of the active berm is relatively straightforward, but the depth of closure is more difficult to estimate and is discussed later in this chapter.

The model also requires a predictive expression for the net longshore sand transport rate. For open coast beaches the transport rate is taken to be a function of the breaking wave height and direction alongshore. The horizontal circulation in the nearshore, which actually moves the sand, is not directly considered.

Finally, the model must be applied where there is a long-term trend in shoreline behavior in order to separate and predict a clear signal of shoreline change from cyclical and random movement in the beach system produced by storms, seasonal changes in waves, and tidal fluctuations. In essence, the assumption of a clear trend in shoreline change implies that breaking waves and boundary conditions are the major factors controlling long-term beach change. This assumption is usually well satisfied at engineering projects involving groins, jetties, and detached breakwaters, which introduce biases in the transport rate.

In summary, standard assumptions of shoreline change modeling include the following:

a. The beach profile shape is constant.

b. The shoreward and seaward limits of the profile are constant.

c. Sand is transported alongshore by the action of breaking waves.

d. Detailed structure of the nearshore circulation can be ignored.

e. There is a long-term trend in shoreline evolution.

7.3 Shoreline Change Equation

The partial differential equation governing shoreline change in the one-line model is formulated by conservation of sand volume under the above assumptions. Consider a right-handed Cartesian coordinate system in which the y-axis points offshore and the x-axis is oriented parallel to the trend of the coast. The quantity y* thus denotes shoreline position, and x denotes distance alongshore. It is assumed that the beach profile translates seaward or shoreward along a section of coast without changing shape when a net amount of sand enters or leaves the section during a time interval dt. The change in shoreline position is dy, the length of the shoreline segment is dx, and the profile moves within a vertical extent defined by the berm elevation D_B and the closure depth

D_C, both measured from the same vertical datum (for example, Mean Sea Level or Mean Lower Low Water).

The change in volume of the section, $\Delta V = \Delta x \Delta y(D_B + D_C)$, is determined by the net amount of sand that enters or exits the section from its four sides. One contribution to the volume change results if there is a difference in the longshore sand transport rate Q at the lateral sides of the section and the associated net volume change is $\Delta Q \Delta t = (\delta Q/\delta x)\Delta x \Delta t$. Another contribution can arise from a line source or sink of sand, which adds or removes a volume of sand per unit width of beach from either the shoreward side at the rate of q_s or from the offshore side at the rate of q_o. This contribution gives a rate of $q = q_s + q_o$ and associated volume change of $\Delta q \Delta x \Delta t$. Addition of the contributions and equating them to the volume change give $\Delta V = \Delta x \Delta y(D_B+D_C) = (\delta Q/\delta x)\Delta x \Delta t + q\Delta x \Delta t$.

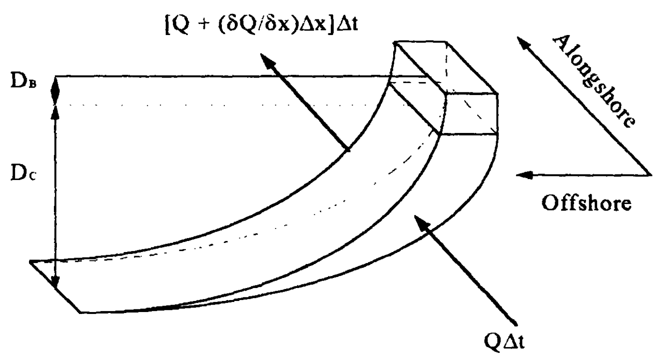


Figure 3. Definition sketch for shoreline change calculation, cross-section view.

Rearrangement of terms and taking the limit as Δt approaches 0 yields the governing equation for the rate of change of shoreline position:

$$\frac{\partial y}{\partial t} + \frac{1}{D_B + D_C}\left(\frac{\partial Q}{\partial x} - q\right) = 0 \qquad \text{(Equation 1)}$$

To solve this equation, the initial shoreline position over the full reach to be modeled, boundary conditions on each end of the beach, and values for Q, q, D_B, and D_C must be given. These quantities, together with information on structure configurations and beach fill, directly or indirectly comprise the main data requirements.

7.4 Longshore Sand Transport

The empirical reductive formula for the longshore sand transport rate used is:

$$Q = (HV_g)\left(\sin 2\Theta_{bs} - \cos\Theta_{bs}\frac{\delta H}{\delta x}\right) \qquad \text{(Equation 2)}$$

H = wave height [meters]

V_g = linear group velocity [meters/second]

Θ_{bs} = angle of breaking waves to the locale shoreline [degrees]

Values are taken at wave breaking condition.

The first term in the longshore sand transport equation corresponds to the Coastal Engineering Research Center (CERC) formula described in the Shore Protection Manual and accounts for the longshore sand transport produced by obliquely incident breaking waves. A value of $K_1 = 0.77$ was originally determined from sand tracer experiments, using root mean square (rms) wave height in the calculations. Kraus et al. (1982) recommended a decrease of K_1 to 0.58 on the basis of their tracer experiments. As this order of magnitude for K_1 is well known in the literature, the standard engineering quantity of significant wave height to be entered in the wave data streams is converted to an rms value by the factor of 1.416 to compare values of K_1 determined by calibration of the model.

The second term is not part of the CERC formula and describes the effect of another generating mechanism for longshore sand transport, the longshore gradient in breaking wave height $\delta H_b/\delta x$. The contribution arising from the longshore gradient in wave height is usually much smaller than that from oblique wave incidence in an open-coast situation. However, in the vicinity of structures where diffraction produces a substantial change in breaking wave height over a considerable length of beach, inclusion of the second term provides an improved modeling result. The value of K_2 is typically 0.5 to 1.0 times that of K_1. It is not recommended to vary K_2 much beyond K_1, as exaggerated shoreline change may be calculated in the vicinity of structures and numerical instability may also occur.

Although the values of K_1 and K_2 have been empirically estimated, these coefficients are treated as parameters in calibration of the model and are called transport parameters. The transport parameter K_1 controls the time scale of the simulated shoreline change, as well as the magnitude of the longshore sand transport rate. This control of the time scale and magnitude of the longshore sand transport rate is performed in concert with the factor $1/(D_b + D_c)$ appearing in the shoreline change governing equation.

In summary, because of the many assumptions and approximations that have gone into formulation of the shoreline response model, and to account for the actual sand transport along a given coast, the coefficients K_1 and K_2 are treated as calibration parameters. Their values are determined by reproducing measured shoreline change and order of magnitude and direction of the longshore sand transport rate.

7.5 Sources and Sinks of Sand

The quantity q in the governing equation for the rate of change of shoreline position represents a line source or sink of sand along the stretch of modeled beach. Typical sources are rivers and cliffs, whereas typical sinks are inlets and entrance channels. Wind-blown sand at the shore can act as either a source or sink on the landward boundary, depending on wind direction. General predictive formulas cannot be given for the shoreward and seaward rates q_s and q_o, whose values depend on the particular situation. These quantities typically vary with time and are a function of distance alongshore. The capability to represent sources and sinks is not included here. As an alternative, a direct change in shoreline position can be implemented.

7.6 Direct Change in Shoreline Position

The position of the shoreline can also change directly, for example, as a result of beach fill or dredging (sand mining). In this case, the profile is translated shoreward or seaward, as required, by a specified amount, which can be a function of time and distance alongshore. This model allows for specification of a direct change in shoreline position, which may be positive (seaward), as caused by beach fill, or negative (landward), as by sand mining.

7.7 Depth of Longshore Transport

The width of the profile over which longshore transport takes place under a given set of wave conditions is used by the model to calculate the amount of sand bypassing (percentage of total) occurring at groins and jetties. Because the major portion of alongshore sand movement takes place in the surf zone, this distance is approximately equal to the width of the surf zone and principally depends on the breaking wave height.

The sand bypassing algorithm in the model requires a depth of active longshore transport, which is directly related to the width of the surf zone under the assumption that the profile is a monotonically increasing function of distance offshore. The depth of active longshore transport D_{LT} is defined and set equal to the depth of breaking of the highest one-tenth waves at the updrift side of the structure. Under standard assumptions, this depth is related to the significant wave height $H_{1/3}$ by:

$$D_{LT} = \frac{1.27}{\gamma}(H_{1/3})_b \qquad \text{(Equation 3)}$$

in which

1.27 = conversion factor between one-tenth highest wave height and significant wave height

γ = breaker index, ratio of wave height to water depth at breaking

$(H_{1/3})_b$ = significant wave height at breaking, m.

If $\gamma = 0.78$ is used, then $D_{LT} \sim 1.6(H_{1/3})_b$. Thus, the depth defining the seaward extent of the zone of active longshore transport D_{LT} is much less than the depth of closure D_C, except under extremely high waves.

The model uses another characteristic depth, termed the "maximum depth of longshore transport" D_{LTo}, to calculate the average beach slope tan B. The quantity D_{LTo} is calculated as

$$D_{LTo} = (2.3 - 1.9H_o)\frac{H_o}{L_o} \qquad \text{(Equation 4)}$$

in which

H_o/L_o = wave steepness in deep water

H_o = significant wave height in deep water, m

L_o = wavelength in deep water, m.

From linear wave theory, $L_o = gT^2/2\Pi$, in which is the acceleration due to gravity (m^2/sec) and T (sec) is the wave period. If spectral wave information is given, T is taken as the peak spectral wave period; otherwise, it is the period associated with the significant waves. The D_{LTo} equation is used to estimate an approximate annual limit depth of the littoral zone under extreme waves. D_{LTo} is calculated at each time-step from the input deepwater wave data and is assumed to be valid over the entire longshore extent of the modeled reach. Because wave characteristics vary seasonally, this definition of the maximum depth of longshore transport will reflect changes in average profile shape and beach slope, as described next.

7.8 Average Profile Shape and Slope

The shoreline change equation (Equation 1) was derived without reference to a specific shape of the bottom profile, requiring only that the profile maintain its shape. However, to determine the location of breaking waves alongshore and depth at the tips of structures that extend offshore, and to calculate the average nearshore bottom slope used in the longshore transport equation, a profile shape must be specified. For this purpose, the equilibrium profile shape empirically obtained by Bruun (1954) and Dean (1977) is used. They demonstrated that the average profile shape for a wide variety of beaches can be represented by the simple relation, $D = Ay^{2/3}$, in which D is the water depth (m) and A is an empirical coefficient called the scale parameter, having the dimensions M1/3. The scale parameter A has been shown to depend on the beach grain size.

7.9 Depth of Closure

The depth of closure, the seaward limit beyond which the profile does not exhibit significant change in depth, is a difficult parameter to quantify. Empirically, the location of profile closure DC cannot be identified with confidence, as small changes along the bottom in deeper water are difficult to measure. This situation usually results in a depth of closure located within a wide range of values, requiring judgment to be exercised to specify a single value. If numerous profile surveys are available, the standard deviation can be plotted as a function of depth. The standard deviation typically decreases sharply at a certain depth, which can be considered to be the depth of closure. The depth of closure is typically in the range of 6 to 8 m for the open Atlantic Coast, where the average wave period is about 7 seconds.

7.10 Sand Transport Calculation Domains

In the model, shore-connected structures (jetties, groins, and breakwaters) are assumed not to transmit wave energy, so that waves entering on one side of such a structure cannot propagate to the other side. Based on the concept of wave energy windows and non-wave transmissibility of shore-connected structures, the shoreline is divided into what are called "sand transport calculation domains." These domains consist of segments of the coast which are bounded on each side by either a diffracting shore-connected structure or a model boundary. The model solves the shoreline change equation independently for each domain, except for conditions such as sand passing around or through groins, which allow exchange of sand across the boundaries of the calculation domains.

7.11 Numerical Solution Scheme

If all information is available to use the shoreline change equation, the longshore sand transport rate equation, and the wave breaking criterion, the response of the shoreline to wave action can be calculated. Under certain simplified conditions, closed-form mathematical solutions of the shoreline change equation can be found, but in order to describe realistic structure and shoreline configurations, including waves that vary alongshore and with time, one must solve the equation numerically. In a numerical solution procedure, the distance alongshore is divided into cells of a certain width (called the grid spacing), and the duration of the simulation is similarly divided into small elements. If the grid spaced and the time-step are small, solutions of the governing partial differential equation can be accurately calculated by numerical solution of the finite difference equation.

7.12 Grid System And Finite Difference Solution Scheme

In the model, calculated quantities along the shoreline are discretized on a staggered grid in which shoreline positions y_i are defined at the center of the grid cells and transport rates Q_i at the cell walls. The left and right boundaries are located at grid cell numbers 1 and N, respectively. In total , there are N values of the shoreline position, so the values of the initial shoreline position must be given at N points. There are N+1 values of the longshore sand transport rate since N+1 cell walls enclose the N cells. Values of the transport rate must be specified at the boundaries, Q_1 and Q_{N+1}, and the remainder of the Q_i and all y_i will be calculated. Since the Q_i are a function of the wave conditions, wave quantities are calculated at Q-points. The tips of structures are likewise located at Q-points. Beach fills, river discharges, and other sand sources and sinks are located at y-points.

7.13 Sand Transmission

A permeability factor is analogously introduced to describe sand transmission, over, through, and landward of a shore-connected structure such as a groin. A high, relative to the mean water level, structurally tight groin that extends far landward so as to prevent landward sand bypassing has a permeability factor of zero. If no structure is present, the permeability factor would be one. The level of permeability is then determined as a percentage of what sand gets transmitted through the structure.

7.14 Beach Fill

Beach fill is a traditional and increasingly popular method of shore protection and flood control, and nourished beaches also have value for recreational, commercial, and environmental purposes. Fill is commonly placed together with the building of coastal structures such as groin fields and detached breakwaters. The model is capable of representing the behavior of fills under the following assumptions:

a) The fill has the same median grain size as the native sand,

b) The profile of the fill represented in the model has the equilibrium shape corresponding to its grain size,

c) The berm height of the nourished beach is the same as the natural beach.

These assumptions are necessary because the transport parameters, shape of the equilibrium beach profile, and berm height are considered to be constant for the entire beach being simulated.

Although beach fills are constructed with a certain cross-sectional area, after a certain time period, typically on the order of a few weeks to months, the fill will be redistributed by wave action to arrive at the equilibrium shape of the beach. A shoreline response model, which the model employed is, interprets any added width of beach as conforming to the equilibrium shape. For implementation of beach fill, the total added distance the shoreline will advance must be computed. This distance is known since the total volume of the fill equals the product of the depth of closure plus berm height, alongshore length of fill, and the total added distance.

7.15 Description of Graphs

The following graphs show the shorelines as calculated by the model. The y-axis represents the distance the beach is from some reference, usually a seawall. What is important is local change not necessarily the distance from this reference. The reference is some cases is across the street from the beach. The x-axis is not on the same scale as the y-axis to facilitate viewing in this report. The x-axis is the distance alongshore in grid numbers. Each grid is 500 ft. long. The total length of this stretch of beach is 136 grid lengths. This would be 68,000 ft. or almost 13 miles. The town of Dania is located between grid numbers 28 and 33. The town of Golden Beach extends from grid number 88 to number 101. There is a five mile stretch between the two towns which was initially included in the Dade County management plan.

The model used above to simulate shoreline change shows that the management steps taken were not inclusive enough to maintain the stability of the width of the beach.

7.16 Graphs

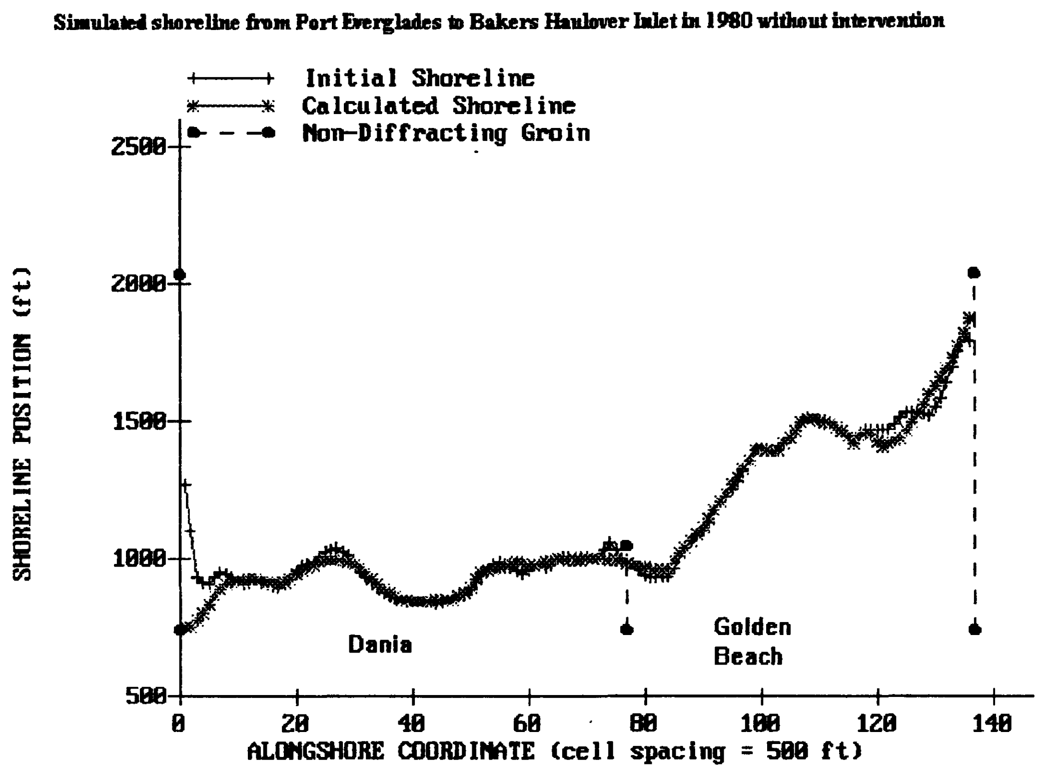


Figure 4. View of simulated shoreline of the towns of Dania and Golden Beach in 1980 if no beach project was implemented.

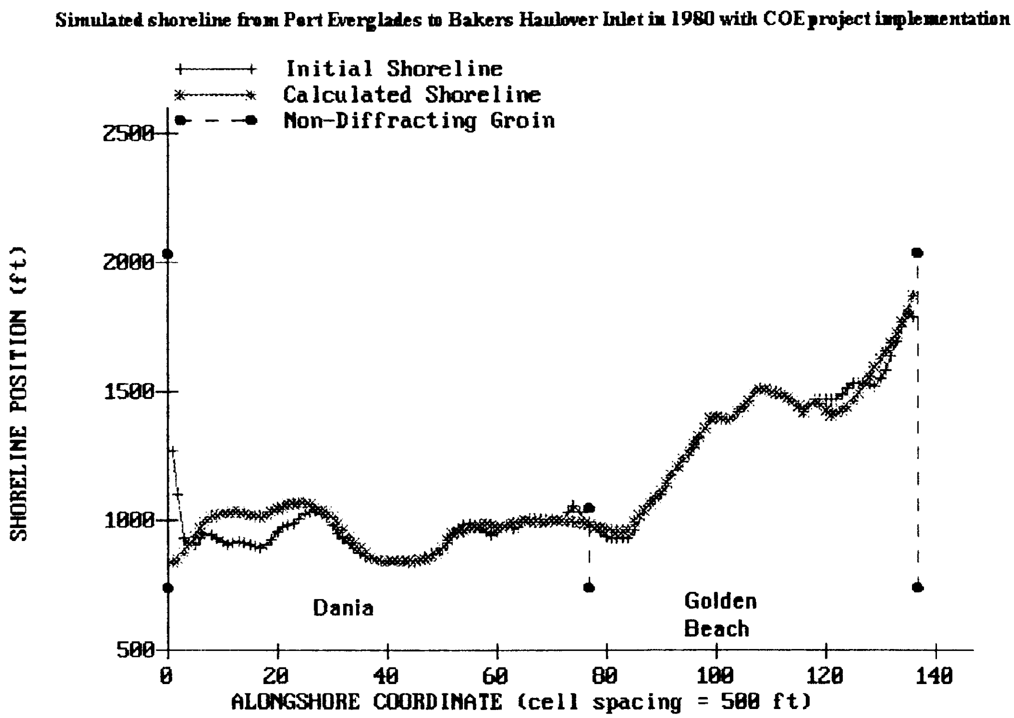


Figure 5. View of simulated shoreline of the towns of Dania and Golden Beach in 1980. After Corps of Engineers intervention.

Simulated shoreline from Port Everglades to Bakers Haulover Inlet in 1980 with regional implementation

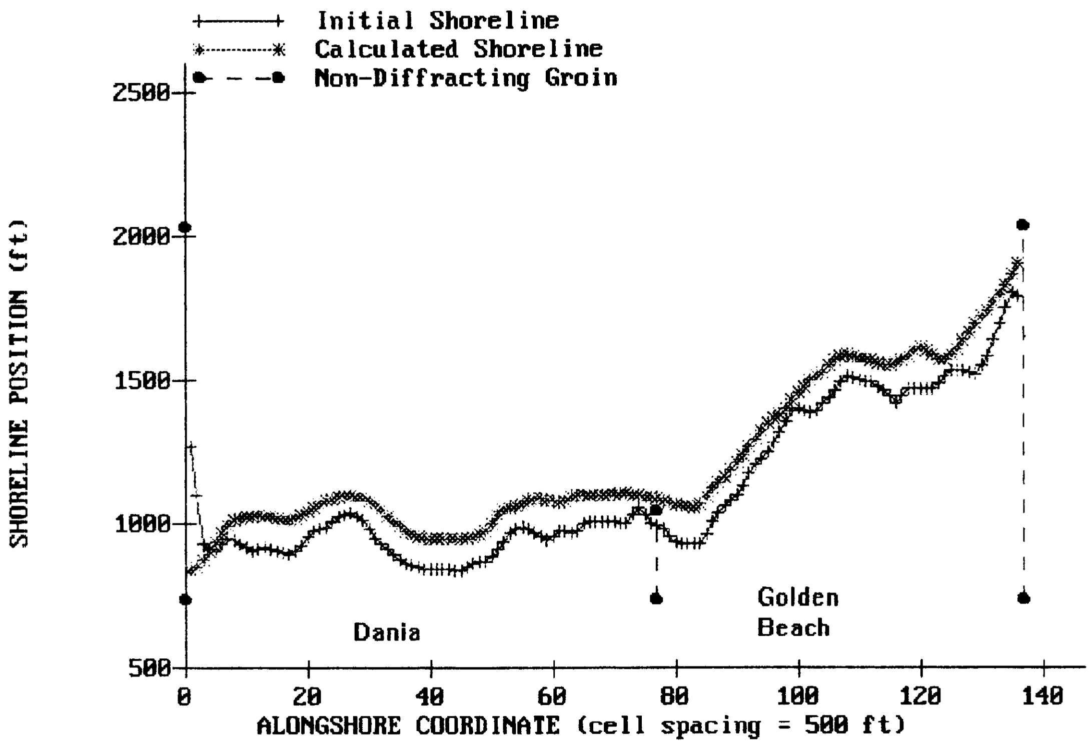


Figure 6. View of simulated shoreline of the towns of Dania and Golden Beach in 1980. After the addition of a uniform beach extension of 80 feet.

7.17 Discussion Of Graphs

One can see in Figure 6 that the well managed beach is much wider over the whole length. There is only one subtle difference between doing nothing and what the Corps of Engineers designed. The beach to the north of Dania is identical to the well managed version. The integrity and stability of the beach is lost by designing beach segments which are unequal in seaward length.

Initially a complete mathematical analysis of the shoreline positions was planned. If there were only small differences, one would have to examine the distribution of sand along the beach and then normalize this with the length of the initial shoreline. The figures above send a clear message. The design of the new beach should have been consistent along the length. The time length chosen (seven years from the start of the building of the new beach) was chosen because that is the current interval the Corps of Engineers uses to implement further nourishment. Basically the Corps believes that in seven years the sand that was manually placed on the beach will wash away. Examining Figure 4 and Figure 5 would lead one to believe that this number is approximately correct. One would have to examine incrementally when the beach returns to its previous state. Such an analysis would require further employment of the model. This purpose of this report is not to determine at what time interval should the Corps of Engineers re-build the beach. The purpose is to show that the Corps of Engineers was short-sighted in its initial design. Examining Figure 6 shows that the beach has not returned to its initial position before intervention. If the beach was managed effectively, the Corps of Engineers would not only have a more stable product but also not require such a short time interval to maintain their project in this case. This would also be more cost effective.

7.18 Conclusions and Recommendations

Through the use the pictures one can visually understand the impact the Corps of Engineers has had on the region. This report does not look at how well the design held up during the seven years from 1973 to 1980. The goal is to examine the long range impact. Over time a management plan that includes the entire region has a better return.

There are lessons that can be learned from this situation. First, the Dade County project has been touted by some as the pinnacle of coastal design. This chapter would suggest that this is not so, or at least if this is the pinnacle then we need to set our goals higher. Second, when manipulating nature for man's benefit, one must be aware of the scale that nature operates on. Usually it is much greater than we initially think. The question of whether or not man should try to manage nature is important, but not specifically addressed here. Instead one should be aware that if one chooses to manipulate nature, the results are not always favorable. One should also tread into such management with caution, seeking to better understand the processes at work, rather then becoming involved with something whose design is beyond was is known as science.

8. Conclusions

This chapter explains how the case study described and analyzed in Chapters 4 through 7 fit the parameters set down in Chapter 3. Chapter 3 sets down seven different parameters to determine the success of a beach project. The Dade County Beach Project satisfies most of these criteria for success.

8.1 Dependency on Tourism

As laid out in Chapter 4, tourism is a vital part of many coastal economies. Because of the proximity of the population to the shore and mankind's need for sanctuary, tourism is often an important factor in the decline of coastal systems. While this is true throughout the world, the Florida coastline, from Boca Raton to Miami, offers an excellent example of the conflict which may exist between the natural, political, social and economic systems.

Florida's tropical climate and broad sandy beaches have made it a popular vacation destination for tourists from America and around the world. In 1972, over 25 million tourists visited the state. Coupled with the large beach-going population in Florida, this made for an estimated 270 million beach visits that year. In 1989, tourism provided $8 billion in beach-related sales, $500 million in beach related sales tax collections and generated 320,000 beach-related jobs with a payroll of $1.9 billion. By 1995, beach-generated income from sales is expected to increase to $50 billion and provide almost $2 billion in beach-related sales taxes. This revenue generation is based upon the fact that more than 75% of Florida's population lives in coastal counties, and over 80% of the state's growing population growth during the last decade has been concentrated in coastal areas. Among the most populous of this areas is located between the cities of Boca Raton and Miami.

It has been evident here that the economy in Dade County is highly dependent on tourism. The other industries that have been built up from banking to the modeling industry have been a result of having consistent tourist dollars in the region. Dade County is the extreme when thinking of dependency on tourism as a spectrum. No attempt to quantify dependency or make a determination as to the degree of dependency necessary to have a beach project be successful is made here. The guidance that can be derived from Dade County is that tourism must play an important economic role and that there is a potential to foster development by assisting the tourism industry.

8.2 Growth of Local Population

The state population in Florida is growing at a tremendous rate. Information regarding population change was given in the Dade County background in Chapter 4 and used in the analysis of Chapter 5. Local population growth insures that funding available to maintain a beach project will be there in the future. It is essential to have future funding available because it factors into the economic feasibility. If a community can only afford to put a beach program in place and can not afford maintenance costs, then in reality it can't afford the beach program because maintenance is part of the total cost.

8.3 Demand for Storm and Flood Protection

The hurricane and storm activity that affects the Dade County area is significant. Storm based erosion can be protected against. Beach projects can be thought of as insurance against property damage. Such insurance in a high storm area like southern Florida is critical to economic continuity. If every other year the county much rebuild its coastal towns, the development there will be limited thus not allowing the economy to grow. Beach re-nourishment supports economic stability.

8.4 Economic Feasibility and Cost Effectiveness

As demonstrated in Chapter 6, the benefit to cost ratio was projected to be 5.9. The resulting ratio was 6.5 (post project). About 15.5 million cu yd of fill were placed (including all advance re-nourishment and the Sunny Isle Extension). Erosion of the fill has been less than expected, decreasing re-nourishment needs. About 680,000 cu yd have been used to re-nourish four eroding sections, which is less than 5 percent of the original placement. Due to the wide beach resulting from the design and advance re-nourishment placed at the time of the original fill, there has been no dune erosion. The Dade County project has paid for itself many times over.

8.5 Magnitude of Erosion-Causing Wave Energy

The larger the magnitude of erosion the less durable a project will be. Success of a beach project can be determined partially by the length of time between re-nourishings. If the sand washes away within a year, beach nourishment is not a good idea; other beach erosion control measures would be required (seawalls, etc. see Chapter 2). A major factor in project durability is the relatively mild wave climate in southeast Florida. These conditions exist primarily due to the proximity of the Bahama Banks, which provide protection from the most severe storm waves generated in the open ocean. As a result, less wave energy strikes south Florida, less sand is eroded, and overall long-term costs of maintaining the beach are reduced. Because of this reduced wave energy, almost all of the most successful projects on the Atlantic cost are located in southeast Florida.

8.6 Size of Program Fits With Natural Boundaries

Chapter 7 shows clearly, possible problems that result from not designing a project based on natural boundaries. There are lessons that can be learned from this situation. First, the Dade County project has been touted by some as the pinnacle of coastal design. Chapter 7 would suggest that this is not so, or at least if this is the pinnacle then we need to set our goals higher. Second, when manipulating nature for man's benefit, one must be aware of the scale that nature operates on. Usually it is much greater than we initially think. The question of whether or not man should try to manage nature is important, but not specifically addressed here. Instead one should be aware that if one chooses to manipulate nature, the results are not always favorable. One should also tread into such management with caution, seeking to better understand the processes at work, rather then becoming involved with something whose design is beyond was is known as science.

8.7 Support From the Federal Government

Federal support is necessary for most projects to get off the ground. The smaller the project the less likely it is to receive federal money. In the future, federal money will be available only for large regional projects. With the new Congress attempting to send political power back to the states, we may not see a project as large as Dade County. The local sponsor, in this case the state and the county, will eventually provide most if not all of the funding unless other states are involved.

8.8 A National Perspective

Taking all of these factors together one can learn that the Dade County Beach Project was highly successful for many reasons (the seven defined in Chapter 3). However, there was a major shortcoming in the establishment of the boundaries which affected the stability of the beach. This is clearly shown in Chapter 7; the project boundaries should coincide with natural boundaries. The points in Chapter 3 are the major factors that need to be addressed in determining the potential success of a beach project. Not all regions meet all of the criteria set out in Chapter 3. One can not model all beaches as if they were identical to Dade County. Instead of merely looking at purely economic terms to determine whether a project should be put in place, the other factors must be included in the decision making process. The region's dependency on tourism and the growth rate of the local population make sure that a beach project will continue to be managed. The demand for storm and flood protection, along with the amount of erosion-causing wave energy, determine the overall stability of a beach project. The critical mistake of Dade County was in setting the boundaries. If need be, projects should be smaller.

Every site is not Dade County; so needy for its beach that a large initial investment can yield a substantial return. The role of the federal government is beginning to change. It is not clear if this change will be long-lived, but if it is, coastal zone management must be re-prioritized. Gone is the notion of re-building the entire east coast with wide expanses of beach. Instead the approach must be more practical, long reaching, and locally funded. Beach engineering can be used to prevent catastrophe; both due to storms and lack of tourism. The role of beach nourishment in protecting our coasts will have to become more limited while retaining a regional perspective.

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