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Coastal Hazard Management Plan

New Jersey's Shoreline Future
Preparing for Tomorrow

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DRAFT

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EXECUTIVE SUMMARY

PHILOSOPHICAL DIRECTION

Development of a 'State Shore Master Plan' is an essential tool in statewide planning that will become increasingly important to guide the development of the coastal zone to produce an enhancement of public safety and the reduction of storm-related losses. To produce this plan, a reassessment of the **1981 New Jersey Shore Protection Master Plan** was conducted. This led to a change of emphasis from the engineering approaches of shoreline stabilization to a consideration of a much wider set of management strategies and options to provide for public safety and loss reduction from coastal storms. Short-term approaches will suffice to manage minor storm effects. Major storms will require the application of post-storm recovery programs that emphasize long-term mitigation of the effects of natural hazards. Reducing the exposure of people in high hazard coastal areas will be the primary objective of the **1996 Coastal Hazard Management Plan**.

Background Basics

More than most other areas of the State, the coastal zone is extremely dynamic and varied. A static approach to management is both inappropriate and unwarranted. Coastal management requires working within the limitations of the system and within the ranges of the dynamics functioning within the system.

1. The shoreline is characterized by a **shortage of available sand**. Each increment of time results in some impact because of the decreasing amount of sand at the shore through natural processes. It may be manifest in shoreline erosion, and/or the general flattening of the barrier islands as sand is selectively shifted spatially. For most of the New Jersey shoreline there are no new sources of sand being added to the beaches by natural processes.
2. **Sea level is slowly rising**. The present rate is about 16 inches per century. All of the coastline is drowning. The barrier islands are becoming narrower and lower as a result of inundation from both the seaside and bayside. Some of the effects of the inundation are perceived as erosion because the shoreline is being displaced inland. Changes are also occurring in the wetlands; they are losing area. The bay shoreline is being drowned, and flooding is more frequent in these sites. It is very likely that the rate of sea-level rise will escalate in the next century, increasing by about 50%. Coastal storms are penetrating farther inland and flooding more area as a rising sea level increases the water levels associated with storm surges.
3. The natural and cultural **characteristics of the New Jersey shore are quite diverse.** Cape May, Atlantic, and Ocean Counties have a barrier island shoreline and are responding similarly to the effects of sediment deficit and sea-level rise. Monmouth County has already lost its beach and is largely a cliffed coast (except for Monmouth

Beach and Sea Bright). The responses of the variable shorelines to forthcoming sediment deficits and sea-level rise will be different and their management needs will also differ.

4. The **coastal zone generates economic activity**, such as income, sales, and jobs via tourism and businesses that are water dependent and/or require to be located in close proximity to the coastal area. Approximately $2.0 billion is generated annually from beach related activities (excluding gambling). There is insufficient appropriate data to address the issue of whether beach nourishment projects, on their own, generate economic activity.

The New Jersey Shore Protection Master Plan of 1981 incorporated a schedule to spend $10 million on structural improvements to the shore in the form of engineering structures and new sand added to the beaches. The Plan contained many statements about the potential impacts of sea-level changes and shortages in sediment, but these issues were not incorporated in the recommended program. It constituted a static approach to the dynamic problems facing the State. However, much of the shoreline characterization contained in that document is appropriate today and the data can be combined with the existing GIS coastal data bank to describe present conditions. Likewise, much of the discussion about State regulations and the history associated with the management of shore development can be updated and utilized in the new document.

Coastal Concerns

A summary of the key concerns and issues identified by coastal decision makers, the scientific community, and the coastal communities during the development of the 1996 Reassessment are as follows:

1. Incorporate scientific information and reports about the dynamics related to the natural conditions of:

- Coastal Processes
- Sea-Level Rise
- Storms and Storm Frequency
- Shoreline Change

2. Incorporate concerns and issues identified by the State's citizens and local officials in public meetings and beach walks. Produce White Papers, Fact Sheets, or detailed discussion on topics identified in meetings, including:

- Coastal Dune Creation and Management
- Coastal Economic Assessment
- Coastal Processes
- Sea-Level Rise
- New Jersey Coastal Zone Bibliography
- Engineering Approaches to Shore Protection
- Public Education and Outreach
- Public Access
- Beach/Dune Ecosystems

- Back Bay Flooding
- Sediment Management
- Beach Nourishment

3. Address other means to manage the shore in addition to engineered approaches, including:

- Coastal Dune Management
- Natural Hazard Mitigation
- Coastal Blue Acres
- Pre-Storm Planning and Post-Storm Recovery Programs
- Appropriate Programs from Other States

4. Conduct information transfer through local forums and town meetings leading to increased concern for public safety and knowledge of coastal hazards. Incorporate information into public school curricula through Project Tomorrow, an existing effort to enrich coastal and marine sciences in the State's curriculum programs.

New Approaches in the 1996 Reassessment

Whereas the issues of sea-level rise, shoreline erosion, and coastal economics are important variables that affect decisions in managing the coast, they eventually lead to questions of what is the future of the coastal zone. What should the coast look like 50 years into the future? That is, if there were options available to alter land use and re-direct the management of resources toward specific goals, what decisions could be made at this time to attain the future objectives.

Management strategies implemented at the coast will result in large expenses. There are no inexpensive alternatives to shoreline management. Whether the decision is to put sand on the beach, build dunes, or purchase private property with public funds, all options involve great expense. Because of the high costs of accomplishing anything at the shore, it is necessary to establish objectives for management of the shore resources and to direct funds toward those objectives. The regional approach is paramount. All expenditures of public funds should be directed toward accomplishing the regional objectives that respond to local concerns.

Because the ultimate solution to enhance protection of life and property along the coast relies on local action by the citizens most directly affected by these concerns, development of the new coastal hazard mitigation policy must involve these stakeholders in the preparation and implementation of this plan. Public participation begun in the process of conducting the 1996 reassessment established a basis of community involvement in coastal management decision-making. Citizen Advisory Committees provided a two-way avenue of information flow and enlightenment. The regional approach should be grounded in the local community involvement.

Mitigation is both a philosophy and an approach to coastal management. Participation in the National Mitigation Strategy Program of the Federal Emergency Management Agency is especially timely. New Jersey has been developing a New Jersey Hazard Mitigation Plan that can lead to a more effective, more efficient utilization of the coastal zone.

The Coastal Future

1. The Federal Emergency Management Agency has been elevated to Cabinet status. The Director of FEMA has announced the creation of a National Mitigation Strategy, whose focus is to remove people from hazards, provide support for public safety, reduce the costs of recovery following damage from natural hazards, and reduce payouts from the National Flood Insurance Program by 50% by the year 2010.

2. The Federal Executive Office has zero-funded the Corps of Engineers for beach protection activity for the second straight year. No new projects will be funded. Costs are to be borne at State and local levels.

3. Insurance companies are targeting coastal areas as sites of unacceptable losses. Rates will be going up and/or insurance will be increasingly difficult to purchase (especially from international companies).

Therefore, in the absence of large subsidies from the Federal government or the State to rebuild and maintain the status quo, coastal planning will become the vehicle to direct and regulate the coastal zone. The focus will become '**Coastal Hazard Management**' rather than 'Coastal Protection'. More effort will be directed toward increasing public safety at the shore with an effort toward identifying the high risk areas to natural hazards. Post-storm recovery programs can become steps to reducing future losses in high risk areas. With FEMA mitigation programs and the NJ Blue Acres program, it may become possible to purchase the high risk sites and reduce the public exposure.

For much of the coast, the short-term, band-aid approach associated with coastal dune development and small beach nourishment projects will provide adequate protection against the small storms. The effects of the slowly-developing negative sediment supply and sea-level rise will be masked by the manipulation of the observable shoreline. However, the large storms will produce larger displacements of the shoreline that are beyond masking and will require changes in land-use or will require major investments in re-nourishment to maintain the position of the shoreline. And the need for major re-investments will escalate into the future. Identifying and targeting the high risk areas for post-storm changes in land use is of critical importance because, realistically, the post-storm period will be the only opportunity to create land-use changes and alter any of the coastal development. Alerting the citizens to the risks at the shore promotes the concepts of public safety and recognizes the fiscal limitations of attempting to respond to the effects of the very large storms. The new plan must strive to achieve a public attitude that is grounded in awarness of coastal hazard issues, stresses safety, and provides disincentives to the occupation of hazardous areas.

Conclusion

- Natural processes are diminishing the coastal resources
- The rate of change will increase with time
- The coastal zone is found to be a source of economic activity
- Existing management approaches will be successful only with minor storms

- Long-term shoreline management objectives developed by the State are needed to provide leadership in directing the management of the shore
- Management strategies should be developed and applied on a regional level
- Post-storm recovery offers the only opportunity to create changes in land-use
- Hazard mitigation programs can incorporate short-term approaches to the effects of minor storms and long-term removal from high risk areas
- Public attitude and perception must be altered to support public safety and risk reduction
- The new coastal program should be the **1996 Coastal Hazard Mitigation Plan**

GENERAL OUTLINE

Concern for the Shore

PERSPECTIVE

Coastal managers and the citizens of New Jersey share a tremendous concern about the character and quality of the New Jersey Shore. Most of the coastal zone is developed in some sort of residential and/or commercial/service land use. There are a few open spaces and these locations are also well-used by the tourism/recreation population. Although the multitude of people and the high density of population during the tourist season contribute to the economic well-being of the coastal zone, they are also a source of environmental degradation and decreasing quality of life in many locations.

There is a justifiable concern that the coast is overdeveloped and that the millions of visitors to the New Jersey shore are exhausting the remnants of the natural character and quality that once was so prevalent. The obvious appearance of groins, jetties, riprap revetments, and bulkheads are nearly everywhere and they are another feature of the human interaction and interference with the shore processes.

A long time interest in the quality of the New Jersey shore and its economic, cultural, and natural resources has been evidenced by the creation of the nation's first State commission on coastal erosion, the Engineering Advisory Board on Coast Erosion of the NJ Bureau of Commerce and Navigation formed in 1922. Its first report, The Erosion and Protection of New Jersey Beaches, called attention to the problems of narrowing beaches and damaged infrastructure in the seaside communities. Likewise, in 1930, the third report of the State Commission on Beach Erosion chronicled the issues of loss of beach width and the recurring damages to the buildings and infrastructure at the shore and portrayed the vast array of hard structures that have been employed in attempting to control coastal erosion. The same theme of loss of beach and damage to structures can be restated today along most portions of the New Jersey shoreline despite decades of attempts to 'stop the erosion' and 'protect the shoreline'.

As is common to most of the shorelines in the world, the New Jersey shore is being eroded slowly, but inexorably, through time and the products of development, structures, and resources are being threatened. This is not a recent revelation, as can be seen in the earlier reports of the State Commission, and as noted in the U. S. Army Corps of Engineers National Shoreline Study (1971). In the portion of this report describing coastal New Jersey, 82% of the 127 mile shoreline is classified as areas of critical shore erosion, another 9% as non-critical shore erosion, and only 9% as non-eroding or stable.

It is against the background of a naturally-eroding shoreline and a concern for the utilization of the shore, that decisions have to be made. The New Jersey shore is a valuable resource, the variety of natural, cultural, and economic attributes draw a multitude of permanent and temporary residents each year to partake in the richness of that variety. The aftermath of the severe storms that have struck the coast bear witness to the vitality of the coastal zone to return and to rebuild. The investments in housing, in commercial ventures, in local infrastructure continue to push the development, to extend into the beach, to the water's edge, and onto the filled land where water or marsh existed previously. Not surprisingly, the quest to move to the water's edge, to transform the barrier island, and to extend into the bays, has been accompanied by an increasing exposure to the natural hazards of the coastal zone, erosion, flooding, and wind damage. and a concomitant interest in securing public assistance and protection from these hazards.

Most communities are attempting to defend a line at the shore. It may be a building line, a bulkhead line, a dune line, or a shoreline. Whatever it is, there is an outlay of public funds to erect barriers or to replace sand, or emplace some sort of structure to maintain the line. However, the costs of maintaining the line are too much for most communities to bear. Thus, they look to the State or to the Federal government to fund most of the cost.

CONCERNS

The presence of a wide beach and the existence of some sort of dune system are regarded to be assets of communities that serve to draw the tourists and the spending that fuels the commercial and service industries. Yet, there is a general unease that the conditions of the natural system are degrading and the beaches and dunes will diminish if left alone. In many quarters, there is a grudging acknowledgement that the coastal zone is dynamic, that many of the conditions are hazardous, that it may be overdeveloped, and that it will not be possible to continue to occupy and use the entire system into the future at the same level it is being used today.

If the coast were in some sort of equilibrium and the problem was that some years it is erosional and other years it is depositional, returning to some original position after a few years, the problem would become much more simplified. The concern then would be to protect against the bad years, assuming that the good years would be non-problem times. However, the natural conditions are such that the shoreline will continue to be displaced inland because the good years of no erosion do not balance the losses produced during the bad years of severe erosion. Further, all of the tidal gauges and monitoring devices in the state show that sea level is rising and drowning the shoreline, causing the shoreline to be displaced inland even without any erosion of the beach sediment.

It is the dynamic natural processes of diminishing coastal resources pitted against a coastal economy and a coastal land-use based on a static commitment of space that are pulling in opposite directions. State and Federal funds directed to build back the beaches are a temporary solution to a long-term problem. Placing sand on the beach is a short-term solution. It is costly and must be repeated again and again to defend the line. Of course, public funds serve the public and there are decisions to be made as to whether this is the best use of these funds. This is a political/economic/environmental decision.

There is concern about public safety. The concentration of people in an area exposed to storm hazards and flooding is an increasingly raised issue. Most of the coastal zone is very low, either naturally or as a result of construction techniques in developing the land. In conjunction with rising sea level, the frequency of inundation is increasing and damage associated with flooding, problems of evacuation across low-lying routes, the traffic congestion, are all raising questions about the exposure of the residents and the visitors to the New Jersey shore. There are acknowledged high hazard areas that suffer damage or flooding with every storm. There are locations where severe erosion threatens to undermine dwellings and cause damage with nearly every storm.

Coastal dunes are regarded with almost holy reverence. The ordinances and fines in support of dune development and maintenance are noteworthy. This is a good program but it doesn't stop erosion. There is a limited amount of protection that is afforded because of the presence of dunes, and that is important. But as with putting sand on the beach, the dune provides an amount of protection that can be lost because of erosion and sea-level rise. The most effective dunes are those that are allowed to migrate into some sort of buffer zone at their inland margin. This buffer exists in very few places at the New Jersey shore and thus, in most places, the dunes are short-term to medium-term approaches to shoreline management.

Most of the shore communities are hoping for beach nourishment to solve their erosion problems. They look eagerly to the placement of new sand on the beach to defend their line. They all acknowledge that this is a temporary solution and that it is available at a high price. However, they expect that their share of the cost will be low and that funds will be generated at the State and Federal levels to cover most of the cost. With only a few exceptions, most of the communities would not be able to raise local funds in support of the total cost of beach nourishment programs for their locale.

The concerns about shoreline erosion and loss of the line are real. The concerns for public safety are real. The massive development is a fait accompli. And the threats posed by natural hazards and the potential damage to infrastructure, and property, and lives are also real. There is an overabundance of manipulating the coastal system at the local level. The early construction of walls, groins, jetties, and other defensive devices were all part of the defensive syndrome that focused on protecting the line in one stretch of the coast. There was no interest nor concern about the conditions of the neighboring communities. That has changed. It is not possible to do anything along the shore now without causing some sort of effects that cascade downdrift. The local approach is no longer appropriate and should not be condoned. There must be a regional approach to shoreline management. The conditions of sediment transport and sediment exchange are occurring in regions (often referred to as reaches or cells). This should be the basis of shoreline management. Regional planning should establish appropriate land uses, land-use densities, and long-term strategies to attain the goals. The flow of funds from the State and Federal sources should be related to these goals. Too often, the public funds are being reinvested in supporting the same approaches which have demonstrated that they are not solutions to the problems only temporary respites. That speaks to a reluctance to accept the basis of the problem and to begin to work on more elemental problem-solving. We have become entrapped in a cycle destined to repeat the earlier failures because of the lack of a broad, regional planning approach and the inability to look to other solutions to the common problem.

OUTLOOK

Regional planning is an important step in taking leadership in directing the steps to attain long-term objectives. The creation of such long-term objectives will provide the local units with knowledge of the programs that are supportable at the higher level and where there may be assistance. There is no question but that the availability of State and national funding support will determine the future of the New Jersey shore.

Two major national policy developments are extremely important to the state's future role in shoreline planning and management. First, the potential loss of Federal funding in support of beach nourishment is critical to the 'defend the line syndrome' in the state. There is little doubt that the funds will become more difficult to procure, even if they don't disappear entirely. That means that the State will have to make plans that involve much larger expenditures for beach nourishment or some alternative scenario to placing large quantities of sand (at great expense) on the beach. The second major federal initiative is a national mitigation strategy to reduce the losses from natural hazards, including coastal erosion and flooding. The national initiative is in support of moving people and structures out of hazardous areas. Funds in support of pre- and post-storm removal and relocation will be fueling this initiative.

Mitigation is also an expensive solution because of the extent of development at the shore. It will require a dedicated pool of public funds to accomplish the reduction of people at risk. It will not be possible to maintain all the existing construction and infrastructure at the shore without massive and continuous expenditures. Likewise, it will not be possible to attain the goal of reducing the exposure to natural hazards at the shore without large expenditures of public funds. The piecemeal approach will not be successful in facing the issue of the long-term erosion and drowning of our coastal resources. We must function at the regional level and make decisions that make sense for the region. The opportunities to exercise decisions will be in the immediate post-storm periods. But the decisions must be made before that time. The long-range needs of the shore must be established in concert with the funds available to execute those decisions.

DISCUSSION OF RECOMMENDATIONS

As the effects of a negative sediment supply are increased by rising sea levels, the present coastline of the New Jersey will continue to erode and encroach upon the coastal communities. In the absence of large subsidies from the Federal government or the State to rebuild and define the present shoreline position, coastal planning is shifting towards 'Coastal

Hazard Management' rather than 'Coastal Protection'. More effort will be directed toward increasing public safety at the shore with an effort toward identifying the high risk areas to natural hazards. Hazard mitigation programs can incorporate short-term approaches to the effects of minor storms as well as long-term removal from high risk areas.

For much of the coast, the short-term, band-aid approach associated with coastal dune development and small beach nourishment projects will provide adequate protection against small storms. The effects of the slowly-developing negative sediment supply and sea-level rise will be masked by the manipulation of the observable shoreline. However, the large storms will produce larger displacements of the shoreline that are beyond masking and will require changes in land-use or will require major investments in re-nourishment to maintain the position of the shoreline. And this need for major re-investments will escalate into the future.

As demand for use of the shoreline continues to grow, better information and more creative management strategies are needed to support continued resource use and stewardship. An integrated, coordinated, management approach has been used by other coastal states to address shoreline processes that occur at regional scales, and are more effectively managed at these scales. Partnerships that transcend jurisdictional boundaries are desirable and necessary to achieve this aim. A single administrative entity should be developed and charged with the sole responsibility of managing the New Jersey coast. This agency would establish well-defined objectives that are coordinated through a single office, and it would function in close cooperation with the public and with county and local planning entities to achieve these objectives.

There is a necessity to develop long-term objectives that strive towards increasing the public's safety. These long-term mitigation strategies should be developed at the State level and implemented on a regional basis. When determining the objectives, they should be consistent with the State's coastal management objectives to the year 2050,* incorporating sea-level rise and a modified coastal zone.

The State's coastal management objectives can be achieved through the development of long-term approaches or directions, such as identifying and targeting the high risk areas for post-storm changes in land use. This is of critical importance because, realistically, the post-storm period will be the only opportunity to create land-use changes and alter any of the coastal development. Of especial importance are those low-lying areas severely affected from minor storms. To implement some of these approaches, new policies may need to be initiated, such as enacting zoning ordinances that limit the density in high hazard areas. It is imperative to continue to support collection of technical data so that local resource managers have access to accurate, current information in their decision making. Additionally, there is a need to foster the education and public awareness of the risks associated with the shoreline. Alerting the citizens to the risks at the shore promotes the concepts of public safety and

* 2050 is an arbitrary year, indicating planning into the future.

recognizes the fiscal limitations of attempting to respond to the effects of the very large storms. The State Coastal Hazard Mitigation Plan must strive to achieve a public attitude that is grounded in awareness of coastal hazard issues, stresses safety and provides disincentives to the occupation of hazardous areas.

1981 - GOALS, APPROACHES, AND ACCOMPLISHMENTS

ESTABLISHMENT OF A PLAN

When the Beaches and Harbors Bond Act was created in 1978, the New Jersey Legislature required that the Department of Environmental Protection produce a comprehensive shore protection plan as a condition for allocating the funds destined for coastal expenditures. Prior to the Act, funds were allocated by the Legislature for specific projects, or small amounts were committed to conduct repairs or to react to emergencies. With a substantial amount of funds, it was possible to think beyond local needs, to consider a more comprehensive approach, and to exercise management by fostering certain objectives at the shore. As stated in Vol. I, p. I-2, the general objective was "to reduce the negative aspects of and conflicts between shoreline erosion management and coastal development, reduce hazard losses, and satisfy user demands in an equitable way." In a traditional manner, the issue of shoreline management was approached by a review of the physical processes causing erosion, the geographical distribution of erosion, a review of shore protection approaches and plans, a review of National and State policies related to shore protection and coastal policies, a discussion and evaluation of alternative approaches to mitigating the effects of shore erosion, and a prioritization of shore protection projects, combining to lead to the development of a comprehensive plan consistent with State management policies and objectives.

A very important characteristic of this approach was using the reach concept as a planning/management unit. This is an approach directed at regionalization or grouping by some defined criteria. In this case, the region, or reach, was a geomorphological unit, a division of the coastal zone nearly always described as sections of the coast, segmented by inlets. Only the northern reach of Long Branch to Sandy Hook escaped from being bounded by an inlet on at least one side. The general thought was that this regional approach (reaches) delineated sediment compartments and that the management of sediment was best accomplished in geomorphological entities rather than artificial political units. Thus, management strategies could be applied in reaches as the basic units. Realistically, it changed the scale of management by reducing the number of units to be considered but perhaps maintained the political boundaries found at every inlet.

The general description of the conditions and processes of the New Jersey shore remains an excellent portrayal of the knowledge available at the time. However, the report is approximately 15 years old and there have been improvements in the data availability and there are more refinements in the specifics of our knowledge. A combination of programs at the national, state, and local levels have generated substantial data sets that did not exist previously or were not so readily available.

PHILOSOPHICAL THRUST

The general New Jersey policy for shore management stated in the 1981 plan is based on a non-disruption of coastal processes and sediment transport in the nearshore zone. Thus, there is a movement away from hard structures either along the beach or at inlets that would 'significantly' alter the transport process and sediment delivery. Further, it is stated that reach-level engineering programs need to be evaluated and implemented only if they are cost-beneficial and that long-term, costly reach projects should not be implemented as emergency projects.

It is evident that the thrust of the 1981 plan is to attempt to reduce the reliance on short-term, stop-gap, local projects as a management tool and to replace them with broader, reach-level programs that tend to foster beaches and dunes in locations where these features existed or could exist. Further, the plan also moved away from trying to protect everything and suggested that there be avenues to move out of hazardous areas and redefine the land uses in exposed locations after damaging events. Thus, the plan called for support for those regions that required minimal investment to continue their economic productivity while enhancing their natural resources; but it attempted to withhold support from those regions that required massive financial support to continue to exist and were in areas of high erosion.

The 1981 SPMP was a very important step in the development of coastal management in New Jersey. It served to focus attention to generic issues and to demonstrate the concept of applying a regional approach to matters as basic as shore protection. This was important in elevating the interest and concern for management from the local conditions of a particular beach property to the broader issues of addressing entire reaches, or entire barrier islands. Further the coastal zone was approached as a dynamic system that was undergoing change and that this change was part of the natural condition that must be accommodated rather than fought. There are many statements throughout the document that recognize that the shore is gradually being modified and that trying to reverse the changes is both costly and futile. The first reports from the State's Engineering Advisory Board on Coast Erosion said something similar and likewise pointed to the continuing investment in the shore and the commitments that were being created by virtue of the housing and the recreational industry (NJ Bureau of Commerce and Navigation, 1930). These reports acknowledged that erosion and shoreline migration were inevitable, but suggested that short-term accommodations could be attempted and achieved. A half-century later we seem to be in the same position of accepting the effects of the natural system but not incorporating them into the goals for managing the shore.

ENGINEERING APPROACH APPLIED TO REACHES

The 1981 document was primarily directed toward evaluating the characteristics of each reach and prescribing a course of action to maintain or enhance each reach. It was driven by a $10 million fund that was derived from the 1977 Beaches and Harbor Bond Issue and a process that allocated these funds among the highest ranked applications for engineered coastal projects using a cost/benefit ratio.

A major portion of the 1981 plan was a cost-benefit analysis of each of the coastal reaches relative to five engineering plans: 1) storm erosion protection; 2) recreational development; 3) combination of storm erosion protection and recreational development; 4) limited restoration; and 5) maintenance. Using traditional assignments of property values protected and costs of the engineering plans, and the non-traditional contributions of the reaches to the recreational economy of the state as well as the additional infrastructure demands, the report concluded that four reaches were cost-beneficial to support. Three of the reaches, Peck Beach, Absecon Island, and Seven Mile Beach achieved high values in support of the recreational development alternative, whereas Sandy Hook to Long Branch supported the maintenance alternative. None of the other reaches and alternative combinations met the 1:1 cost-benefit ratio, although the recreational alternative for Long Beach Island was very close to unity.

Significantly, the document incorporates considerable basic information beyond the narrow concepts of applying a cost-benefit ratio. There is a lengthy section on basic coastal processes that helps to explain the rationale for some of the erosional problems. The issues of sediment deficits, human interference with sediment transport, and sea-level rise are raised and noted as important variables in the totality of system dynamics. The concept of hazard mitigation is proposed as an approach to management of the coast. Generally, all of the issues and concerns raised in the 1981 document exist today and, also, most of the approaches to management are introduced in the 1981 plan. However, background data are missing in some instances because information was in the process of developing, and in other cases the approach was introduced but procedures for implementation did not follow.

REASSESSMENT

Now, 15 years later, it is time to review the accomplishments of the original SPMP. It is also time to revisit the objectives of creating a shore master plan and to consider the range of strategies that may be possible in striving to reach those objectives. New knowledge and new priorities have emerged at the state and national levels that will guide as well as limit what can be accomplished in the future. With leadership, New Jersey can take advantage of these new directions and look to a renewed emphasis on enlightened stewardship of the human and natural resources that abound at the coast. It is time to consider the opportunities that exist to manage the resources as part of the dynamic system that is in slow but continuous flux. With an eye to the long-term objectives of reducing damage and loss while maintaining the economic and natural vitality of the shore, it is necessary to turn to innovative strategies that provide for short-term protection of the existing development and infrastructure, and long-term reduction of the development in the high hazard areas.

THE PROCESS OF REASSESSMENT

CONCEPTUAL BASIS FOR PRESENT EFFORT

As with most studies of public policy issues or concerns, development of a Coastal Hazard Management Plan (CHMP) required a thorough process to review and analyze existing information, collect and evaluate new information, and to ensure broad-based participation from the general public throughout the effort. In addition to the project team, the process involved participants from many federal, state, local, and private organizations with expertise across a broad range of coastal research, engineering and management issues. This expertise, combined with public participation, ensured that the resulting report contained the best available information on coastal hazard mitigation that responded to local needs.

UPDATE OF THE 1981 PLAN

One of the first tasks addressed by the project team was to conduct a thorough evaluation of the 1981 Shore Protection Master Plan. This included a review of the process used to collect information, an evaluation of the technical information contained in the document, and identification of actions or public policy resulting from this past effort. From this review an information gathering process was designed, elements of the 1981 effort that required updating were noted, knowledge gaps for new data collection and synthesis were identified, and approaches to coastal hazards were evaluated for application to the current study.

COLLECTION AND SYNTHESIS OF NEW INFORMATION

Much information has been generated on the topic of shore protection or coastal hazard management since the publication of New Jersey's Shore protection Master Plan in 1981. This includes many publications such as reconnaissance reports prepared by the U.S. Army Corps of Engineers, numerous studies including several conducted by the National Research Council, and development of new mitigation approaches being used by other countries, other coastal states, and several municipalities located right in New Jersey. The goal of the project team was to assemble as much of this information as possible, ensure that it was accessible to users, and to synthesize the information for potential application in New Jersey. This involved literature searches, workshops, interactions with many technical experts and government agency representatives, and employment of consultants. As this information was collected, it was also made available to the public via maintenance of a home page on the world wide web, construction of a bibliography, and the preparation and dissemination of white papers on coastal hazard issues identified by the public. Throughout the information gathering process, emphasis was placed on being responsive to local concerns, a consideration which demanded a process in and of itself.

PUBLIC PARTICIPATION

An essential component of the effort to reassess shoreline management in New Jersey was the design and conduct of a process that ensured public involvement in the evaluation of existing and potential shore management alternatives. The importance of this component stems from shortcomings associated with the timing and structure of the public participation process used to prepare the 1981 N.J. Shore Protection Master Plan. In the 1981 effort, the process was not initiated until the report had been largely drafted. This placed the public in a reactive position during the latter stages of the project to respond to a report that was already prepared. Consequently, there was little opportunity for substantive change emanating from key stakeholders in this issue--the public. In addition, the structure of the process to solicit input did not promote incorporation of local concerns into the project.

As a result of these shortcomings, much attention during the CHMP effort was devoted to design a process that ensured public access and input to the project team. Given that policy making authority in New Jersey is vested in local governments through home rule, and that recommendations resulting from this study would rely on local government for implementation, it was critical that the process be designed for grass roots participation. Consequently, the process was structured to ensure that citizens in coastal municipalities became stakeholders in the project and had a well-defined role in guiding the direction of the effort. With this approach, results of the study were more likely to be accepted and used. In essence, state government was not dictating how change would occur in shoreline management along the coast. Rather, local governments would receive assistance in defining their long-term goals for coastal hazard management, as well as help with evaluating the most appropriate strategies to meet their specific shoreline needs and concerns.

Following efforts aimed at designing an accessible and participatory public process, a kickoff workshop was held to begin to address key questions identified by the public, and served as a key driver for the overall effort. Specifically, the workshop was organized to discuss and evaluate potential alternatives for coastal hazard management in three major areas of public concern--shoreline management strategies, socioeconomics, and policy. Each thematic discussion was led by a Chairperson who served as facilitator for each work group. Chairs were selected from the steering committee which was established to review material generated by the project team and public participants throughout the course of the reassessment project. These three individuals were asked to solicit a list of priority shore management issues from the participants and posed a series of charges/questions to their groups (Table I).

Table I. Questions addressed at the July 12, 1994 workshop to develop potential alternatives for coastal hazard mitigation.

Shore Protection Strategies

- What are the most important shore management issues that must be addressed by the project team? Which of these issues should be addressed by "white papers?"

- What coastal research and engineering factors/properties must be considered in order to select the most appropriate shore management strategies?
- How would you characterize an area or coastal reach that is best suited to a "hard" management strategy? A "soft" management strategy?

Legal/Policy Issues

- What are the most important legal/policy issues associated with shore management that must be addressed by the project team? Which of these issues should be addressed by "white papers?"
- Which regulatory impediments (state and federal) are burdensome to local and county authorities responsible for shore management?
- What measures should the project team investigate to mitigate these impediments?
- What shore protection policies have proven successful for other coastal states, especially those with high population density?

Socioeconomic Issues

- What are the most important socioeconomic issues associated with shore management that must be addressed by the project team? Which of these issues should be addressed by "white papers?"
- Should the costs associated with shore management be allocated any differently from the present method?
- What methods are best suited to ensuring public participation in the project to reassess shore management?

Shore Management Strategies (Drs. Michael Bruno and George Klein, Co-Chairs)

This work group focused on four areas: 1) strategies and associated needs in coastal areas, 2) white paper topics, 3) data sources, and 4) contact groups for outreach efforts. The group discussed a diverse range of strategy issues, with several emerging and demanding immediate attention. These were:

o Incorporation of local needs into shore protection strategy.
o Advance planning to support a rapid response to emergencies.
o Consistency among building codes and enforcement.
o Strategies must reflect the inherent differences between post-disaster planning and long-term planning.

The group recommended that case scenarios should address specific issues such as the effects of mitigation strategies on neighboring communities (regional approach), and the compatibility of various mitigation strategies deployed within an area--especially compatibility between "hard" and "soft" engineering approaches.

The group identified a broad range of existing data sources, and compiled a list of outreach contacts for the project team. Finally, this group proposed five topics as potential white papers:

o Use of GIS in the planning process.
o Compilation of existing data.
o Review of protection priorities for individual coastal communities.
o Post-disaster planning and long-term mitigation strategies.
o Historical review of coastal planning and responses to disasters including

experience of other coastal states.

Socioeconomics (Dr. Peter Parks, Chair)

From the questions posed for this group, four major considerations were deliberated. The first consisted of proposed white paper topics. These were:

- o Assess the 1981 Shore Protection Master Plan as a resource for data and methods.
- o Quantify the magnitude and distribution of benefits from coastal hazard mitigation.
- o Specify the spatial and temporal scale by identifying stakeholders.
- o Identify linkages between management alternatives and environmental or natural resource indicators.
- o Specify how multiple impacts will be incorporated by inside/outside benefit-cost analysis.
- o Clarify hazard mitigation options by linking socioeconomics with varying approaches to shore protection.

The remaining considerations centered on the allocation of shoreline protection costs, public involvement, and improving public access. The latter issue involved whether public funding for shore protection projects should be linked to public access.

Policy (Dr. David Kinsey, Chair)

This group identified and discussed a variety of key policy issues. These were:

- o Beach-ocean access.
- o Coastal hazard and resource protection area maps.
- o Economics of shore protection.
- o Public perceptions.
- o Use of flood insurance claims.
- o Adequacy of coastal flood insurance.
- o Regulatory vs. non-regulatory approaches to shore protection.
- o Cost-sharing approaches.

The group also recommended that shore protection policies in other coastal states be examined. Although New Jersey's shoreline is somewhat unique, the group noted that other states do possess similar regions of coastline characterized by high population and use. North Carolina was identified as one such state that possesses barrier islands and employs a land acquisition program that appears to work. In addition and as with the other two work groups, this group agreed that public input will be the most useful resource for the study.

Workshop Summary

Each Chair summarized results of their group deliberations during a final plenary session, and submitted written reports following the workshop. Priority issues were then to be addressed in white papers prepared by disciplinary experts with drafts distributed to and discussed with the public to ensure that local concerns were indeed addressed. Copies of the work group reports may be found in Appendix A.

OTHER INFORMATION TRANSFER

The project team also participated in a variety of national and international meetings to keep abreast of reform efforts associated with coastal hazard mitigation. Results of these interactions were fed directly into a variety of communication mechanisms designed to reach the public.

ORGANIZATION OF THE PROCESS

The broad scope and nature of this project demanded that expertise be brought to bear on a diverse range of coastal research, engineering, and management issues. Therefore, the Institute of Marine and Coastal Sciences at Rutgers University, as principal investigator for the project, drew upon the expertise of individuals at a variety of educational and research institutions throughout New Jersey (Figure A). These included the Stevens Institute of Technology, N.J. Marine Sciences Consortium, and Stockton State College. Some of these individuals served on project committees and/or were subcontracted to complete specific project tasks.

Three committees were established for the project (Figure B). These were a steering committee, working committee, and a local government committee (Figure C). The **steering committee** consisted of legislators, researchers, state officials, and local citizens who were charged to:

o recommend and review white papers,
o assist with one-on-one meetings with key individuals,
o review education and outreach material,
o attend public meetings, and
o assist with development of the Coastal Hazard Management Plan and make recommendations for implementation.

The **working committee**, staffed by the project team, was responsible for the public participation, education, and outreach components of the project. Specific duties included:

o development and dissemination of education and outreach material,
o coordination and conduct of the one-on-one meetings,
o organization and conduct of public meetings,
o establishment and management of citizen advisory committees,
o documentation of information generated by the public and results of public interactions.

The **local government committee** included mayors, freeholders, and other elected officials, and provided a direct means to communicate and interact with local elected officials. Consultants also were used to prepare and analyze information on issues requested by the public for which outside expertise was required.

COMMITTEE ACTIVITIES

One of the first actions taken by the working committee was to anticipate concerns held by the public on issues associated with coastal hazard mitigation. Several documents were prepared to address these concerns and included a 1-page description of the project, a question and answer document, and a "top ten" list of characteristics developed to describe what the project was and was not. Copies of these documents may be found at Appendix B. Once the priority issues had been developed via this process, fact sheets also were prepared on specific topics such as sea level rise, dune management, and shoreline management strategies.

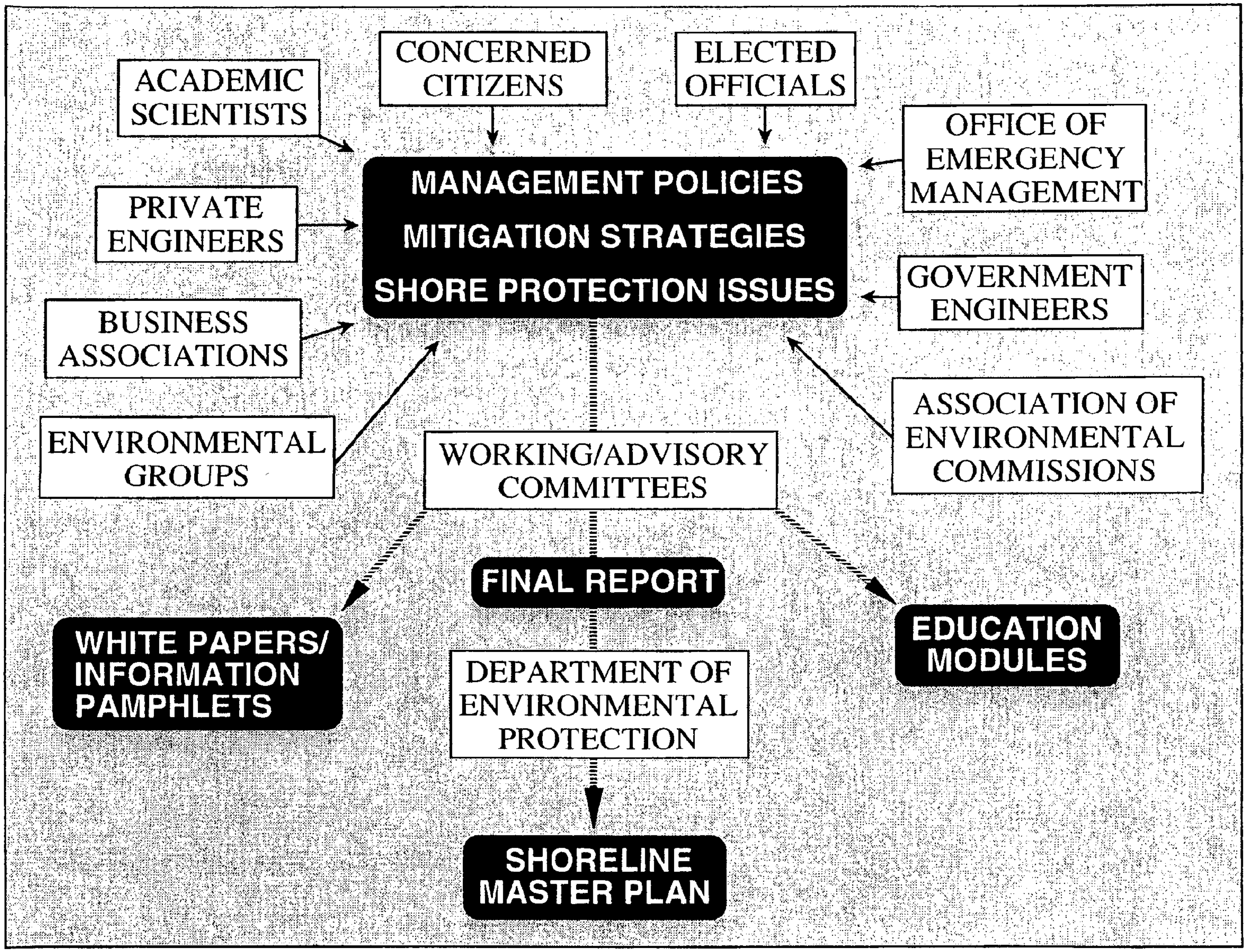

Figure A. Chart of process and information flow

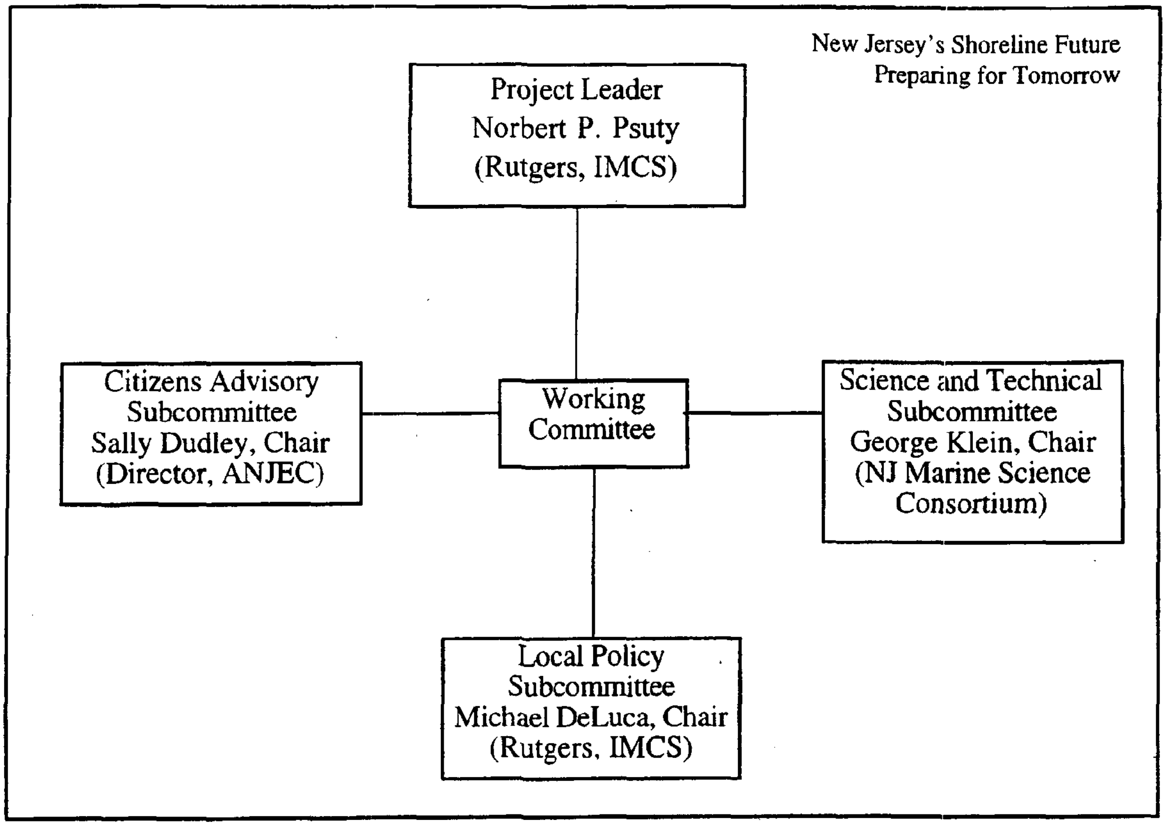

Figure B. Diagram of three subcommittees established for the project.

Figure C. Chart of Committee members

NEW JERSEY'S SHORELINE FUTURE: PREPARING FOR TOMORROW

Project Leader
Dr. Norbert P. Psuty

Advisory Committee

Science and Technical Sub Committee

George Klein, Chair
(NJ Marine Sci. Consortium)
Derry Bennett
(American Littoral Society)
Michael Bruno
(Stevens Institute of Tech.)
Stephen Kempf
(Vice President, Killam Assoc.)
Mark Mauriello
(NJDEP)
Bernard Moore
(NJDEP, Div. of Coastal Eng.)

Local Policy Sub Committee

Michael De Luca, Chair
(Rutgers, IMCS)
Thomas Gagliano
(Pres., Jersey Shore Part.)
Phillip Guenther
(Mayor, Brigantine)
Gary Jessel
(Cape May Cty. Freeholder)
David Kinsey
(Kinsey & Hand)
Joseph Kyrillos
(NJ Legislature)
Anthony Mangeri
(NJ OEM)
Kenneth Pringle
(Mayor, Belmar)
Robert A. Roman
(Mayor, Mantoloking Bor.)
P. Victor Sencindiver
(Mayor, Beach haven Bor.)
And other elected officials

Citizens Advisory Sub Committee

Sally Dudley, Chair
(Director, ANJEC)
Caron Chess
(Rutgers, CEC)
Community Leaders
Interested Public
County Working Groups
Education and Outreach
Working Group

Working Committee
(Rutgers University)

Tali P. Aldouby
Daniel Collins
Michael P. DeLuca
Michele Grace
Elizabeth Hanratty
Wendy Keppe
Gregory Martinelli
Janice McDonnell
Douglas Ofiara
Michael Padula
Susane Pata
Marianne Shaffer
Kimberly Sheehan
Michael Siegel
Erica Spence

Initially, key stakeholders were targeted for one-on-one discussions with project personnel to discuss the project goals and tasks, local concerns, and to solicit support to disseminate information on the project to their respective constituents, peers, or group members. Stakeholders included local elected officials (such as mayors and freeholders), county engineers, state and federal officials, public interest groups, and marine trades groups. These local meetings were followed by more formal presentations at "town meetings"in each of the four coastal counties. Town meetings were designed to initiate the outreach process which was designed to heighten public awareness of the project and coastal hazard issues.

Following the one-on-one and town committee meetings, the Working Committee held a series of public meetings to discuss the reassessment project and organization of citizen advisory committees. These meetings included presentations by disciplinary experts, fostered dialogue between the project team and the general public, and led to the creation of the Citizen Advisory Committees. Several documents were created for these meetings and included a list of charges to Citizens Advisory Committees, and a list of specific tasks for the Citizens Advisory Committees which are in Appendix C. A traveling exhibit also was constructed for display at the project meetings as well as for use at organized events throughout the duration of the project. Members of the project team capitalized on events such as seafood festivals and other shore-related activities to discuss the project with event patrons as well as to hand out project literature.

Questionnaires were distributed to help gather public concerns and flyers were distributed among each of the coastal communities to network about the Project. Copies of these handouts are located in Appendix D. Committees and interested citizens were updated with the Project's progress through mini Progress Reports which are located in Appendix E.

To assist with dissemination of information about the project and mechanisms for participation, members of the Rutgers Cooperative Extension Service were briefed and asked to inform their constituencies. These individuals also helped to publicize and arrange public meetings, and distributed written material such as fact sheets.

A kickoff meeting was then held to organize the citizen advisory committees. At this meeting, advisory committees were organized for each of the coastal counties (Atlantic and Cape May County committees were merged). This structure reflected the different priorities held by the public across diverse regions of the New Jersey coastline. Consensus was reached on the charge for the advisory committees and the process to be used to meet their objectives. Specifically, their charge was to:

o Identify local concerns (by community) related to coastal hazard management to drive preparation of "white papers."
o Prepare a history of shore protection for each community including any information on the date and extent of past beach nourishment projects, construction of engineered structures, etc.
o Collect copies of all local ordinances related to coastal hazard management, especially those that address dune management.
o Become knowledgeable about the project and prepare to disseminate information on shore protection and shoreline management to local municipalities including seminars, distribution of handouts, exhibits, school projects, etc.
o Establish a timetable for advisory committee meetings to complete the tasks identified above.

Chairs were elected for each coastal committee, priorities were initially discussed, and plans were made to arrange a timetable and agree on a format for addressing these priorities. Project staff were then assigned as a liaison to each of these committees and provided a direct link to any resources required by them. Several Citizens Advisory Committee meetings were held thereafter where interested citizens gathered with Committee Chairs and Project Team members to raise and discuss issues of concern (Figure D).

One of the most effective means to solicit input on local concerns resulted from the conduct of beach walks with local elected officials (especially mayors), emergency services personnel, and citizens (Figure E). These walks were held up and down the coastline and provided the project team with examples of coastal mitigation measures that performed well and those that presented problems for local decision makers (Figure F). In some cases, the project team was able to deliver on-site advice and guidance to address some of the problem areas. However, the intent of the walks was to ensure that local problems would be addressed by the project, and to select suitable areas for case studies or scenarios to help guide coastal communities in their selection of mitigation strategies to meet specific needs.

Other means of communicating about the Project included television news interviews. Television stations spoke with Project Team members regarding the most pertinent coastal issues of the time and gave the Project Team opportunities to discuss the Reassessment Project (Figure G).

In association with the education and outreach effort, several exhibits were created to enhance public awareness of the project, coastal hazard issues, and what citizens could do to become involved in the process. These exhibits were displayed in a variety of formal and informal venues ranging from legislative events at the statehouse to regularly-scheduled meetings of public interest groups.

EDUCATION, OUTREACH AND INTERPRETIVE PROGRAMS FOR THE PRECOLLEGE COMMUNITY

In the 1981 Shore Protection Master Plan, one of the report recommendations identified public education and training as a means to raise awareness of shoreline management programs and policies. In addition, it was stated that support for these programs should be provided by the state and used to support public participation workshops, meetings, and hearings. Although these activities are necessary for informing the general public, they typically do not reach the precollege or K-12 community. Because this community possesses the next generation of decision-makers, our youth, and the process of change as it relates to public policy and behavior is long-term, the value of targeting this community should be recognized.

A broad range of educational initiatives have commenced recently to capitalize on the precollege community as a vehicle for developing an informed public. Through the existing precollege school system, information on public policy issues can be incorporated into existing curricula, and designed to enrich teaching of basic skills, problem solving, and the development of critical thinking skills. Obviously, this approach can reach the many students that comprise our next generation of decision-makers and educators, but it also can be designed to reach the parents of these students or the present community of decision-makers. Through Project Tomorrow, an existing collection of science-based learning programs aimed at the precollege community which is based at the Institute of Marine and Coastal Sciences, these approaches were used to foster education and outreach activities on the topic of coastal hazard mitigation. At the core of this effort were activities that recognized the long-term nature of increasing public awareness to reduce the loss of life, injuries, economic losses, and the disruption of families and communities caused by natural hazards.

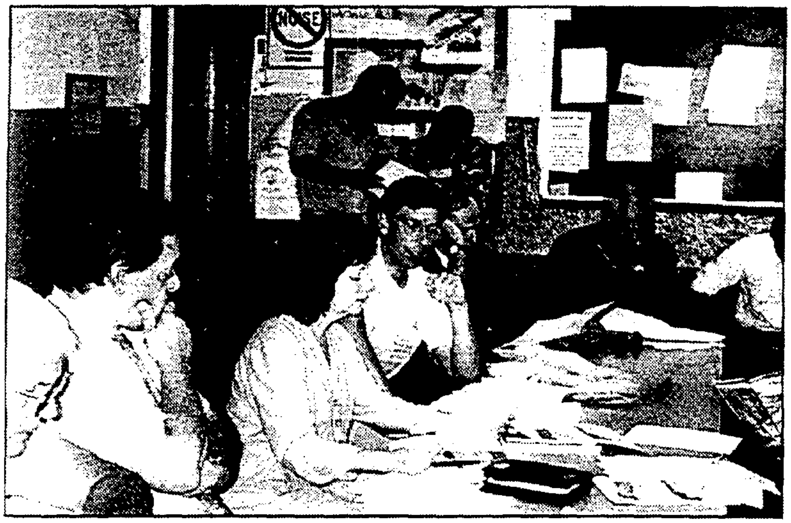

Figure D.
Monmouth County Chair, David Grant and Citizen Advisory Committee members examine some Sandy Hook shoreline documents.

Figure E.
Dr. Norbert Psuty (center) discusses Sea Isle City's coastal issues with Katy Giebel (left) and Teresa Barry (right), and Susane Pata notes the concerns (far right).

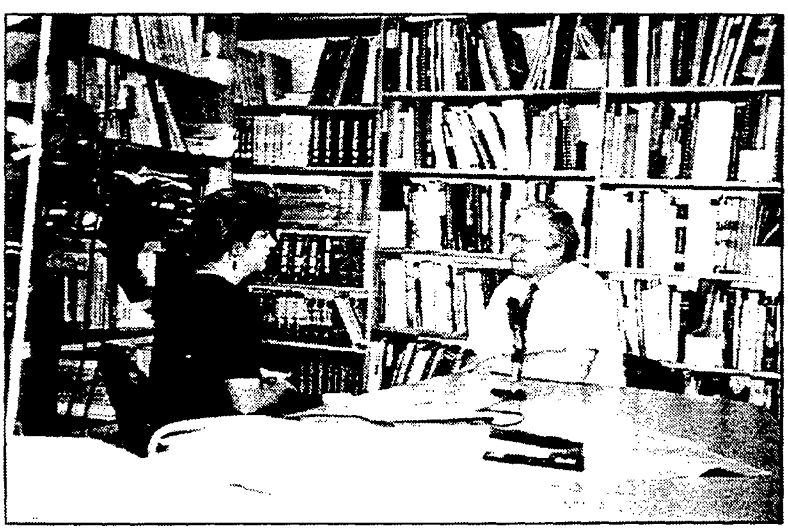

Figure G.
Dr. Norbert Psuty is interviewed by New Jersey News regarding the Project and other shoreline issues.

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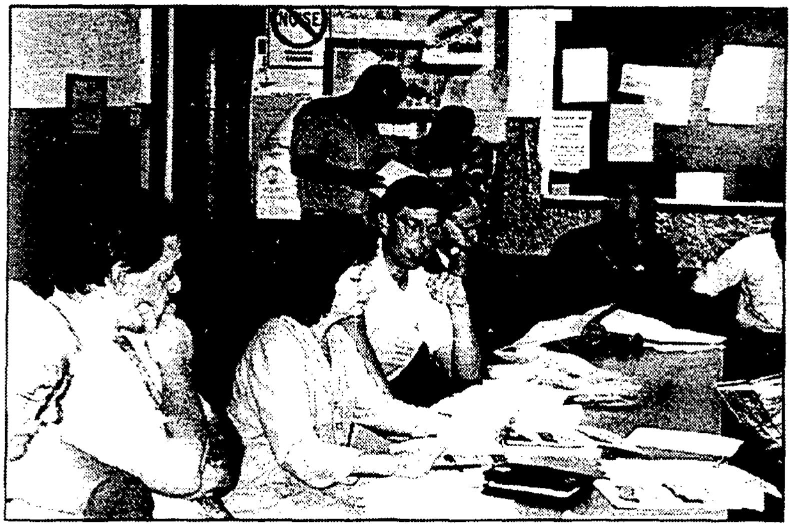

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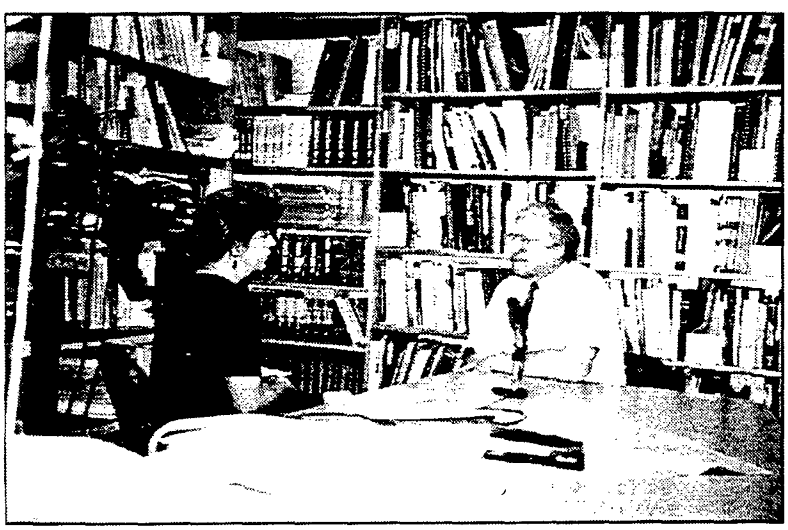

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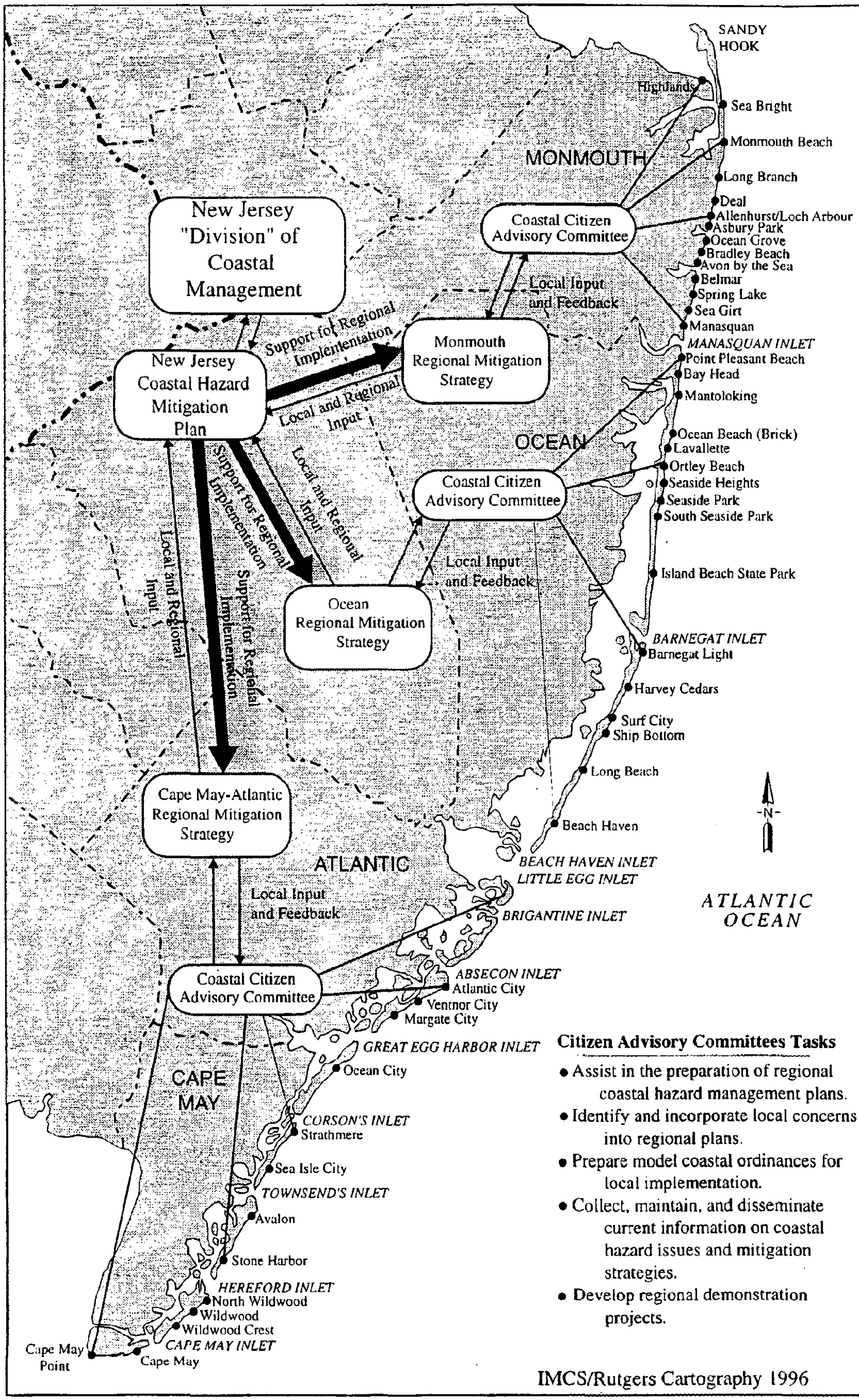

Figure H. Chart of integration of Committees and NJDEP

THE EDUCATION AND OUTREACH PROCESS

Education and outreach programs employed a broad range of methods to elevate public awareness of the policy issues associated with coastal hazard mitigation. Among these were establishment of the Citizen Advisory Committees, creation of public exhibits, conduct of beach walks, and the preparation of fact sheets and background material. Since these activities dovetail with the public participation process presented above, the scope of this section will be limited to a discussion of those education and outreach activities that focused on the precollege community.

In a joint effort with Project Tomorrow staff, the project team developed educational activities for application in formal settings (i.e., public and private schools) and informal settings (i.e., nature centers, aquariums, and museums). These efforts focused on development of educational materials through the enrichment of existing curricula, conduct of teacher workshops, and establishment of library information systems and a home page on the Internet.

ENRICHMENT OF CURRICULA

Efforts to enrich curricula were based on the guiding principle of the Project Tomorrow program; a hands-on and minds-on approach that links real-time research to classroom science education is paramount to the development of problem solving and critical thinking skills among our students. Development of these skills, along with support of basic skills training by capitalizing on the natural public fascination with the ocean, is essential to prepare the next generation of informed decision-makers and to raise environmental awareness generally among the public.

The project team organized a group of twenty precollege educators to assist with development of classroom and field activities that focus on issues associated with coastal hazard mitigation. Two supplementary curricula served as the basis for this effort--*Marine Activities Resources and Education (MARE)* developed by the Lawrence Hall of Science at the University of California at Berkeley and *Event Based Science* produced at the University of Maryland. Each of these curricula was used as a model to design and test a 14-lesson classroom and field activity guide for precollegiate application. Activities were organized under four major themes including coastal geology, coastal biology, sustainable development (environmental planning and management), and global influences (e.g., sea-level rise and storm frequencies). The first draft of this guide has been produced and will undergo pilot testing in several schools during the 1996-97 academic year. Once the field assessment is complete, the final guide will be incorporated as a component of the *MARE* curriculum for New Jersey. Teacher Enrichment workshops also will be held once the pilot testing has been completed. In addition, the project team developed an Internet activity that employs real data to demonstrate issues associated with sea level rise in an interactive manner as part of this exercise.

TEACHER WORKSHOPS

Two enrichment workshops were organized and conducted for precollegiate educators on the topic of sea-level rise and its effects on the coastal zone. One workshop was targeted for formal educators and the other for informal educators. These workshops produced supplementary curricula materials to illustrate the importance of a healthy coastal ecosystem that enables development to occur in a manner compatible with environmental concerns. The curricular material addressed the 1996 science core standards for New Jersey students with a focus on development of critical thinking and problem solving skills.

In addition, the project team presented information on sea-level rise and shore protection strategies to precollege educators participating in the 1996 Earth Science Teachers Conference. This meeting provided an ideal opportunity to demonstrate and disseminate classroom-based activities for incorporation into existing curricula. More informal workshops also were held to continue the process of incorporating coastal hazard information into the school system. These included the Teach at the Beach Conference, Global Change and Sustainable Development Teacher Workshop, and the annual meeting of the N.J. Marine Educators Association.

LIBRARY INFORMATION SYSTEMS AND AN INTERNET HOME PAGE

During the conduct of the overall study, the project team collected a wealth of reports, articles and other literature ranging from technical reports on beach erosion to digital data of coastal structures in New Jersey. This led to the creation of a comprehensive bibliography and an effort to incorporate this information into a library information system for broad dissemination and easy access. A copy of the bibliography is located in Appendix F.

The project team also constructed a home page for the project on the Internet. This developed into an effective means for sharing information and updates on the project, and enabled the project team to maintain a dialogue with the general public on coastal hazard issues. Requests for project information also were received and handled electronically. The home page can be reached at http:// marine.rutgers.edu. A copy of the home page flyer indicating the email and homepage address, and a copy of the home page are in Appendix G.

In association with the education and outreach effort, several exhibits were created to enhance public awareness of the project, coastal hazard issues, and what citizens could do to become involved in the process. These exhibits were displayed in a variety of formal and informal venues ranging from legislative events at the statehouse to regularly-scheduled meetings of public interest groups.

RESULTS OF PUBLIC INTERACTIONS

From the participation process and the education/outreach effort, the project team was able to develop priorities that were responsive to the public, focus discussions on specific problem areas such as the demand for more recent information on dune management practices, and to factor public concern into the products resulting from the study. A summary report on the public meetings and interactions associated with the project and a summary report of the General Meeting held on January 18, 1995 which served as a follow-up to the July 12, 1994 Workshop, may be found at Appendix H. A list of the white paper topics resulting from these interactions is provided in Table II.

Many of the discussions fostered by this study centered on the need for new approaches to mitigate the risk associated with maintaining the current infrastructure along the New Jersey coast in the face of rising sea level, erosion and frequent storms. Clearly, the prescriptive approach of the past does not promote the dialogue necessary to develop mitigation strategies that respond to local concerns--consultation on a draft plan, as was done with the 1981 plan, is not the same as direct involvement in the preparation and ownership of the final product. Since the ultimate solution to enhance protection of life and property along the coast relies on local action by the citizens most directly affected by these concerns, development of a new coastal hazard mitigation policy must involve these stakeholders in the preparation of the plan and its implementation.

CONTINUED PUBIC INVOLVEMENT

Table II. List of White Paper Topics

Coastal Processes
- Erosion and accretion
- * Dune management
- Sand transport

***Beach Structures and Engineering**
- Hard and soft protection measures
- Artificial reefs
- New technology

***Socioeconomics**
- Costs and benefits
- Beach use
- Tourism

***Sea Level Rise**
- Rate of increase
- Relationship of storm magnitude

***Storm Frequencies**

Education and Outreach
- Formal and informal education
- Public awareness
- Informed decision-making

***Coastal State Comparisons**
- Federal coastal zone program
- New Jersey coastal program
- Coastal approaches used by other states
- Regional strategies

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* Denotes that these topics were addressed in stand-alone documents as well al in the final report.

An essential element of this stakeholder-driven process is to continue to engage coastal residents and decision makers in the collection and dissemination of information on coastal hazard issues. Such a process should be designed to give the public greater access to information and involvement in the decision making process. This can lead to a more informed public where decision making is grounded in reality, and coastal management policies are more likely to be accepted and implemented.

Recognizing that change in the manner that coastal communities approach shoreline management relies on an informed public, one of the most significant recommendations resulting from this study is to continue the work of the Citizen Advisory Committees. These groups played an important role in shaping this project and should be utilized to facilitate implementation of a revised coastal hazard management plan, which is expected to be produced in part from the results of this study in the near future. One can draw upon the experience of other coastal states and nations to determine the appropriate structure and scope of activities for such committees. One such example exists in the United Kingdom.

Regional coastal groups have been used in England and Wales to prepare regional shoreline management plans (Oakes, 1994). Although these are voluntary groups, they are empowered by the government to improve management of coastal hazards. This includes:

- o furthering cooperation between agencies with responsibility for coastal management,
- o sharing data and experience,
- o identification of best practices,
- o identification of research needs,
- o promotion of strategic planning for coastal hazard management,
- o identification of impediments to implementation of alternatives, and to
- o maintain awareness of policy developments, results of research and initiatives.

The groups meet quarterly and consist primarily of representatives from relevant government agencies, technical experts, and citizens. Periodically, the group chairs meet to discuss common concerns and to develop a national approach to coastal hazard management.

Although this approach has been used in England and Wales to foster national mitigation strategies, organization of the effort is divided into "littoral cells" or reaches that recognize the importance of compatibility among mitigation measures deployed within a reach. Coastal processes do not respect political boundaries and therefore regional approaches which address the broad scale at which physical forces operate along the coast are warranted. This situation demands greater coordination among coastal municipalities, especially to develop and implement reach-wide mitigation programs. The county-level nature of the citizen advisory committees established in New Jersey is well-suited to address coastal hazard issues at such a regional scale or on a reach by reach basis.

The NJDEP should establish the Citizen Advisory Committees as a formal mechanism to assist with development and implementation of a new coastal management strategy that is designed to mitigate the risk associated with coastal hazards as discussed in the Recommendation Section. Each committee should consist of representatives of relevant government agencies (U.S. Army Corps of Engineers, Federal Emergency Management Agency, U.S. Geological Survey, NJDEP, NJ Office of Emergency Management and Preparedness), technical experts from academe and the private sector, local elected officials and emergency management personnel, and representatives drawn from coastal municipalities and interest groups. These committees would interact directly with DEP on coastal management issues (Figure H).

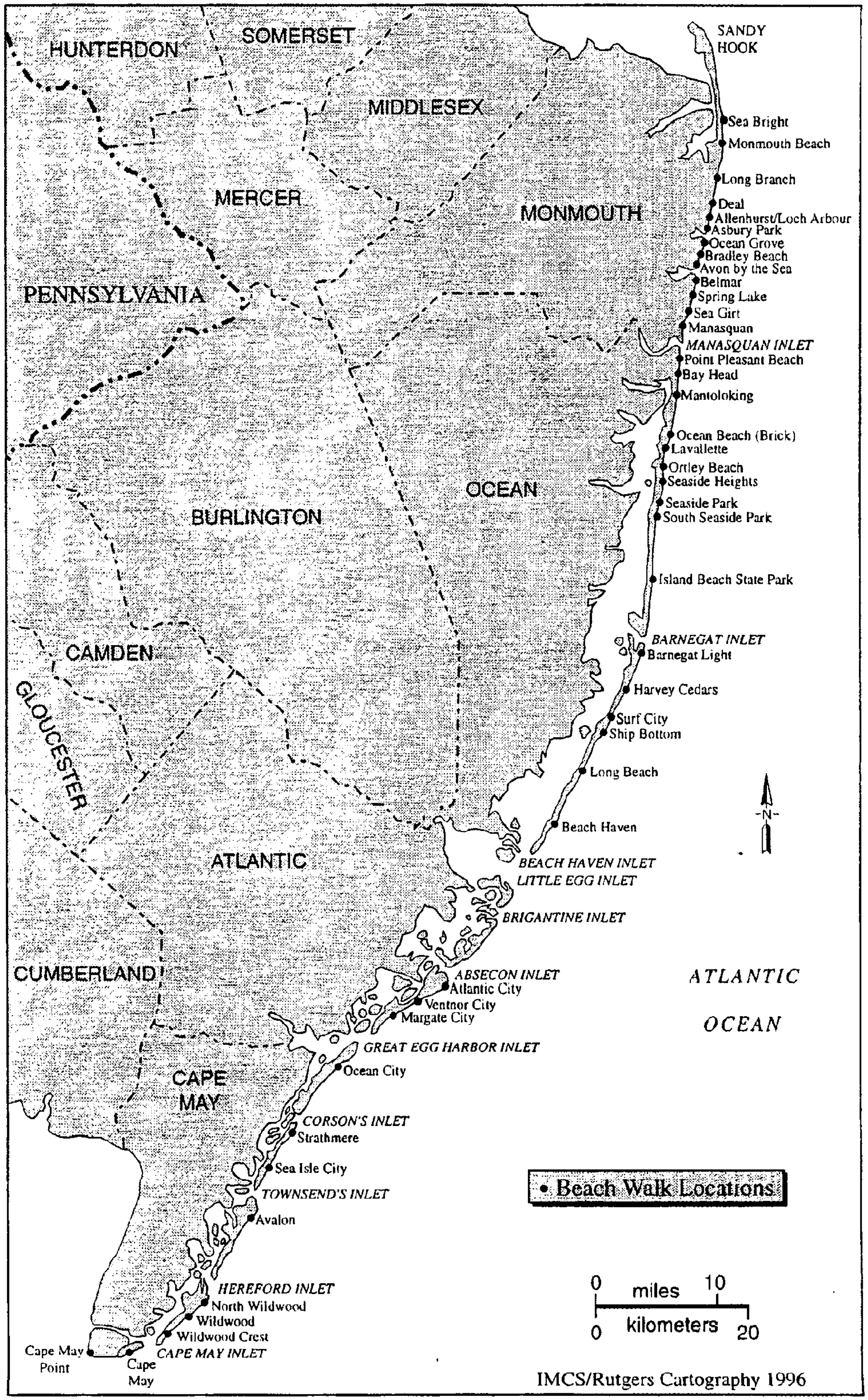

Figure F. Map of coastal communities

The primary goal of these committees will be to assist the state with development and implementation of a long-term, coastal hazard mitigation program. Specific duties are to:

o Assist in the preparation of regional coastal hazard management plans,
o Identify and incorporate local concerns into the regional plans,
o Prepare model coastal ordinances for local implementation,
o Collect, maintain, and disseminate current information on coastal hazard issues and mitigation strategies, and
o Develop regional demonstration projects.

These responsibilities must be supported with state funding to enable the committees to hire technical experts when necessary, establish regional information repositories at county libraries, conduct public outreach efforts, and to establish volunteer mitigation and monitoring efforts. An example of the latter is the organization of community groups and schools to conduct remedial action on dunes damaged by storms or erosion and to monitor recovery of these efforts. In addition, these groups could be mobilized and equipped to collect beach and sediment information which can be used by the advisory committees to track coastal change over time, much similar to the water quality monitoring efforts underway in Barnegat Bay and other water systems throughout the state. This information could then be factored into the decision making process.

With the construction of the program bibliography, home page, and background information generated by the study, electronic means are available to store, manage, and make available a great deal of information on coastal hazards. This system should be maintained and continuously updated as a support service for the advisory committees. The system also could be linked with the county-based repositories and used to help coordinate activities between the regions or advisory committees. Further, and as with the regional coastal groups employed in England, representatives from each of the three advisory committees should meet periodically to foster interactions and transfer information among the county-based committees. These committees also should be used by the state to solicit public input on many coastal issues, not just those related to coastal hazard management.

CONTINUED EDUCATION AND OUTREACH

The nucleus of FEMA's national mitigation strategy focuses on how public education and training can affect changes in the way coastal communities manage their shorelines. Successful change is grounded in education. Change can be effected through the two principal target audiences--the formal precollegiate and the informal education communities.

Many coastal education efforts and programs exist to reach the formal and informal education communities. Obviously, partnerships with existing programs can be used to make efficient use of resources and to capitalize on the participants already engaged with these groups. For example, the current effort to designate a national estuarine research reserve in New Jersey provides an excellent example where a productive partnership can be developed to raise awareness of coastal issues. In this program, federal, state, and academic institutions have united to design and conduct educational programs where students and the general public receive information and training on topics ranging from shore protection to coastal monitoring and stewardship. Partnerships should be used wherever possible to leverage the necessary talent and make use of existing networks to disseminate information.

Formal Precollegiate Education

Efforts are underway to expand the MARE initiative throughout New Jersey by Project Tomorrow staff. This, and other science-based supplementary curricula, can be used as an effective means to transfer information to the precollege community on issues associated with coastal hazards. The hands-on activities, Internet activities, and field guide based produced by the project team and soon to be tested in New Jersey schools, will be incorporated into the N.J. MARE program. Once the evaluation is completed and any necessary modifications made, the supplementary materials will be made available generally to N.J. educators through the Marine/Environmental Science Curriculum Repository located at the Institute of Marine and Coastal Sciences.

Informal Education

Interpretive Media, Placards, and Signs

Interpretive displays and public placards are recommended as a general means for creating a better understanding of coastal processes and human vulnerability to storms and the longer term implications of sea-level rise. Actions to consider include a pole depicting the high water marks and storm surges from past New Jersey storms to a display illustrating the projected cumulative increase in water level due to sea-level rise over the next 100 years. Interpretive displays such as these could be located in popular shoreline locations such as boardwalks, nature centers, public meeting places, and the Coastal Heritage Trail that winds through Cape May, Atlantic, Ocean, and Monmouth Counties.

Short Videos

Brief educational videos have provided an effective medium for interpreting scientific information and represent an excellent tool for doing the same with the CHMP. Other states have had great success with this approach. This includes the Louisiana Department of Natural Resources which developed a short video called *Reversing the Tide* that highlights the importance of wetland restoration and the dynamic nature of the coastal zone. This video has been played on public television and is available to all elementary, middle, and high schools at no charge.

Public Service Announcements

The nation's Coastal Zone Management Program sponsors annual public events such as Coast Week and Estuaries Day. These activities feature canoe trips, interpretive marsh walks, beach clean ups and bird watches, all designed to heighten public awareness of estuaries and the importance of their preservation. As part of these programs radio and TV air 1-2 minute public service announcements to increase public awareness of these events and their importance. Information on the CHMP could be piggy-backed with these events or developed as stand alone announcements to CHMP information during these recognized public events. This would increase public awareness and exposure to coastal hazard issues.

Print Media and Newsletters

The education program can benefit from the widespread distribution of local papers and popular press. Press releases to local papers, editorials, and short articles are an effective means of increasing exposure and awareness of coastal hazard issues. Submission of short articles and editorials in environmental and civic group newsletters are an effective way of keeping natural coastal hazards and mitigation measures in the minds of the readership.

Speakers Bureau

Throughout the development of the CHMP, a speakers bureau was used to conduct outreach activities with state and local government agencies, the precollege community, and the general public. This consisted of an informal group of disciplinary experts and project staff who responded to requests for detailed project information, or information on a specific coastal hazard issue. This was an effective means to raise public awareness and solicit local input on the project.

Use of Existing Education Programs

Formal precollegiate and informal education programs should be created in partnership with existing programs in the coastal zone in order to take advantage of existing resources and audiences. This approach will provide a focus so that groups and alliances already in existence can synthesize existing information and concentrate actions.

The National Estuarine Research Reserve System (NERRS) and the current effort to designate the Mullica River - Great Bay as a NERR site is a primary example of a potentially fruitful educational partnership. As part of the 1972 Coastal Zone Management Act, the NERRS program officially recognizes the resources of the coastal zone and their national significance and is working with federal and state authorities to establish, manage, and maintain reserves, and to provide for long -term stewardship. The Coastal Heritage Trail is an additional venue for the outreach and education program. The trail is visited by millions of New Jersey shoreline tourists and would serve as an excellent venue for informal education programs.

BACKGROUND BASICS, INFORMATION, AND UPDATES

UPDATES

The intervening years since the 1981 SPMP have been especially productive in the generation of information pertinent to the management of the New Jersey shore and basic processes pertaining to the shore, the human utilization and economic vitality, the effects of storms, the evolution of strategies to manage the shore , and the creation of new policies employing hazard mitigation. All of this new information has a bearing on the development of state policies toward shoreline management. It is improved knowledge that can better lead to the establishment of long-term goals in the utilization of the shore and short-term and long-term strategies to attain those goals.

As identified in the National Research Council publication on Beach Nourishment and Protection (Seymour, 1995), the most critical component of shoreline management is the availability of appropriate basic information on the processes and function of the coastal system. With knowledge, it is possible to make better decisions about the long-term objectives and the various paths to achieve steps toward these objectives.

Among the new informative data sets that are highly valuable to shoreline managers are the data about basic processes. A very fundamental data base is the Wave Information Studies (WIS) produced by the U.S. Army Corps of Engineers (Jensen, 1983). This program resulted in the development of wave data for the entire coast, in 10-12 mile stretches. Created from 20 years of weather data (1956-1975), a wave climatology has been developed from a predictive model that provides information about the magnitude and direction of waves at the New Jersey shore. These data complement the limited wave gauges gathering empirical data and create a generalized data set of waves conditions in these 10-12 mile units. Using these climatologies, the US Army Corps of Engineers has further generated wave-induced current flows that illustrate the variation of longshore current directions related to wave approach (USACOE, 1990). They describe the persistence of the northerly currents in the northern portion of the coast, the southerly flows in the southern half of the state, and the transition zone with similar magnitudes of flow in both directions located between the areas of more persistent flows.

Several types of studies have been completed by the U.S. Army Corps of Engineers that have collated a large range of data and provided descriptions of the segments of the coast. The Limited Reconnaissance Report (USACOE, 1990) provides an overview of the entire coast. Several other studies have been accomplished or are in progress for segments of the coast, including Manasquan Inlet to Barnegat Inlet (in Reconnaissance phase); Barnegat Inlet to Little Egg Inlet (Reconnaissance has been completed); Brigantine Inlet to Great Egg Harbor Inlet (in Feasibility phase); Great Egg Harbor Inlet to Townsends Inlet (in Reconnaissance phase); Townsends Inlet to Cape May Inlet (in Feasibility phase),; and Lower Cape May Meadows to Cape May Point (in Feasibility phase) (USACOE, 1996). All of those projects currently in their feasibility phase have produced a reconnaissance report. Further, a design program product has been completed for Cape May, Ocean City, and the northern section of the state from Manasquan Inlet to Sandy Hook.

FEMA has produced a number of reports and studies that have revamped the Flood Insurance Program, redefined exposure at the coast, and fostered a strong emphasis on coastal dunes. Mitigation has been elevated from a catchall approach to a national strategy to reduce loss from natural hazards (FEMA, 1995). Mitigation is now a proactive approach to moving away from hazardous areas supported by funds for pre-storm mitigation planning and post-storm mitigation of hazard. This ties together with the New Jersey State Hazard Mitigation Plan of 1994 (NJ Office of Emergency Management).

The state of New Jersey has generated significant data-producing projects that are contributing to the evaluation of risk and exposure in the coastal zone. On a historical level, there is the shoreline mapping project that has registered the shorelines of 1836-42, 1855, 1866-68, 1871-75, 1879-85, 1899, 1932-36, 1943, 1951-1953, 1971, 1977 and 1986 to the common base year of 1986. Thus it is possible to determine the past trend of shoreline migration form over a 150+year period. This is part of a NJ Department of Environmental Protection program to develop and produce a Geographic Information System for the collection, storage, retrieval, and analysis of spatial data. Also, since 1986, beach profiles have been surveyed annually at about one mile intervals. The survey line extends from the dune down to about -15 to -20 feet in water depth. The most recent product of this program is reported by Farrell, et al. (1995) The length of record is now approaching a point where the more general trends can be distinguished from the year to year perturbations. The NJ Geological Survey has produced a comprehensive report on the volumetric losses off sand as measured from these profiles and has identified opportunities to recover appropriate sand resources from the offshore (Uptegrove, et al., 1995).

A report to the Governor on the effects of sea-level rise has brought together information on the rates of rise in New Jersey that have been occurring this century and the longer term environmental effects that are being driven by sea-level rise (Psuty, 1991). This effort joins the US Environmental Protection Agency (Titus and Narayanan, 1995) interest in sea-level rise and the reports issued by the international Intergovernmental Panel on Climate Change (Warrick, 1993). Sea-level rise is a fundamental driving force creating a drowning of the coastal zone. Some of the coastal features are able to accommodate the rising water and adjust. However, much of the coast is 'stabilized' by development that it is unable to shift and adjust to the encroaching water. Further, a rising sea level is much more than inundation and drowning at the periphery. Higher water levels mean greater incidence and greater magnitude of flooding associated with storm conditions.

Shore erosion has received a lot of attention. The 1990s have been relatively stormy and there has been considerable loss of sand from the beaches and dunes. The State Legislature has responded in 1992 by approving an annual fund of $15,000,000 for shore protection efforts and it has reactivated its State Beach Erosion Commission. This Commission is largely responsible for the creation of a $15,000,000 'Blue Acres' program in 1995 that provides funds for the purchase of coastal properties at risk or are damaged by storms.

Whereas the growth in knowledge and information about the functions and characteristics of the coast is increasing, it is imperative that these facts be put to use in enhancing public protection and safety. It is necessary to decide on goals related to what do we want the shore to become over the next 30-50 years, or even to 100 years. And with these goals, we should create

State policy that provides clear direction regarding the expenditure of public funds. What is it that should be accomplished with the support of state funds? Given the improved knowledge of the trends of the changes in the shore and environs, to what end should efforts be directed to be most effective in accomplishing programs at the state, regional, and local levels. The establishment of realistic goals should lead to the creation of procedures and strategies to achieve these goals. Further, the integration of state programs and objectives within national programs and strategies toward common objectives could open avenues of financial support to assist in the achievement of the state's coastal plan.

THE CONDITIONS AT THE SHORE

The coastal zone may be thought of as waves, currents, and winds operating upon sediments to form features such as barrier islands, spits, inlets, and dunes; with people situated on this coastal landscape and accessing the coastal resources. The coast is an area of dynamic processes shaping and molding the landscape. It is constantly changing, and either accumulating or losing sand within the system and across the boundaries of the system. As we gather more information about the coast, we begin to understand the conditions that occur today and the conditions that have occurred in the past. The future, on the other hand, is not so clear. There are trends that can be interpreted from past conditions and there are forecasts of events that are derived from the historical record but continue to have a measure of uncertainty about them. We can list the storms of the current century and apply probabilities to their future occurrence and be reasonably certain that storms will occur and there will be some big storms in the future, but it is nearly impossible to predict the 'big storm'. Yet, we know it will happen. Also, we can determine that sea level has risen in the past century and we can apply a rate to it. However, nearly all scientists predict a higher rate of rise in the next century. There are many estimates about what that rate may be. There is agreement that the rate will be greater than the rate of the past century, but then the absolute numbers tend to diverge, from about 50% greater to several times greater.

THE DEVELOPMENT OF INFORMATION

WAVES

Although there are, and have been, several wave gages in operation in coastal New Jersey, the information is scattered both temporally and spatially. This is an area where more data are needed to determine the conditions that are created by storms of varying direction, duration, and intensity. Some information is available in the form of a 20-year record of hindcast wave data produced by the U.S. Army Corps of Engineers (Jensen, 1983). The National Ocean Data Center has a station at Ambrose Light (#ALSN6) that has been collecting non-directional wave data since December, 1989. Additional non-directional and directional wave data are available from a moored buoy (#F291), located about 40 miles off Long Branch, since April, 1991. A more time-limited wave data set has been collected at the Rutgers University Long-Term Environmental Observation Site (LEO-15), located about 3 miles (5 km) off of Little Egg Inlet. Directional waves measurements have been recorded sporadically at the LEO-15 site from October 1991 to February 1996, deploying one or two S4 current flow meters equipped with pressure transducers. The time periods of record vary from weeks to months.

The 1983 U. S. Army Corps of EngineersWIS data set (Jensen) was produced by simulating the weather systems of that 20-year period and allowing the wind to blow over the water to generate waves. These waves then move onshore with wave heights, wave lengths, wave periods, and wave direction determined by the physical relationship of winds moving across the water surface and transferring energy to the waves. This methodology of using wind information to back-calculate the dimensions of the waves associated with a storm or wind is known as wave hindcasting. This method produces what is referred to as the significant wave, it is the average dimension of the largest one-third of the generated waves at a site.

Waves that are created out at sea and then move out of the storm area to traverse the ocean conserve most of their energy as they pass through the water. They are referred to as deep water waves because their progress is not impeded by the ocean bottom. However, as they approach the continent, they begin to enter shallower water and the orbital motion of the water particles in the waves begin to interact with the bottom and cause most of the wave dimensions to change as the waves come onshore and the wave crests begin to bend or refract. The WIS data set recognizes the effects of the bottom and creates a wave climatology near the boundary between the deep and shallow water waves. This is in about 30 feet of water. Inland from this depth, the wave orientation to the shoreline is more greatly affected by the bottom topography. The WIS data, therefore, describe the waves as they occur in the offshore, before they are subjected to much refraction.

The WIS data are assigned to compartments along the shore which extend for about 10-12 miles **(Fig. 1)**. They are composed of wave heights and percentages of occurrence of these heights from the offshore directions. Individually, each 10-mile compartment documents the exposure of that section of the coast to wave buildup from the offshore directions. In the aggregate, the full assemblage of 10-mile sections portrays the role of Long Island and New England in shielding the northern coast from the direct impact of northeasterly storms. Because the large waves from northeasters must be refracted around New England before they arrive in New Jersey, the direction of the waves is out of the east or southeast. As a result, nearly all of the waves reaching the Monmouth County Atlantic coast arrive from the east or southeast and produce beach sediment transport to the north **(Fig. 2)**. In Ocean County, the protective effect of New England is reduced and more waves arrive from the northeast **(Fig. 3)**. Although the calculations show most of the waves are from the southeast, the larger waves are out of the east-northeast. The southerly drift direction becomes more pronounced toward the southern margin of the county. However, for the northern half of Ocean County, there is a considerable portion of the wave rose that is directly out of the east, indicating that nearshore longshore drift may be determined primarily by the local topography at the inshore position, or that the predominant exchange of sediment is onshore/offshore rather than alongshore. The protective effect is absent for Atlantic and Cape May counties and the presence of larger waves out of the east-northeast causes net sediment transport to the south **(Fig. 4)**.

Although the WIS data are excellent for generating the regional variations in wave climatiology and potential drift directions, they are not a detailed description of the actual wave

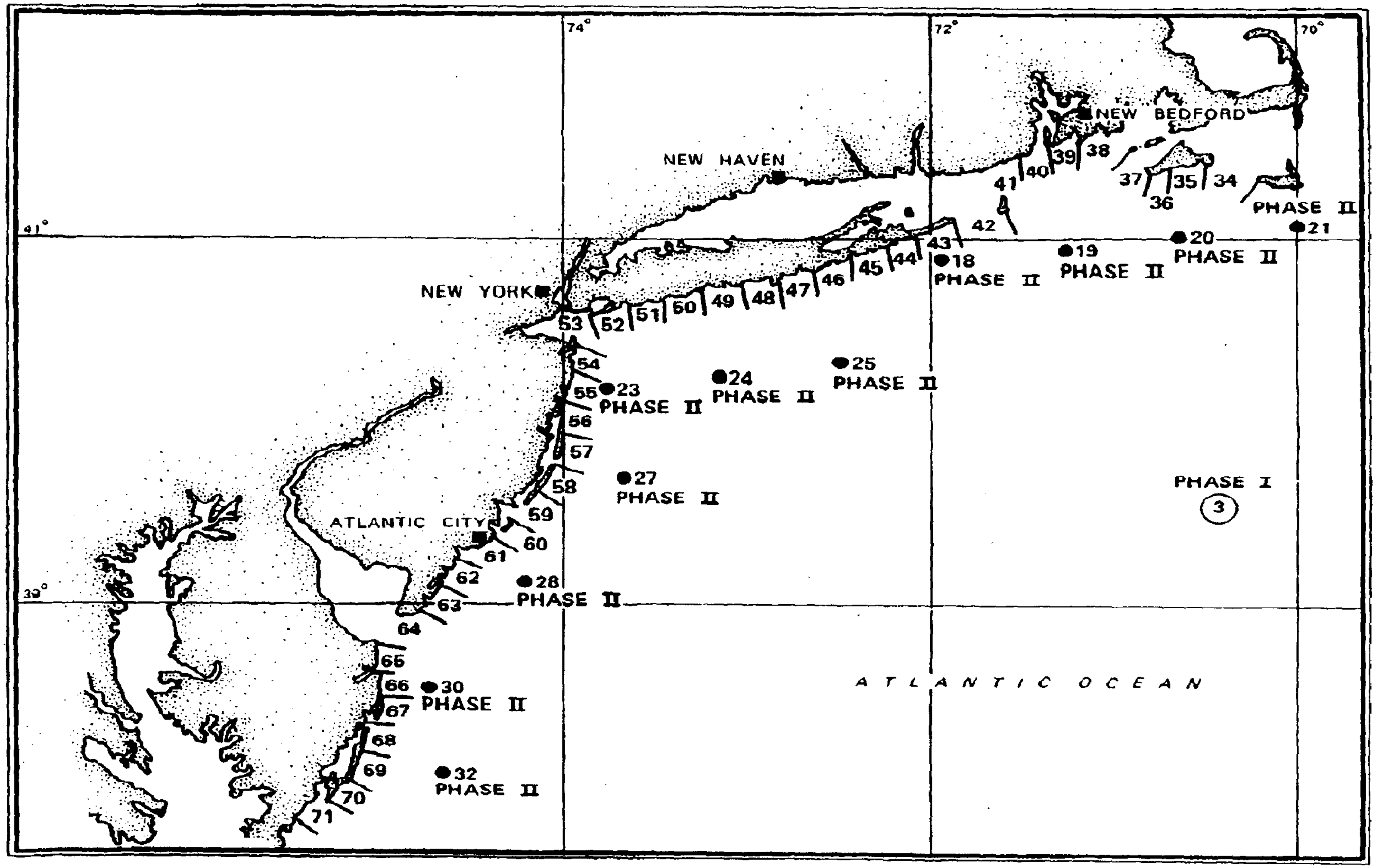

Figure 1. Distribution of Wave Information Stations 54 to 64 along coastal New Jersey. Phase I and II stations are deep water locations in the computer simulation program. The inshore locations are identified as Phase III stations. Source: Jensen, 1983

STATION 54 20 YEARS FOR ALL DIRECTIONS
SHORELINE ANGLE = 4.0 DEGREES AZIMUTH
WATER DEPTH = 10.00 METRES
PERCENT OCCURRENCE(X100) OF HEIGHT AND PERIOD FOR ALL DIRECTIONS

HEIGHT(METRES)	PERIOD(SECONDS)										TOTAL
	0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	
0. - 0.49	538	982	553	396	577	1301	744	143	85	134	5453
0.50 - 0.99	.	182	589	272	79	403	272	57	85	127	2066
1.00 - 1.49	.	.	26	178	88	124	92	18	19	37	582
1.50 - 1.99	.	.	.	6	54	85	39	7	3	15	209
2.00 - 2.49	.	.	.	.	7	53	27	2	.	4	93
2.50 - 2.99	.	.	.	.	.	7	15	2	.	1	25
3.00 - 3.49	.	.	.	.	.	.	.	1	.	.	1
3.50 - 3.99	.	.	.	.	.	.	.	1	.	.	1
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	538	1164	1168	852	805	1973	1189	231	192	318	

AVE HS(M) = 0.42 LARGEST HS(M) = 3.70 TOTAL CASES = 58440

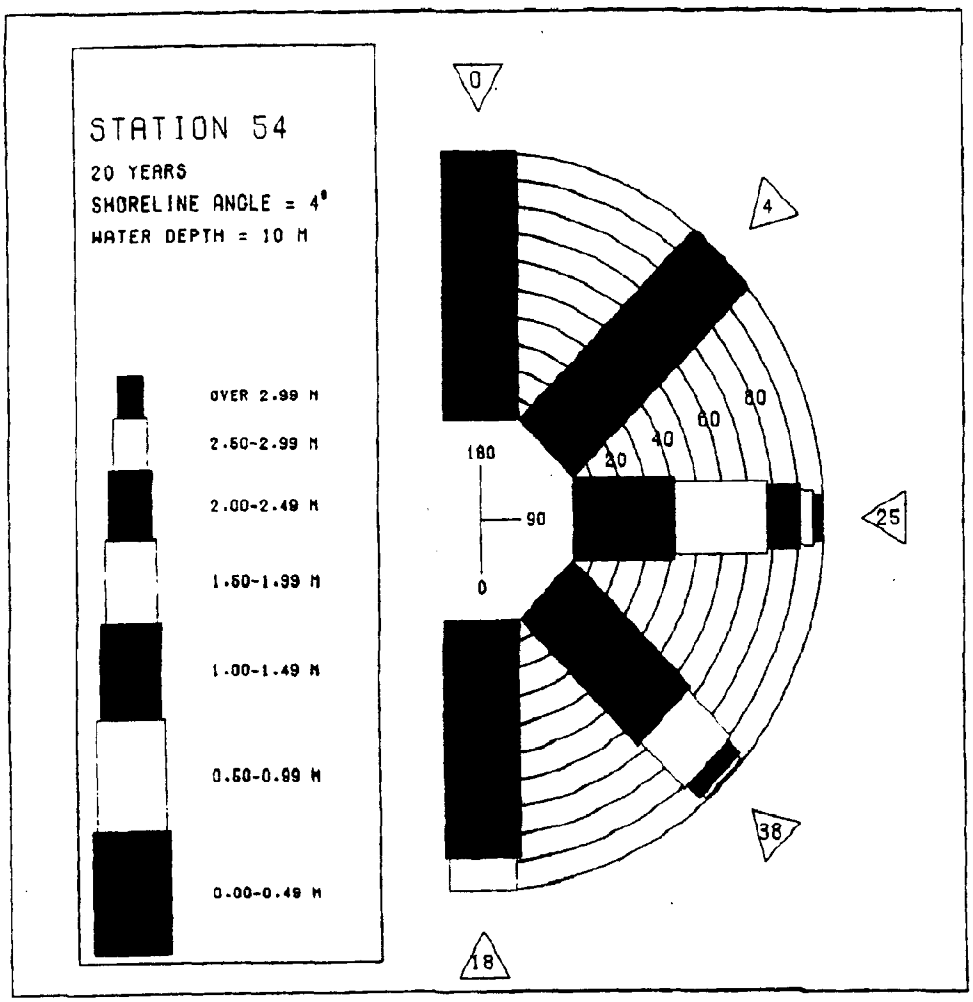

Figure 2. Wave rose for northern Monmouth County, Station 54. Largest and most frequent waves are out of the east and southeast, respectively. Source: Jensen, 1983

STATION 57 20 YEARS FOR ALL DIRECTIONS
SHORELINE ANGLE = 12.0 DEGREES AZIMUTH
WATER DEPTH = 10.00 METRES
PERCENT OCCURRENCE(X100) OF HEIGHT AND PERIOD FOR ALL DIRECTIONS

HEIGHT(METRES)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	TOTAL
0. - 0.49	438	938	572	421	581	1159	643	167	95	110	5124
0.50 - 0.99	.	255	732	281	128	450	405	155	61	102	2569
1.00 - 1.49	.	.	47	236	109	168	113	19	10	41	743
1.50 - 1.99	.	.	.	11	81	128	51	14	2	19	306
2.00 - 2.49	.	.	.	.	14	91	32	5	1	4	147
2.50 - 2.99	.	.	.	.	.	10	25	9	1	1	46
3.00 - 3.49	.	.	.	.	.	.	2	6	1	.	9
3.50 - 3.99	.	.	.	.	.	.	.	.	1	.	1
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	438	1193	1351	949	913	2006	1271	375	172	277	

AVE HS(M) = 0.51 LARGEST HS(M) = 3.97 TOTAL CASES = 58440

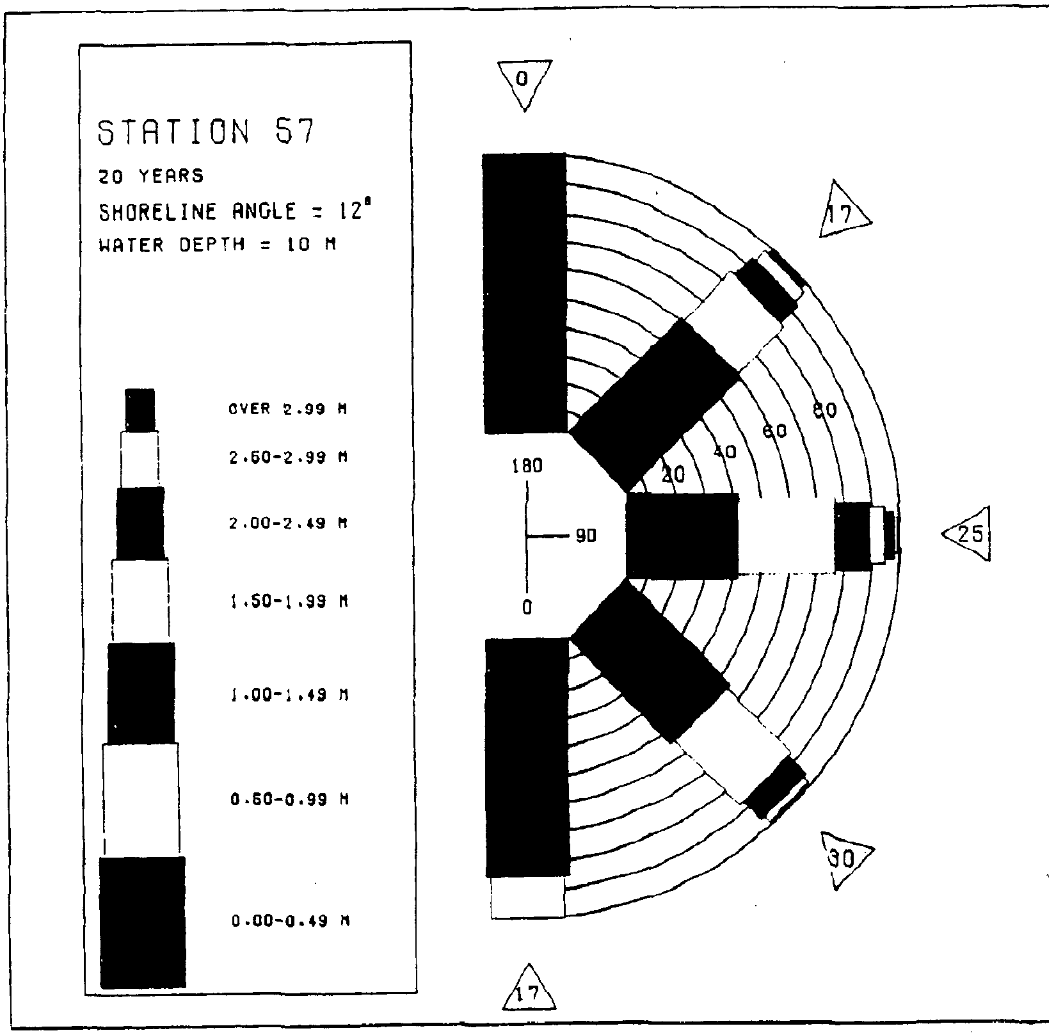

Figure 3. Wave rose for southern Ocean County, Station 57. Largest waves out of the east and northeast. Most frequent waves out of the southeast and east. Source: Jensen, 1983

STATION 61 20 YEARS FOR ALL DIRECTIONS
SHORELINE ANGLE = 54.0 DEGREES AZIMUTH
WATER DEPTH = 10.00 METRES
PERCENT OCCURRENCE(X100) OF HEIGHT AND PERIOD FOR ALL DIRECTIONS

HEIGHT(METRES)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	TOTAL
0. - 0.49	389	884	402	372	528	1094	443	71	98	197	4478
0.50 - 0.99	.	403	1084	394	107	617	446	63	113	227	3454
1.00 - 1.49	.	.	74	352	147	220	146	23	150	119	1231
1.50 - 1.99	.	.	.	15	91	155	71	12	19	22	385
2.00 - 2.49	.	.	.	.	17	81	44	10	5	6	163
2.50 - 2.99	.	.	.	.	.	8	19	11	3	4	45
3.00 - 3.49	.	.	.	.	.	.	1	3	3	1	8
3.50 - 3.99	.	.	.	.	.	.	.	.	1	.	1
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	389	1287	1560	1133	890	2175	1170	193	392	576	

AVE HS(M) = 0.65 LARGEST HS(M) = 4.13 TOTAL CASES = 58440

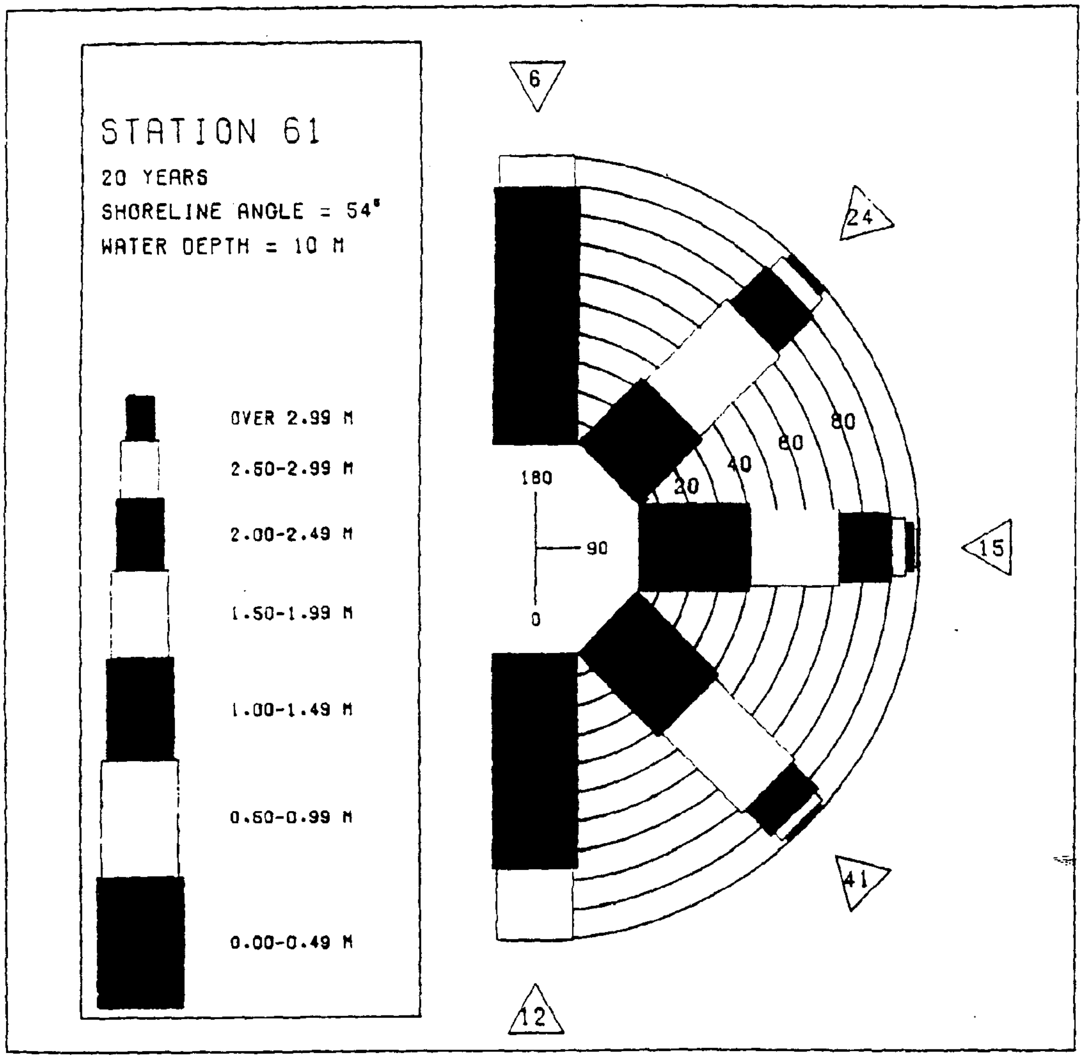

Figure 4. Wave rose for Atlantic County, Station 61. Larger waves out of the east-northeast, more frequent waves out of the south-southeast. Source: Jensen, 1983.

data. Further, the numbers present average conditions for long time periods and thus diminish the effects of storms. Wave dimensions are especially low for planning purposes.

TIDES/WATER LEVELS

The tides along the coast of New Jersey are semi-diurnal, two high tides and two low tides each day **(Fig. 5)**. Because the tides are based on the gravitational attraction of the sun and moon on the earth's oceans as they pass through their predictable orbits, it is possible to predict the water levels that will be caused by the interaction of the three planetary bodies. Tide tables are available for years in advance from the National Ocean Service of the National Oceanic and Atmospheric Administration.. Tide ranges at Sandy Hook average 4.66 ft, reaching over 7.0 ft during maximum spring tide and only about 3.0 ft during minimum neap tide. Atlantic City has an average tidal range of 4.1 ft, increasing to about 6.5 ft during spring tides. These are the predicted tides, or water levels produced as a result of the gravitational effects of the three planetary bodies.

The actual water level will vary from the predicted because of wind or storms which cause water to accumulate at a site or to remove water from an area. Recently, the National Ocean Service has begun to make available actual water levels recorded at their gauging stations. With these data, it is possible to determine the effects of the wind or storm on the predicted water levels and to determine the accompanying storms surges **(Fig. 6).**

BEACHES AND COASTS OF NEW JERSEY

Beaches differ from coasts primarily in terms of scale. The beach is the mass of sand that exists near the water line and it is in constant interaction with the waves, currents, and wind that move sediment around. The beach is often referred to as a sand-sharing system that extends from the coastal dune out to the offshore bar. That means that sand moves among the beach, dune, and offshore zones, usually building up one aspect at the expense of the other. Coasts may be thought of as broader views of the shoreline. The coast is the zone that extends along the shoreline, and also is thought to be farther inland as well as seaward. We often speak of the

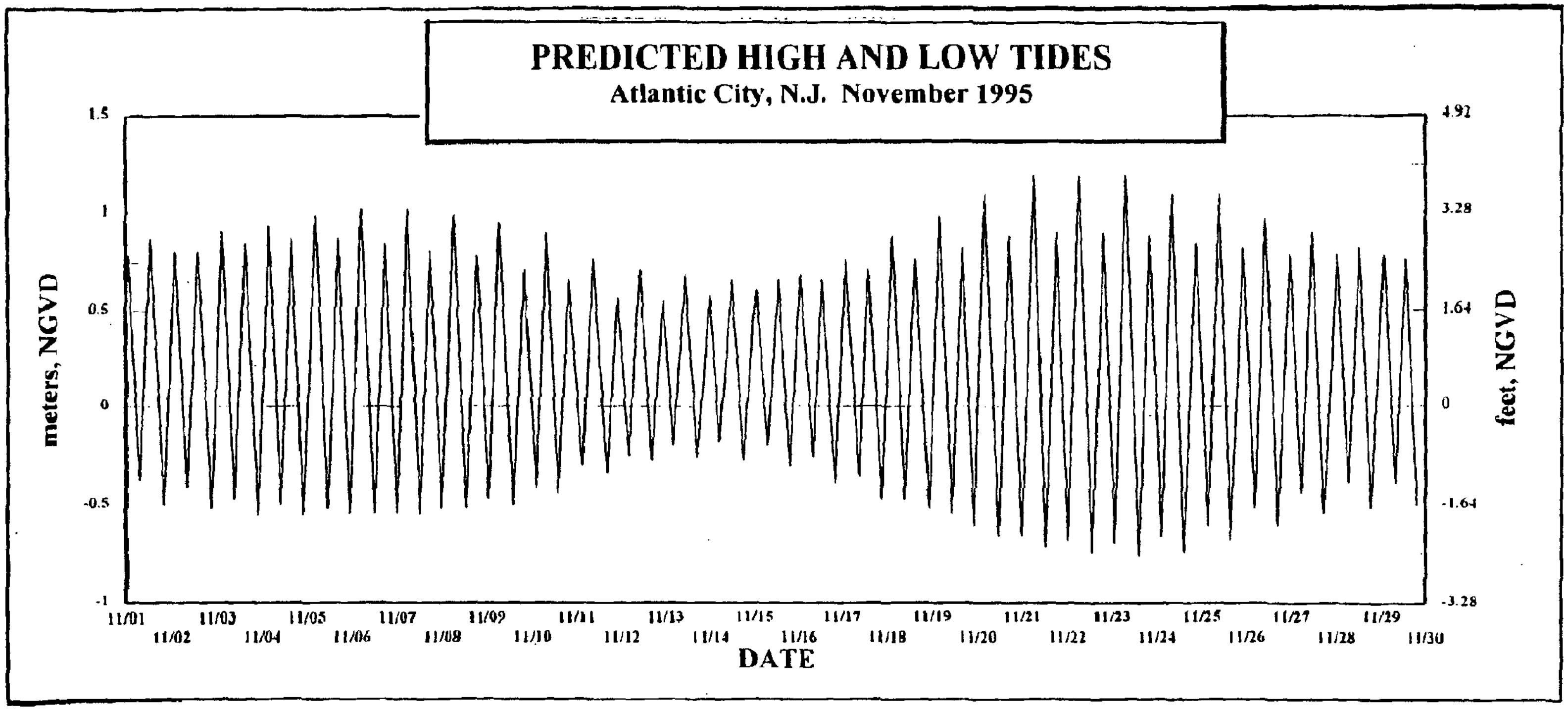

Figure 5. Predicted tidal variation of water levels at Sandy Hook, November, 1995. Source: National Ocean Service, 1995.

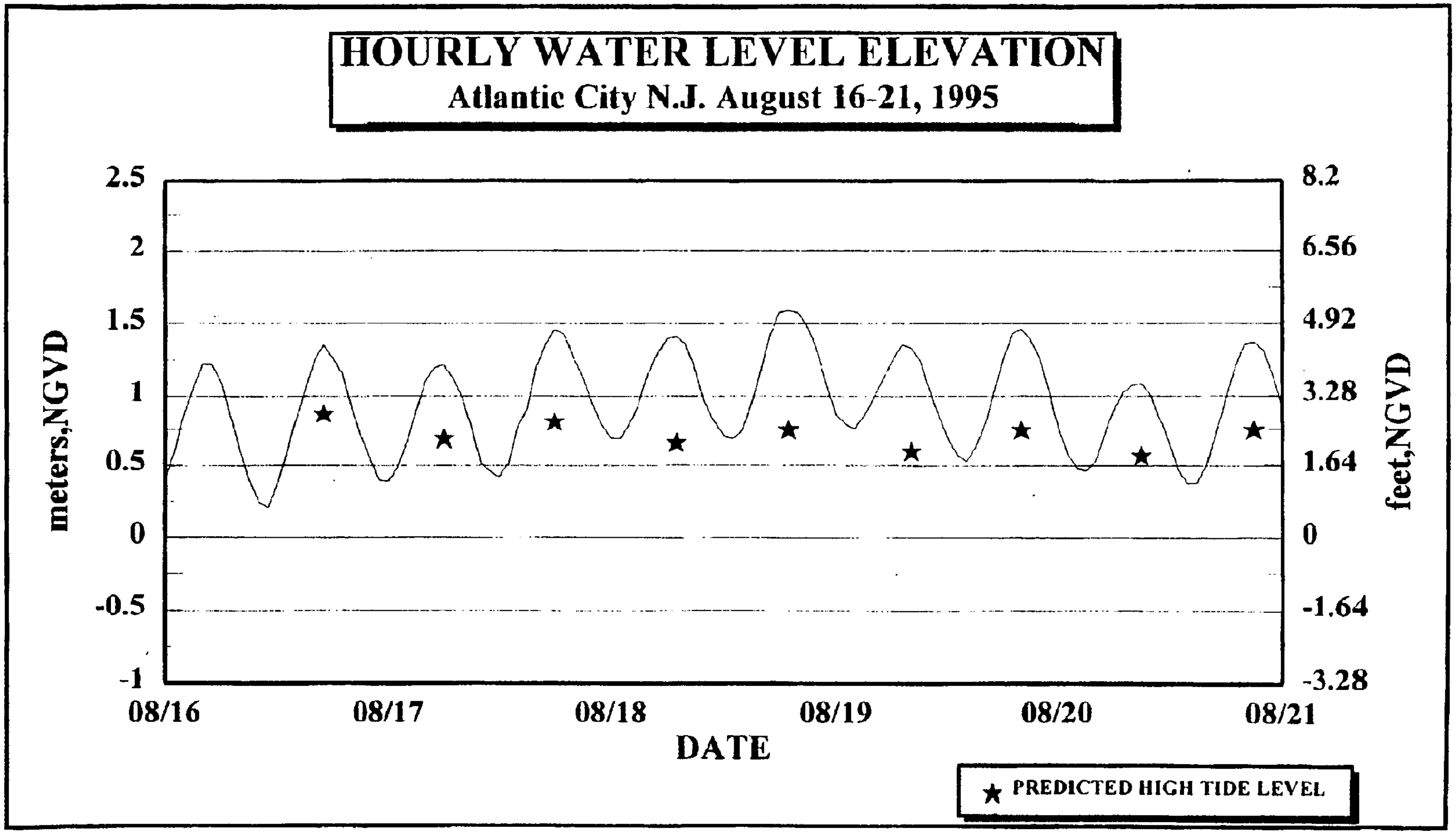

Figure 6. A comparison of the predicted water levels and the actual water levels reached during Hurricane Felix at Atlantic City, August 1995. Source: National Ocean Service: Website: www.olld.nos.noaa.gov

coastal counties of New Jersey, or the southern coast of the state. The coast includes the beach (beach, dune, and offshore bars) but it also includes the entire barrier island, the inlets, the wetlands, the bluffs, and anything else that is near the oceanic boundary of the state.

BEACH PROFILE

In areas of adequate sediment availability, the classical beach/dune profile can develop which is in harmony with the processes that mobilize sand and shift the sand from one portion of the profile to another (**Fig. 7**).

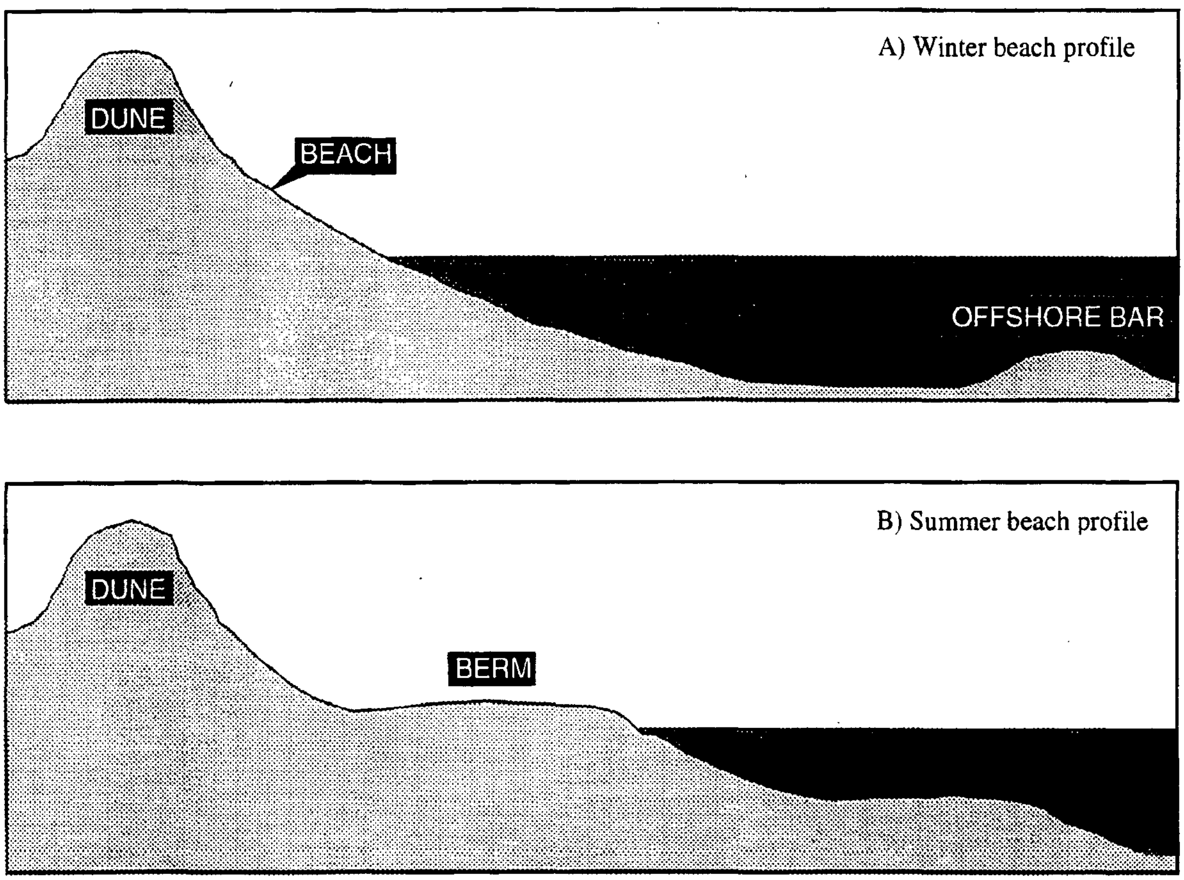

Figure 7. Sand sharing system of dune/beach/offshore bar. Panal A. Winter profile of narrow steep beach and well-developed offshore bar. Panal B. Summer profile of broad flat berm, flatter offshore.

The beach/dune profile is a sand-sharing system that extends from the position of the offshore bar through the beach and into the coastal foredune. Waves, currents, and wind interact with the components of the beach/dune profile to mobilize, transport, and deposit sediments. If more sediments are received by the profile than leave, the result is accumulation and buildout. However, if more material is removed from the total profile, the result is erosion. Because the profile is a product of the processes that are operating on it, the features and forms of the profile are usually retained as the profile either advances of retreats. The erosion or accretion is seen as a seaward or landward shift of the profile.

Waves begin to interact with the beach profile in the offshore zone because waves extend vertically through the water column and introduce motion where the water is in contact with the sediment. Generally, the initiation of sediment motion on the profile caused by surface waves is considered to be at a depth of 30-35 feet. Thus, inland from that depth, waves have a capacity to interact with the bottom and set sediment in motion. The amount of sediment mobilized increases as the waves enter shallower water.

As the three-dimensional wave comes onshore, it may break on an offshore bar or it may break directly on the beach is no bar is present. In the case of the wave breaking on the offshore bar, or with multiple bars, a new wave will be generated in the shallower water and eventually, the wave will break on the beach. The breaking wave sets a lot of sediment in motion, which may settle quickly, or which may be entrained in nearshore currents and transported.

The low, long waves tend to have low breakers and the level of agitation of the bottom is reduced. The sand tends to move up the beach profile and accumulate on the beach, building out the beach. Much of this sediment is derived from the sand that formerly composed the offshore bar. In conditions of larger, steeper waves, there are usually areas of sediment agitation in the vicinities of the bars and at the beach face. A lot of this sediment is transferred from the beach to the bars, and from the beach and bars to greater offshore depths. This is a time of bar development. However, is sediment is transferred to depths greater than 30-35 feet, it is lost to the system because the calm-water surface waves are unable to remobilize these sands and return them to the beach. In other words, transfers of sand to deep water represent a loss to the beach/dune system and consequently an erosional condition.

The importance of this process is seen at the beach in association with storms. After a storm, the beach profile recovers by a return of sand from the offshore. The recovery is related to loss of sediment to deep water, to the downdrift beaches, and to the input from the updrift beaches. If the total exchange is balanced, the beach profile returns to an original configuration. If the total shows a negative balance, there will be some loss in the profile and that is represented by a net displacement of the profile and the shoreline to an inland position. Transfers of sediment that stay within the sand-sharing system effectively are not lost. They are temporarily rearranged but can be continually redistributed to rebuild the profile.

Dunes and offshore bars are important components of the beach profile. They represent sand in storage; dunes store sand above water whereas offshore bars store sand below water. In those locations where there is a shortage of sand, it is likely that the dunes will be very small if they are present at all, because there is not much sand in storage above the beach. Also, in areas of sand shortage, there will be a lack of offshore bars. This absence is noted in front of structures such as seawalls in which the offshore slope continues to drop seaward without any evidence of sand storage in the form of offshore bars. This means that no sand is available to return and rebuild the beaches after storms. The same condition tends to apply to sand placed in front of seawalls. The slope remains steep and no offshore bars develop and no sand returns after storm events.

THE COAST

The coastal zone of New Jersey is a highly diverse component of the State. It retains aspects of the natural landscape in parts of Island Beach State Park and Little Beach while hosting the high rises and complete development of Atlantic City. It displays the ultrawide sand beaches of the Wildwoods in contrast to the much narrower and, at times, diminished beaches in most other portions of the State. Variety and diversity are important characteristics of the coast. They are the attributes and the allure that are part of the coastal zone and provide for a wide range of experiences to the citizens of this State and neighboring states. If the shoreline were not eroding, the concerns for the shore would relate to the types of land use and the opportunities available to meet the needs of the citizens. If storms did not threaten the safety of the citizens and cause damage to the infrastructure, the community concerns would be directed to managing the resources within the political unit. However, a fundamental truth in the coastal zone is that long-term erosion is displacing the shoreline and shifting the beaches and dunes inland. Further, the short-term events such as particular storms, storm surges, flooding, and wave attack provide dramatic and immediate modification of the coastal forms and cultural features found in the coastal zone. These long-term and short-term natural processes are responsible for the dynamic and changing nature of the coastal system. However, the coastal zone is replete with many static cultural phenomena and the severe dynamic processes that create the natural forms pose a constant threat to the lives of the coastal inhabitants, to the investments in the form of houses, buildings, and general infrastructure, and to many of the forms of livelihood practiced in the coastal zone. Management of the coastal zone is management of the exposure of the human occupants and their infrastructure to the hazards of being at the coast and adapting to the dynamic conditions that are continually modifying the system. Understanding the basis for the changes and longer-term directions of the changes provides a foundation for the application of management to enhance public safety and to encourage appropriate stewardship of the natural and cultural resources of the coast.

COASTAL GEOMORPHOLOGICAL HISTORY

The coastal features that occur on the New Jersey shore are products of events that began several millennia ago. What we see at the shore now are but the latest forms that have been developing as sea level has risen and inundated the ancestral coastal zone. Conditions have been altered as periods of barrier island development have waxed and waned as a result of the natural processes of wind, waves, and currents transporting sediments along the coast.

It is likely that sea level was on the order of 150 m (450 feet) lower than today about 20,000 years ago. This was during the last major stage of glacial ice accumulation during the Pleistocene. With a great quantity of water locked up on the continent in the form of the large glacial mass, the world's sea level was lower. At this time, the shoreline off New Jersey was about 100 miles (160 km) from the present shoreline. As the glacial ice began to melt, the water returned to the ocean and sea level began to rise and submerge the margin of the continent and encroach upon the exposed continental shelf. The rate of sea-level rise was not uniform and there were times when the level probably dropped as small glacial re-advances occurred. However, by about 7500 years ago, sea level was about 45 feet below the present and the shoreline may have been only a few miles offshore from its present day position. The rate of sea-level rise was slowing as can be determined by comparing the large vertical change of sea level in the earlier period and the remaining 10% of the rise in the last 7500 years. Sea level continued to rise at a diminishing rate until about 2500 years ago when it slowed markedly **(Fig. 8)**. At this time, sea level was about 5-6 feet (<2 m) lower than today and the shoreline was in the general vicinity of where it is today. In the northern portion of the state it may have been seaward, whereas in the southern part of the state it may have been landward. It is likely that the shoreline at about 2500 years ago was a modest, low, narrow sand ribbon that was frequently overwashed and was extremely mobile. During the rapid sea-level rise of the previous millennia, the shoreline was probably very poorly developed and resembled the condition presently found in parts of Brigantine Island **(Fig. 9)**. The constantly increasing water level continued to operate higher and higher on the continental shelf and whatever beach existed was continually propelled inland accompanying the encroaching sea **(Fig. 10A)**. However, with the slowing of the sea-level rise, it is likely that the shoreline began to accumulate a little more sand and became a better-defined, linear sand ridge. With the virtual cessation of sea-level rise, about 2500 years ago, it is likely that the rate of accumulation of sand at the shoreline became sufficient that the beach began to build out and the barrier islands began to increase in width and height **(Fig. 10B)**. It is likely that washover became less frequent and the barrier islands either ceased migrating inland or certainly reduced their rate of inland migration. The sand that now accumulated and that led to the enlargement of the barrier islands came from the offshore. It was probably material that was previously inundated as the sea was rising quickly in the past. Now there was an opportunity for the waves and currents to transfer the sediment to the shore and build the beach. Also, sediment began to fill the bays at this time and change the bays from an open water habitat to one which was initially composed of a fringing marsh and later to large tidal flats and marsh expanses that extended from the margins of the bays into the diminishing open-water habitat. It is

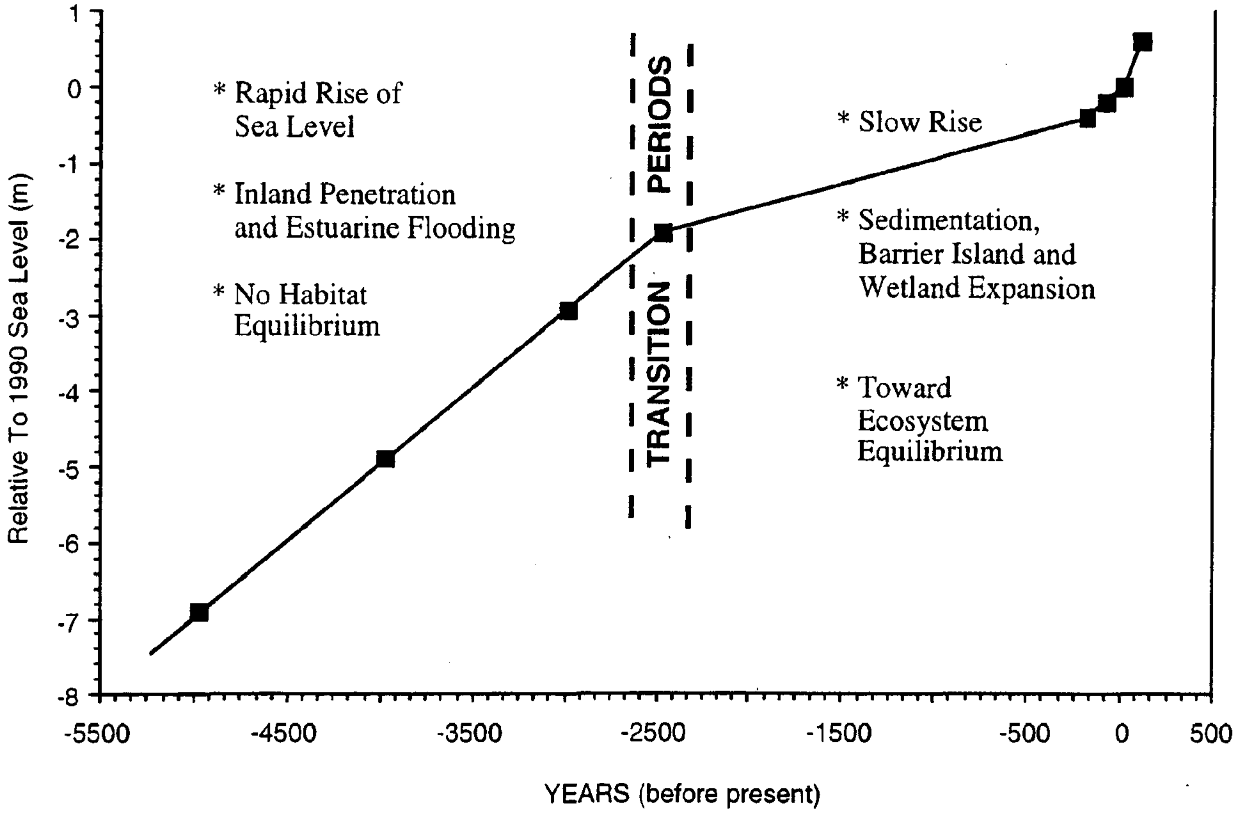

Figure 8. Generalized sea-level rise curve at coastal New Jersey. Most of the coastal features developed after the slowing of sea-level rise about 2500 years ago, and before the rapid rise of the past few centuries

Figure 9.
Narrow beach, low dune, broached by overwash, inland migration system. Old marsh exposed in beach as sand shifts island. Northern Brigantine Island.

Figure 11.
Very wide barrier island, site of great sediment accumulation during low sea level rise period.
Ocean City

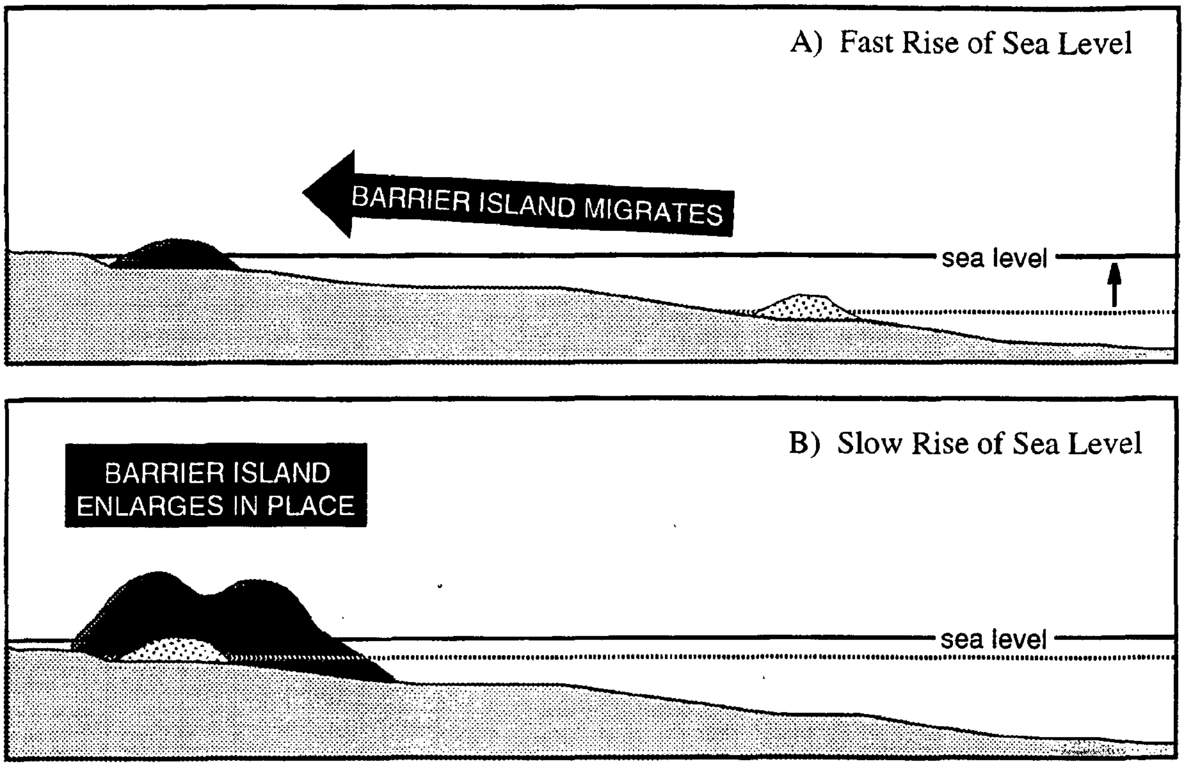

Figure 10. Stages of barrier islands development associated with sea-level rise. A. During rapid rise of sea level, barrier was low and narrow. B. During recent slow rise of sea level, barrier widened and became higher, with dune growth.

important to realize that the reason for the change to a condition of shoreline growth and wetland development was the relative reduction in sea-level rise and the availability of sediment. The very slow rate of rise was now accompanied by a rate of sediment delivery that was greater than the rate of drowning and the result was a change from a narrow sand ribbon that was being overwashed and displaced inland to a barrier island with dune development and sufficient width that washover was infrequent. Now the barrier islands were storing sand and building seaward. The bays were also storing sediment and building extensive wetlands were open water existed previously **(Fig. 11)**.

However, the sand supply in the offshore, the area inundated by the rising sea, is a finite source. That is, the amount is limited. Once the sediment that was available to build the islands and fill the bays was exhausted, the process of accumulation ended and there became a transition from stability to slow loss. This transition was of varying time periods. It was dependent on whether other sources of sediment replaced some of the offshore source. Some of the barrier islands had accumulated large masses of sand and it is likely that sediment from one group of islands helped to nourish some of the downdrift islands. However, the primary source of sediment that was responsible for the height and width of the islands was completely used up and the situation had changed to one of slow losses of sediment as conditions now transferred sediment alongshore and offshore out of the New Jersey shoreline.

This general reversal may have occurred about 500 years ago. It was later in some areas. What we see now is a general reduction of the available sediment in the barrier islands and in the nearshore zone. Sediment is moving into deeper water and is not returning. Parts of the barrier islands are disappearing. In some cases, we see the loss as erosion of the beach and dunes. In some cases, we see that the ends of the barriers have been lost. In other cases, we see the remains of a low, narrow sand sheet that is being displaced inland as washover events begin to occur again. Washover is common in the very early stages of barrier island development and in the very late stages of barrier island attenuation **(Figure 9)**. Barrier islands migrate inland during these two end stages, when sediment supply is at a minimum and the islands have little height or width. Many of the New Jersey barriers still have sufficient sediment **(Figure 11)**, washover is uncommon, and therefore island displacement does not occur. However, in those locations where washover is occurring, it is symptomatic of barrier island attenuation and it is the process by which sediment is transferred from the oceanside to the bayside of the island. It is the same process that was dominant when the low, narrow islands migrated inland during the time of rapid sea-level rise.

Thus, the development of the features that are composing the New Jersey Shore can be traced back thousands of years to times of lower sea level, but the features that we currently see at the shore are only a couple thousand years old at most. Most of the barrier island development can be traced to the time when sea-level rise slowed markedly about 2500 years ago. As noted by Fisher (1967), New Jersey shares an association of coastal barrier island configuration that is repeated several times along the East Coast of the United States **(Fig. 12)**. Starting with the central section of Monmouth County that is currently devoid of barrier islands, there is a short spit, Sandy Hook, extending alongshore from the mainland. In the other direction, there are several long narrow barrier islands (Island Beach spit, Long Beach Island), leading to a series of shorter, drumstick-shaped barriers (the southern section of islands). The presence of numerous active inlets in the south is also accompanied by more extensive wetlands in the back bays. The end product of the long-term development is a shoreline that incorporates considerable spatial variability. Further, the processes of shoreline development have not stopped. There are waves, currents, and wind acting upon the existing shoreline to continue to modify the remaining features.

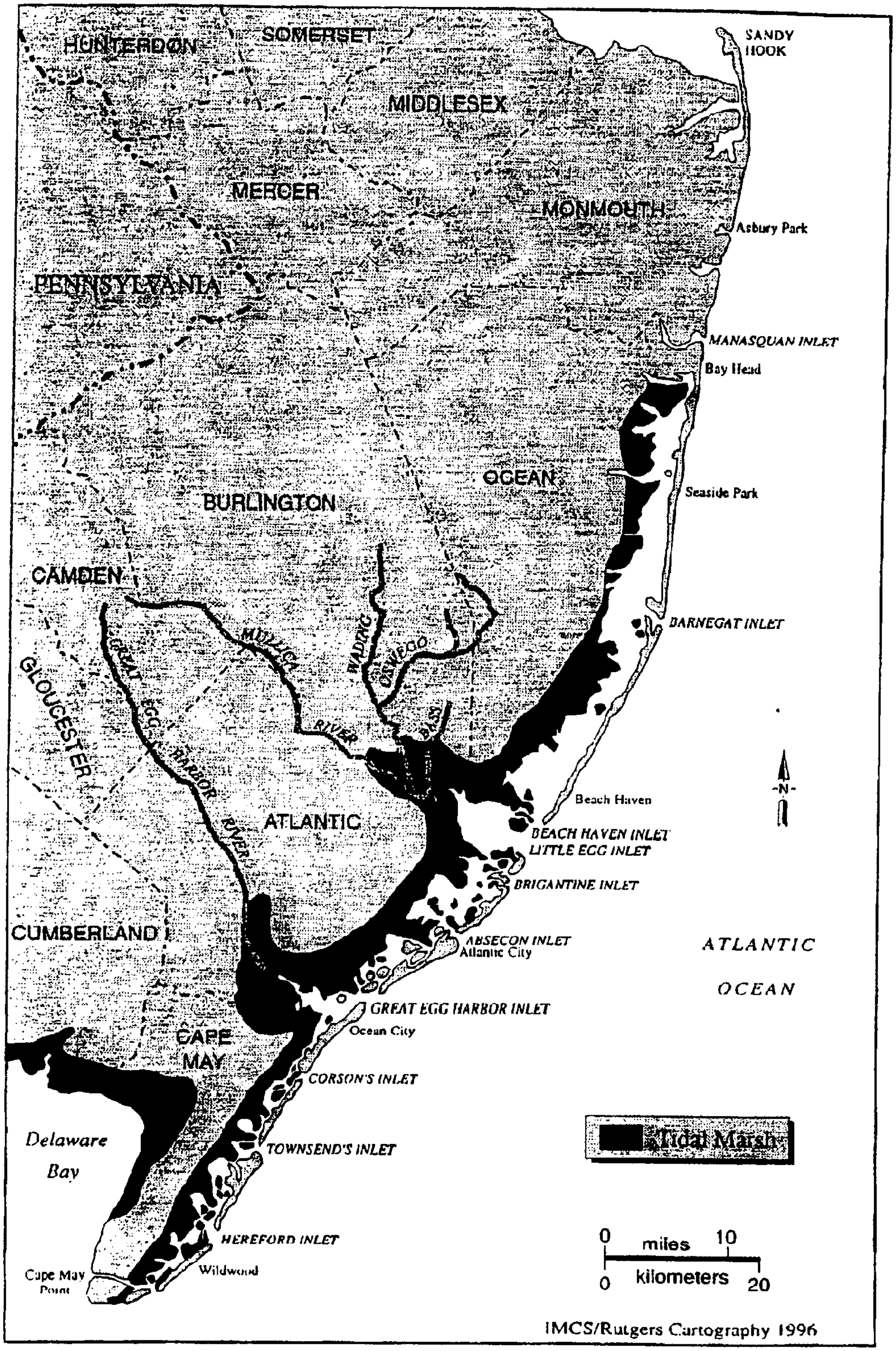

Figure 12. Map of coastal New Jersey.

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New Jersey Coastal Reach Characterizations

Coastal New Jersey is composed of five broad geomorphological units. They are the products of coastal processes operating on the continental margin to produce an assemblage of coastal forms. They incorporate the amount and direction of sediment transport. These speeific geomorphological areas include the following sections (Fig. 1):

Northern Barrier Spit (10 miles)
Northern Headlands (19 miles)
Northern Barrier Islands Complex (42 miles)
Southern Barrier Islands Complex (50 miles)
Southern Headlands (3 miles)

Within these geomorphological areas exist 13 separate oceanfront entities called "reaches (Fig. 2). These New Jersey reaches are defined as coastal regions where a particular set of coastal processes affect the physical characteristics of the area. The combination of processes and resulting forms describes each reach. In many cases, inlet positions define reach boundaries and break the coast into sediment transport or circulation cells.

The reaches contain finer geomorphological associations and definitive erosional/ depositional patterns. The Shore Protection Master Plan of 1981 includes maps of erosion rates of particular areas within reaches. This erosion rate system ranges from I through IV, describing a predominant erosion or accretion trend:

Category I - Critical erosion
Category II - Significant erosion
Category III - Moderate erosion
Category IV - Non-eroding

Because particular magnitudes and spatial associations of coastal processes are specific to reaches, and not jurisdictional regions, coastal management options for New Jersey's coastal region should be employed based on a "reach" approach. In avoiding the reach-breakdown of the coast, coastal management methods can actually aggravate problems found on adjacent shore areas because these management methods would be "piecemeal" and may not involve the entire area which is affected by similar coastal processes. The reach concept for the management process endeavors to reduce the potential for any shore erosion control program to produce adverse effects in adjacent shore areas (e.g. down-drift effects) (1981 SPMP).

The following list of New Jersey reaches is derived from the New Jersey Shore Protection Master Plan of 1981. The first reach is numbered "2" because it is the first "oceanfront" reach in the list. Reaches 1, 15 and 16 in the 1981 SPMP are "bay" and "river" reaches and as these areas are not included in this reassessment of the 1981 Plan, they have not been included in this list (Fig. 2).

2. Sandy Hook to Long Branch
3. Long Branch to Shark River Inlet
4. Shark River Inlet to Manasquan Inlet
5. Manasquan Inlet to the Borough of Mantoloking
6. Mantoloking Borough to Barnegat Inlet
7. Barnegat Inlet to Little Egg Inlet (Long Beach Island)
8. Little Egg Inlet to Absecon Inlet (Pullen Island & Brigantine Island)
9. Absecon Inlet to Great Egg Harbor Inlet (Absecon Island)

10. Great Egg Harbor Inlet to Corsons Inlet (Peck Beach)
11. Corsons Inlet to Townsends Inlet (Ludlam Island)
12. Townsends Inlet to Hereford Inlet (Seven Mile Beach)
13. Hereford Inlet to Cape May Inlet (Five Mile Beach)
14. Cape May Inlet to Cape May Point

Much of the data within these characterizations were obtained through sources such as USACE Reconnaissance Reports, Living with the New Jersey Shore, actual tours of the area, New Jersey Beach Profile Network Reports, the 1981 New Jersey Shore Protection Master Plan, aerial photography, and personal communication with experts of the coastal area in question. The main USACE publication utilized for the characterizations was the Limited Reconnaissance Report of 1990. This source contained an inventory of the engineered structures that have been placed along the New Jersey coastline, a list of beach nourishment projects which have been completed along the New Jersey coastline between the years 1936 through 1990, and general characterization summaries of New Jersey coastal areas. The book Living with the New Jersey Shore was helpful in providing an overview of coastal characteristics. The actual tours aided in proving a firsthand observation of the coast in its most recent condition. The New Jersey Beach Profile Network Reports of 1986 through 1995 provided information of sediment accretion and erosion specific to the area, outlined a historical background of coastal processes of New Jersey, and helped indicate what coastal areas may be dangerous to people and development. The 1981 New Jersey Shore Protection Master Plan was used for its background information, which was updated with other sources, along with mapping erosion rates up and down the coast, and, delineating the geomorphological breakdown of the entire coast. Aerial photography taken in 1995 provided a recent holistic view of the coastal area enabling updates to older sources used to describe the coastline. Beach tours and meetings with local town officials and coastal experts helped to outline the main issues of concern at the coast based on the factors that were affecting development, beach width, dune development, and the effectiveness of structures and beach nourishment operations.

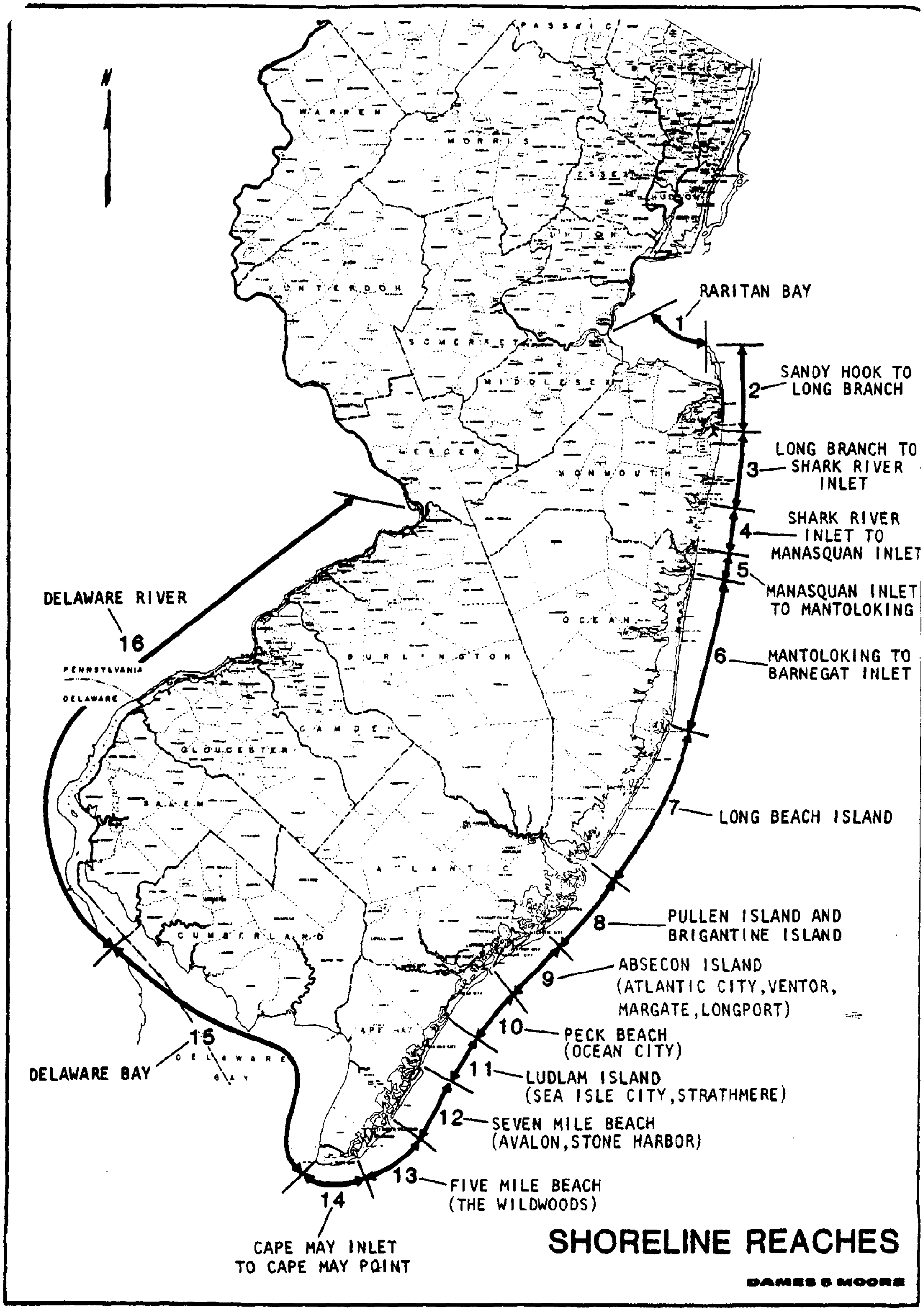

FIGURE I.B-1

Figure 1

Reach 2: Sandy Hook to Long Branch

Reach 2 forms the northernmost portion of the coast of New Jersey. It extends for 11.2 miles (17.9 km) from the northern tip of Sandy Hook southward to Long Branch. It consists of the Sandy Hook Unit of the Gateway Recreational Area, Sea Bright Borough, and Monmouth Beach Borough. Geomorphologically, Reach 2 is the portion of the Northern Highlands leading to and incorporating the Sandy Hook Northern Barrier Spit. The Northern Highlands has a cliffed coast, on the order of 15 to 20 feet from water level to the top of the small bluff that looks out to the ocean. This portion of the coast is exposed to the direct attack of waves which, because of the protective effect of Long Island and New England, either approach from the east or more commonly from the southeast. The result is a longshore drift carrying sediment primarily to the north throughout the year. Through time, the northerly drift has transported great quantities of sediment from the eroded cliffs toward Raritan Bay and has built and extended Sandy Hook spit which is presently approximately 5.8 miles (9.3 km) long (Fig. 1).

The attachment of Sandy Hook to the Northern Highlands, however, has waxed and waned as variations in sediment availability, storm effects, and drainage from the Navesink River-Shrewsbury River systems have alternately breached and sealed inlets in the spit. At times, Sandy Hook has been an island, it has been connected to the Highlands, and it has been attached to the Northern Highlands at Long Branch as it is today.

Most of Reach 2 is sediment starved. The only portion which has a history of accumulation and accretion is the northwesterly-trending component at the distal end of Sandy Hook. Otherwise, the cliffed portion of the Highlands and the lower portion of Sandy Hook spit are eroding. Around the turn of the century, the construction of a 15 foot high seawall was begun to prevent breaching of the spit and to protect the very narrow southern portion of the spit. The seawall eventually lined the entire oceanfront of Monmouth Beach, which has 1.6 miles (2.6 km) of oceanfront, and Sea Bright, which has approximately 3.7 miles (5.9 km) of oceanfront.

Numerous groins of varying dimensions and shapes extended seaward from the seawall in efforts to catch and hold meager amounts of sand in northerly transport. Sandy Hook has five timber groins and six stone groins which extend from 100 to 600 feet in length; Sea Bright has 25 groins: six of stone, twelve of timber, four of stone and timber, and three of stone and steel with groin lengths varying from 160 to 600 feet; Monmouth Beach has only four groins: one of stone and steel, two of stone and one of stone and timber (USACE, 1990). At times small pocket beaches would be created in the corners of the attached groins. For long stretches, the waves would break directly on the seawall with no beach to intercept them. Even after the seawall was constructed, erosion continued to remove sediment from the spit. The offshore zone was steepened and the seawall was undermined by the loss of supporting sediment. Storm conditions would cause collapse of portions of the wall.

When the seawall was completed in 1926, it terminated in what is now part of the Gateway National Recreation Area. The seawall curved seaward, following the trend of the shoreline, and ended at a wide portion of the spit, about 2000 feet at the time. However, small quantities of sediment transported in the beach zone to the end of the seawall were insufficient to maintain the beach at this position and erosion began to displace the beach inland (Fig. 2). By 1978, the erosion had extended so far that the Hook was in danger of being breached. In 1978, the first of several overwashes occurred and eventually a small breach destroyed the road and threatened to sever the connection to the northern portion of the spit. Two major episodes of beach fill have temporarily filled the critical zone at the end of the seawall. However, the shoreline erosion continues. This portion of Sandy Hook is classified as Category I, critically eroding, in the 1981 SPMP. The area to the north of the Critical Zone has been relatively stable during this century, indicating that there is a sediment balance. The extreme northwesterly portion of Sandy Hook is accreting and extending into Sandy Hook Channel and into Raritan Bay.

The Sea Bright-Monmouth Beach shoreline had been directly at the base of the seawall for many decades. However, in 1994-96 a major beach nourishment project began that was designed to create a beach 100 feet wide, at an elevation of 10 feet above mean low water (Fig. 3). This project is active now. Previously, the Sea Bright shoreline was at the seawall. Prior to the beach nourishment, both areas had been classed as Category I, critically eroding (1981 SPMP).

There are no dunes in front of the seawall, not even on the beach fill portion. Several areas of well-developed dunes exist in the Sandy Hook Park, north of the Critical Zone. Some of the foredune areas are natural, whereas others have been constructed by the managers of the Park or by the previous occupants of this section of Sandy Hook.

Sea Bright is mostly a recreational community. Residential development with commercial development is concentrated in the center of town. There is a trend toward townhouses and condominium units. There is also a trend toward more year round housing. The elevations are very low and flooding is a recurring problem and will remain so even with a beach in front of the seawall. Monmouth Beach is a residential community, and as in Sea Bright, there is a tendency for more townhouse and condominium development, with more year round housing.

Figure 1.
Base of Sandy Hook spit attached to the uplands. South Monmouth Beach. Seawall lining ocean side of spit.

Figure 2.
Narrow Sandy Hook spit. Seawall at ocean side ends in foreground, causing critical erosion area. Sandy Hook unit, Gateway National Recreation Area.

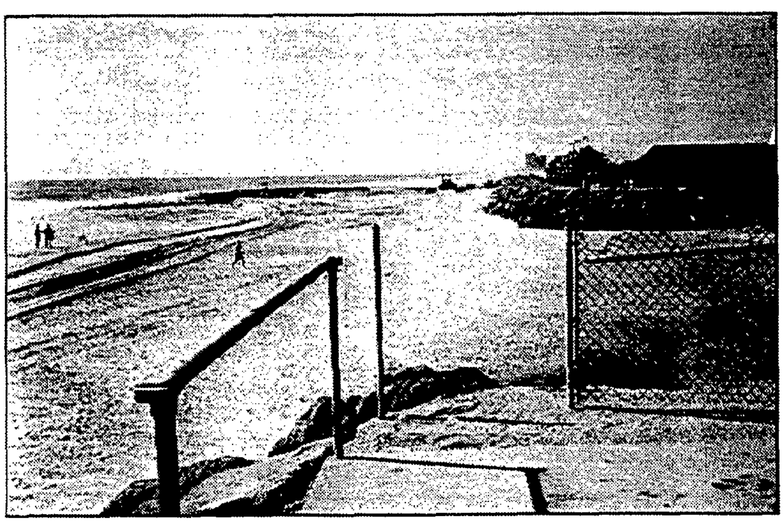

Figure 3.
1995 beach nourishment in front of seawall. Sea Bright.

Reach 3: Long Branch to Shark River Inlet

Reach 3 occupies the northern area of the Northern Headlands section of the coastline. It extends from Long Branch to Shark River Inlet and is approximately 7.2 miles (11.5 km) in length. It consists of Long Branch City, Deal Borough, Allenhurst Borough, Loch Arbour Village, Asbury Park City, Ocean Grove (Neptune Township), Bradley Beach Borough, and Avon-by-the-Sea Borough. Reach 3 is a cliffed coastal zone with the predominant littoral drift to the north. The elevation of the scarp in the bluff is the greatest between Long Branch and Deal and gradually decreases heading south to Avon-by-the-Sea. The bluff elevation is interrupted in places by shoreline perpendicular stream valleys which reduce the upland elevation to below sea level.

There are numerous freshwater lakes along the central Monmouth County coast which occupy stream valleys that drain eastern Monmouth County. These valleys were blocked at the beachfront by a sand ridge (bay-mouth barrier) preventing direct water flow to the sea during the early history of shoreline development (Fig. 1). Deal Lake, Wreck Pond and some other valleys have been temporarily open to sea after storm events, but were closed rapidly by post-storm wave activity because stream flow was not sufficient to keep inlets open. None of these small valleys had any significant estuary associated with it to allow the existence of a tidal prism.

Reach 3 has been losing sediment offshore and alongshore over an extended period of time. Generally, the beach width increases from north to south. Beaches in Long Branch are very narrow and do not normally exist between the West End area and Allenhurst. The beaches gradually widen south to Ocean Grove, and finally, narrow near the north jetty of Shark River Inlet. According to the New Jersey Beach Profile Network (NJBPN, 1987-95), these beaches did not show rapid changes in accretion or erosion, and very few trends of chronic accretion or erosion. The gains and losses within Reach 3 did not occur in any particular sequence.

Shore protection in Reach 3 is varied. The seawall from Reach 2 continues south into Reach 3, ending just north of 404 Ocean Avenue in Long Branch (Fig. 2). There are no shore protection structures at Long Branch's Seven Presidents State Park, but a rock revetment and vertical steel bulkhead begin at the north end of Ocean Avenue in Long Branch and run continuously south to the West End. Deal and Allenhurst have both groins and shoreline parallel walls for most of the length of oceanfront. The Darlington Avenue site in Deal does not have a bulkhead at the bluff's edge. From Asbury Park south, shore parallel structures are mostly wooden bulkheads, a few with rock toe protection. There was little beach nourishment activity in the period from 1986 to 1992, but modest fill was placed on Allenhurst beach in 1989 (NJBPN, 1993). Between Allenhurst and Deal there is a very long groin and it acts to restrict the littoral transport of sediment, adding to the scarping in Deal. The beach conditions at this area allow for hundreds of feet of beach on the south side of a groin and no dry beach on the north side of the same groin. The minor reentrants in the bluff edge have left healthy "pocket" beach segments which see intense use (Long Branch's Seven Presidents State Park), or no beach (West End in Long Branch, and Phillips to Roosevelt Avenues in Deal) because of varied land use decisions or structural failure.

Recent development in the Reach 3 area demonstrates a trend towards townhouses and condominium units. The area behind the revetment in Long Branch is extensively developed with many stately homes lining the shorefront. The land use in Deal is single-family residences on large lots. The coastal area has also seen a trend towards more year round housing. There are very few open space segments of this shoreline. The Seven Presidents State Park is the only public use open space, along with five or six public/private beach clubs.

The oceanfront in Long Branch is about 4.3 miles (6.8 km) in length. From Lake Takanasee south, the erosion rate classification is Category I, critically eroding (1981 SPMP); Long Branch from Lake Takanasee north is Category II, significantly eroding (1981 SPMP). The city has approximately 34 groins and five T-groins having lengths of 200 to 500 feet in front of a stone and timber seawall/bulkhead that extends for 10,450 feet (USACE, 1990). The groins were made of several materials: 13 were made of stone-timber, one of timber, 23 of stone and two of stone-steel (USACE, 1990).

Deal's oceanfront area runs approximately 1.6 miles (2.5 km) and is characterized by narrow pocket beaches between stone groins, backed by a scarp varying by ten to 20 feet in height at different places (Fig. 3). This scarp erodes during storms, and in most cases there are no dunes at the back of the narrow beach. Deal is identified as Category I, critically eroding (1981 SPMP). As local short-term protection to the upland, concrete riprap and bulkheads have been used in scarped places by Deal residents. The borough has ten groins extending from 200 to 585 feet: six are made of stone and four of stone-timber (USACE, 1990). The revetment is made of stone and stone-steel, and is sectioned into three parts measuring 700 feet, 650 feet and 1500 feet in length (USACE, 1990). The steel bulkhead is 23 feet high and 500 feet long (USACE, 1990).

Loch Arbour and Allenhurst have a very small shoreline and essentially act as a single unit. Both municipalities have shorefront located between two long groins. The oceanfront section of Allenhurst is about .3 mile (.4 km) and Loch Arbour's is around .2 mile (.3 km). Loch Arbour and Allenhurst differ in profile in that Loch Arbour has one vegetated dune at the back of the beach and Allenhurst has no dunes. The 1981 SPMP had classified the entire area as Category I, critically eroding. Allenhurst has two groins: one of stone and one of stone-timber ranging from 105 to 564 feet in length. Allenhurst also has a large concrete bulkhead which is about 22 feet high and 1500 feet long (USACE, 1990).

The Asbury Park beach extends for approximately .9 mile (1.5 km). The elevation of the back shore is low, and storm waves have frequently washed sand onto the road. Erosion has occurred just downdrift of a very long groin and has produced a flanking of the groin at its northern landward end. This groin is now protected by a riprap wall constructed parallel to the shore, but this wall has also been flanked. The town does not have a dune system on the narrow beaches. The boardwalk runs along the beach with a bulkhead beneath it to prevent overwash. Asbury Park has five groins. One of them is in the shape of an "L" and located in front of the Paramount Convention Hall. Three are constructed of stone and two of stone-timber and they range from 548 to 603 feet in length (USACE, 1990).

Ocean Grove has slightly less than .6 mile (.9 km) of narrow beach, with a modest dune system at the back preserved with dune grass and dune fencing. Ocean Grove has four groins made of stone-steel that range from 444 to 548 feet in length. The two newer groins that have been built are notched (USACE, 1990).

Bradley Beach, with slightly less than a mile of ocean frontage is deprived of sediment in the littoral zone because of the northern drift and the impact of the jetty at Shark River Inlet. Bradley Beach is Category I, a critically eroding zone (1981 SPMP). Bradley Beach has three stone groins and numerous dilapidated wooden groins. The stone groins have been reduced in length and the extra stone was placed at the inland margin of the groin on the beach to support the timbers. There are no dunes but there are intentions to create a dune system once the beach replenishment project has been completed in Bradley Beach. The new boardwalk is made of patio blocks and it has been reconstructed back about 40 feet as a result of extensive damage in 1992.

The oceanfront section of Avon-by-the-Sea is about .5 mile (.8 km) long and is immediately updrift of Shark River Inlet. Avon has very narrow beaches and no dune system. There is a jetty and four very long groins in Avon; the jetty is 620 feet long while the groins are between 192 to 615 feet in length (USACE, 1990).

Figure 1.
Many groins and other structures at upland edge. Lake in drowned stream valley. Allenhurst to Asbury Park.

Figure 2.
Upland edge at Long Branch, multitude of groins, revetment line contact Drift is to the north. 1994.

Figure 3.
Rip rap revetment protecting erosional margin of northern highlands. Narrow beaches at reentrants in coastal bluff. Deal. 1994.

Reach 4: Shark River Inlet to Manasquan Inlet

Reach 4, which is both residential and commercial, lies between Shark River Inlet and Manasquan Inlet, and is approximately 5.9 miles (9.4 km) long. The reach consists of Belmar Borough, Spring Lake Borough, Sea Girt Borough, and Manasquan Borough and is a continuation of the Northern Headlands portion of the New Jersey coastline. As in Reaches 2 and 3, the littoral drift in this area is predominantly to the north and it is a cliffed coastal zone. The upland bluff occurs at the ocean's margin with the sand beach situated at the base of the scarp and some dune forms masking this scarp.

The area south of Shark River has the widest beach between this point and Sandy Hook. The inlet jetty traps large volumes of sand being transported to the north (Fig. 1). The beach narrows in the southern part of the Belmar oceanfront to a minimum at the boundary with Spring Lake, and beach widths are narrow between Manasquan and Sea Girt as well.

Reach 4 has dune systems running along the coastline. Belmar has a low, narrow, vegetated dune system alongside the boardwalk at the back of the beach. The dune system ends in the vicinity of Lake Como in South Belmar. There is a dune system that covers the bluff edge in Spring Lake and National Guard Beach (part of the National Guard Armory, a state-owned shorefront between Sea Girt and Manasquan). The original foredune still exists in Manasquan, but beachfront cottages are built on it. The new man-made dune system here was built in the 1980's east of the walkway.

There is some variety of beach protection structures north of the National Guard Beach. A Beachsaver Reef, which is a new form of engineered approach for coastal management, has been utilized in Spring Lake and it has been in place since July 1994. The studies regarding the Reef's effectiveness have not been conclusive. Groins, jetties and bulkheads are other forms of coastal management within this area. Groins and jetties are common south of National Guard Beach.

Shark River Inlet, the northernmost portion of Reach 4, was stabilized in the early 20th century with stone jetties to prevent the inlet channel from meandering at the area of its exit into the ocean. The accumulation of sediment, as a result of the jetties, is greater on the updrift side of this inlet.

Belmar's oceanfront is approximately 1.5 miles (2.3 km) in length with the beach at its widest at the north end near the jetty, narrowing to the south. At Lake Como in South Belmar the road is fronted by a concrete bulkhead and, to the north of that, by a riprap, concrete-capped bulkhead/seawall. The area from Shark River Inlet to Lake Como in South Belmar is classified as Category III, moderately eroding, (1981 SPMP) and the area in front of Lake Como is Category II, significantly eroding (1981 SPMP). The shore structures at Belmar consist of four notched stone groins and one stone jetty (USACE, 1990). The jetty is 885 feet long and the groins range from 600 to 620 feet in length (USACE, 1990).

Spring Lake has over 2 miles (3.2 km) of beach. The northerly end has a narrow beach, with an old bulkhead which is no longer effective. There is a boardwalk located in front of the dune system at this beach and parts of this coastal section have a concrete chain of discs located in front of the boardwalk as a form of coastal management to retain sand. Spring Lake is classified as Category III, moderately eroding (1981 SPMP) and has eleven stone groins ranging from 325 to 640 feet in length (USACE, 1990).

Sea Girt has approximately 1.4 miles (2.3 km) of narrow beach. This beach has a high scarp masked by some sand, especially at the southern end, and no dune system. In the northern portion of Sea Girt, buildings are farther back from the beach. The infrastructure and boardwalk located in front of these buildings provide some protection from storm activity. The center of Sea Girt's coastal zone has a boardwalk over the beach in front of the cliffed area. The southern portion of Sea Girt is private and has no boardwalk and no infrastructure. Sea Girt is classified as Category II, significantly eroding (1981 SPMP). Sea Girt has six stone groins and seven timber groins and the National Guard Armory's coastal zone has three stone groins and one timber groin (USACE, 1990). These structures range 120 to 550 feet in length (USACE, 1990).

Manasquan is 1 mile long (1.6 km) and characterized by narrow beach which is a result of the effects of the jetty at the Manasquan Inlet. A macadam "boardwalk," runs along the back of the dune system. At E. Preston Street, one side of the groin located in this area was well-exposed whereas the other side of the groin had accumulated sand up to the height of the groin's top surface. To the north of this street the groins are notched. Manasquan was classified as Category II, significantly eroding (1981 SPMP). Manasquan has twelve groins along the coast and the jettied Manasquan Inlet causes the downdrift erosion. These structures are constructed of the following: three of stone, one of stone-timber, and three of stone-steel (USACE, 1990). The groins range from 150 to 545 feet and the jetties are 1230 and 1030 feet (USACE, 1990).

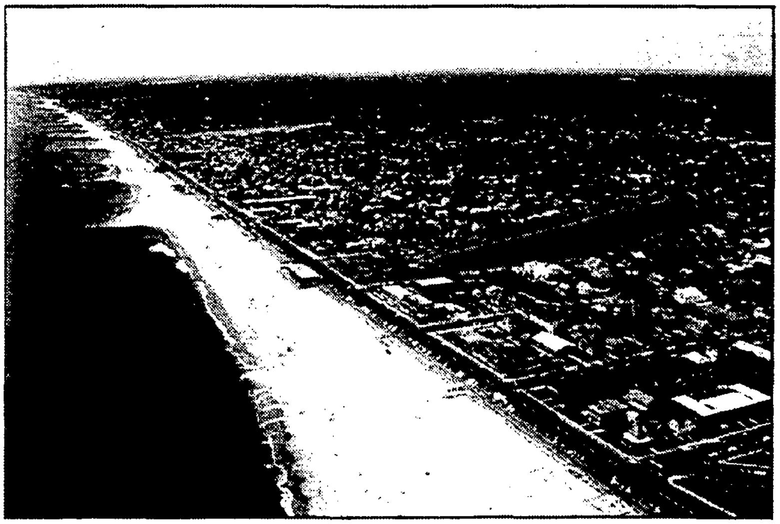

Figure 1.
Widening beach caused by inlet at Shark River inlet, groins at margin. Northerly drift, Belmar.

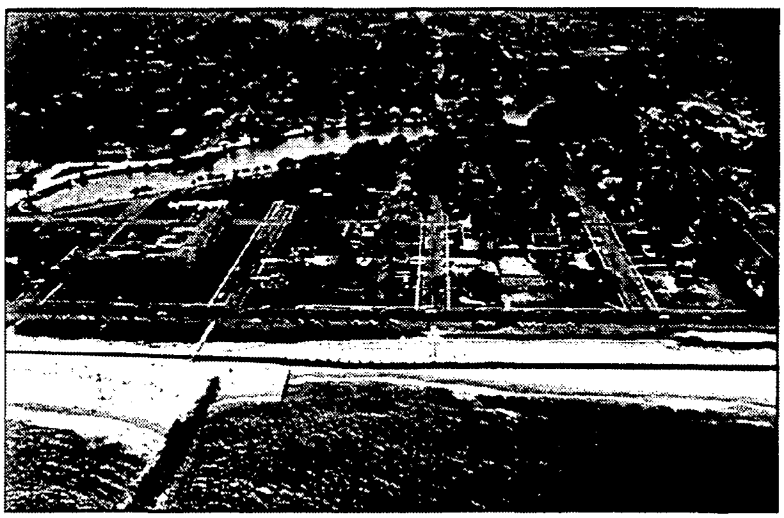

Figure 2.
Narrow Beach at contact with upland, boardwalk over beach, dunes capping upland contact. Spring Lake.

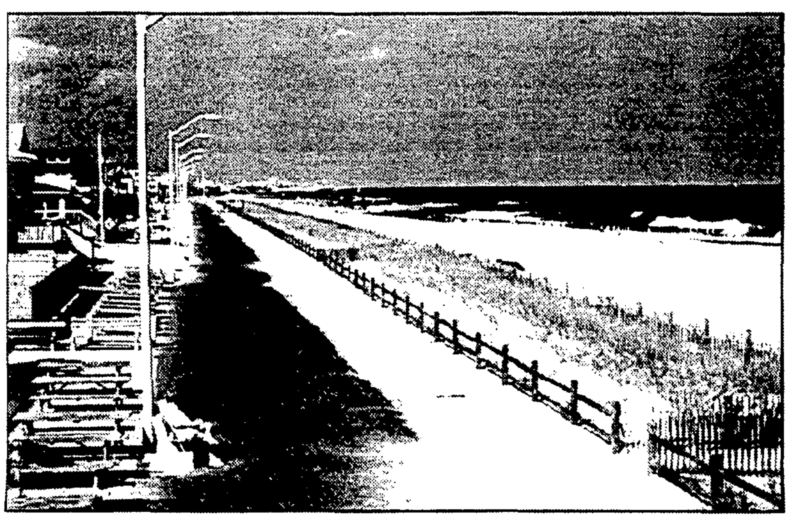

Figure 3.
Boardwalk and artificial dunes. Steep beach, with structures. Manasquan.

Reach 5: Manasquan Inlet to Mantoloking Borough

Reach 5 begins at the Manasquan Inlet and extends south to Mantoloking Borough making up the southern segment of the Northern Headlands and the beginning of the Northern Barrier Island Complex. Most of Reach 5 is within the headlands portion of the coast south of Manasquan Inlet and the extreme northern part of the peninsula around the middle of Bay Head's oceanfront. The rest of Bay Head comprises the beginning of the Northern Barrier Island Complex. This reach is approximately 3.1 miles (4.9 km) in length and consists of Point Pleasant Beach Borough and Bay Head Borough. The region is characterized by moderate-to-narrow beach widths, and steeply sloped beaches.

The bluff area, which is primarily in Point Pleasant Beach, has an elevation masked by beach sand which is only a few feet above sea level. Forsythe Avenue in Bay Head marks the southernmost point on the New Jersey coast where the older coastal plain sediments are exposed directly adjacent to the ocean shoreline. The shoreline south of Forsythe Avenue is a combination of spits built from local headland segments, bay-mouth barriers, and small barrier islands. All the individual coastal features eventually coalesced into the present-day "spit-like" peninsula which ends at Barnegat Inlet. It is entirely constructed of sands eroded from upland bluffs and from sand moved westward on the continental shelf by wave processes as the sea level rose over the past 20,000 years.

The beach of the Reach 5 Northern Headlands segment gradually narrows to the south. The net littoral sand transport direction in Reach 5 favors the north as evidenced by an accumulation of sand on the south side of the Manasquan Inlet jetties produced by the northerly littoral drift and the jetty interference with this sediment transport. Moving south of Manasquan Inlet, there is an increasing component of a southerly littoral drift to the longshore transport. Eventually, the balanced drift produces a null net transport zone and a moderately eroding shoreline.

Point Pleasant Beach has an approximate 1.8 mile long (2.9 km) coastal area that narrows to the south. The northern section of Point Pleasant Beach is classified as Category IV, non-eroding (1981 SPMP). The southern section of Point Pleasant Beach is classified as Category III, moderately eroding (1981 SPMP). The northernmost portion of Point Pleasant Beach has greater width than the rest of the area and dunes should be present naturally, but extensive recreational activities have eliminated natural dune development (Fig. 1). There is a small dune line just east of part of the boardwalk that was constructed after Hurricane Gloria in 1985. The stretch of beach from New York Avenue to Carter Avenue has been contracted a proposal for dune enhancement. Dunes were to be created within the amusement park area of Point Pleasant Beach in 1995 as well. Homes have been built behind the dunes and some private owners have utilized dune fencing. A portion of Point Pleasant Beach has an amusement park area and accompanying recreational facilities which classify it as a recreational community.

The oceanfront in Bay Head is about 1.2 miles (1.9 km). The beach is of moderate width and has a dune system which is moderate to large-sized, well-vegetated and fenced. This dune system is present all throughout Bay Head and serves for both buffering purposes and to fortify the gaps at street ends. Walkways through the dunes exist and are perpendicular to the beachfront. This residential community is classified as Category III, moderately eroding (1981 SPMP). Bay Head has ten groins which are exposed at low tide and are covered up the rest of the time. Eight of these groins are made of timber and two are made of stone (USACE, 1990).

These groins range from 150 to 250 feet in length (USACE, 1990). Bay Head also has a stone seawall that is 4150 feet long (USACE, 1990) located under the dune system (Fig. 2).

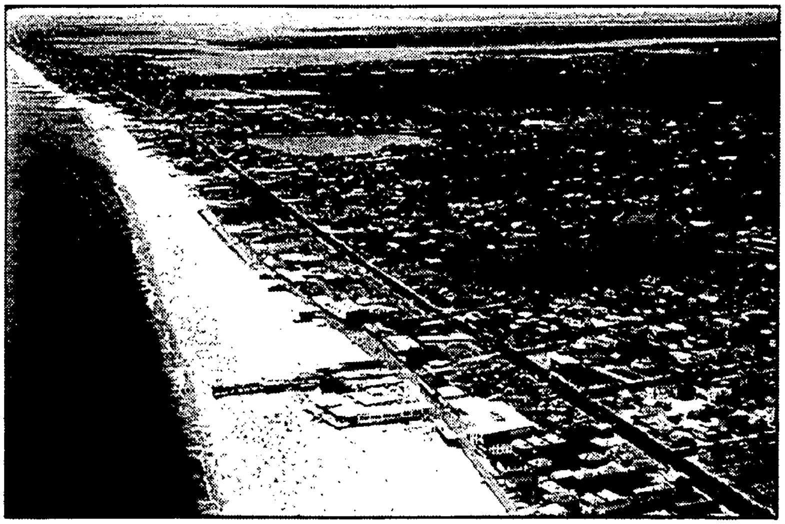

Figure 1.
Widening beach north to Manasquan Inlet, sand against upland margin, lakes in drowned valleys.
Point Pleasant.

Figure 2.
Exposed rip rap seawall at inner margin of beach, under dune ridge, after storm. Beginning of barrier island.
Bay Head, Dec. 1992.

Reach 6: Mantoloking Borough to Barnegat Inlet

Reach 6 extends from Mantoloking Borough to Barnegat Inlet and makes up the northern part of the Northern Barrier Islands Complex. This reach is approximately 20.3 miles (32.5 km) long and consists of Mantoloking Borough, Normandy Beach, Ocean Beach (Brick Township), Lavallette Borough, Ortley Beach (Dover Township), Seaside Heights Borough, Seaside Park Borough, South Seaside Park (Berkeley Township), and Island Beach State Park. The long Northern Barrier Island Complex is a peninsula which extends south from Bay Head to Barnegat Inlet, comprising a Holocene barrier beach complex.

Major storms have occasionally broken through this reach's long peninsula and created new inlets. The Ortley Beach-Seaside Heights boundary was once the site of Cranberry Inlet which existed immediately seaward of the mouth of the Toms River estuary. This historical inlet situation is an example of how inlet creation and inlet migration are commonplace on a long barrier island such as that in the Reach 6 segment. Barnegat Inlet had migrated 3,700 feet south (56 feet per year) between 1866 and 1932 when the first rock jetty structures were started (Farrell and Leatherman, 1989). Ten of the twelve miles from the Toms River estuary to Barnegat Inlet is presently the site of Island Beach State Park, which is the longest section of continuous open space on the New Jersey coast and the largest State-owned section of the shoreline anywhere in the State.

Beach surveys conducted from 1986 to 1995 indicate that the sediment losses occurred for the most part at the northern section of the reach and a substantial sediment gain occurred at the southern end in Island Beach State Park at the jetty (NJBPN, 1986-95). Reach 6 has beaches of moderate width, and many communities have promoted the development of dunes. Removal of sediment has possibly been limited due to the lack of a significant net longshore transport direction along a large part of this shoreline segment. Dunes are present throughout most of this reach, except for the northern end of Seaside Heights south to Stockton Avenue.

The development in Reach 6 varies from a nearly all privately owned shorefront in Mantoloking to extensive public amusements and boardwalk-oriented recreation in Seaside Heights. South of Seaside Heights, the development is mostly single family homes and small motels. Island Beach State Park is an undeveloped coastal area.

Mantoloking has 2 miles (3.2 km) of beach. The beach is moderately wide, and has sizable dunes measuring 16 to 21 feet in elevation that remain because lots are large enough that the houses can be built well back from the beach. Mantoloking is classified as Category III, moderately eroding (1981, SPMP). In the vicinity of South Mantoloking the dune system serves as a buffer to overwash and inlet creation which are characteristic of Reach 6. Downer Avenue, located on the southern end of Mantoloking is the most threatened section of the borough.

Normandy Beach is .5 miles (.8 km) long and the beaches have a moderate width. Normandy Beach has been classified as Category III, moderately eroding (1981 SPMP). Near Normandy Beach the houses are protected by a dune, although it is narrow and discontinuous in places. Often, houses have been built on top of the dune. As a result, these houses are vulnerable because of dune erosion during large storms which may undermine their foundations and cause structural failure.

Ocean Beach has .8 miles (1.2 km) of moderate width oceanfront. This beach is classified as Category III, moderately eroding (1981 SPMP).. Portions of the beach have dunes with vegetation and fencing. A large exposed condominium is located on the beach, farther seaward than any other structure within the area, and it does not have any dunes or much beach width in front of it.

The generally narrow oceanfront of Lavallette is approximately 1.3 miles (2.1 km) in length. Lavallette is classified as Category III, moderately eroding (1981 SPMP). A boardwalk lines most of the shore in this community (Fig. 2). The dune system, which measures 12 to 15 feet in elevation, is sparsely vegetated and fenced. In some areas, sandbags have been placed underneath the face of the dunes in pyramid fashion and storm scarped dunes have been fenced for strengthening purposes as previous storms had washed them out. Lavallette has nine stone groins ranging from 300 to 350 feet in length (USACE, 1990). The town also has a timber bulkhead that is 2100 feet long (USACE, 1990).

Ortley Beach is approximately .7 miles (1.2 km) long and has a beach of adequate width for recreational purposes. Ortley Beach is classified as Category III, moderately eroding (1981 SPMP). It has a vegetated and fenced dune system along the back of the beach seaward of the boardwalk, but the dunes are not fertilized. The beach does not have any structures. There is a boardwalk and a gazebo on each end of the boardwalk.

Seaside Heights has approximately .8 miles (1.2 km) of oceanfront with moderate beach width for recreation. Seaside Heights is classified as Category III, moderately eroding (1981 SPMP). The town does not have any dunes or any particular beach management plan other than maintaining a moderate width for the recreational season. The beach has not eroded drastically within recent years. The boardwalk extends throughout Seaside Heights and into part of Seaside Park. The two piers extending seaward are the only structures on the beach in Seaside Heights.

Seaside Park is about 1.7 miles (2.7 km) long and the beach, which does not have any hard structures, is of moderate width with angled beach entrances located about every 500 feet. This beach is classified as Category III, moderately eroding (1981 SPMP). The town utilizes a dune maintenance program on its wide, artificial dune system. The continuous line of fenced dunes are fertilized regularly and have a significant amount of vegetation. In some parts of Seaside Park, the boardwalk is situated between dunes: the eastward dune is located at the back of the beach and the westward dune located alongside the road. There is an offset of dunes at Stockton Avenue, where the Seaside Park dune system ends and where the Seaside Heights amusement park boardwalk begins.

South Seaside Park has approximately .7 miles (1.1 km) of oceanfront and has a moderately wide beach. The area is classified as Category III, moderately eroding (1981 SPMP). The fenced dunes in this area have developed over the past 15 years and have accumulated into a substantial size with most of the vegetation being natural.

Island Beach State Park has 9.5 miles (15.2 km) of natural beach of moderate width that is sectioned into different areas, with each area each enforcing a separate set of rules and regulations for maintenance and use. The northern area has limited beach use for recreation (Fig. 3); the central area is used for bathing and recreation; and the southern end allows beach buggies onto the beach as a recreational activity. The dunes are relatively natural and presently unaffected by construction or modification. There are multiple dune lines in this park and the rear dunes are thickly vegetated with brush, dune plants and small trees. Some dune breaches that exist within the system are wide enough to permit four-wheeled drive vehicles to pass through, and although the access roads are not straight, they may permit entry of large storm surge waves into the interior parts of the park during serious storm events. The coastal foredune is a continuous line ranging from 15 to 20 feet in elevation with beach grass vegetation. The inland dunes are thickly vegetated with shrubs, trees and other vegetation. All of these dunes have been able to form naturally without much human interference. The only engineered structure in Island Beach State Park, which had been raised in 1987-91, is the stone jetty located on the northern end of the inlet which extends for approximately 4900 feet.

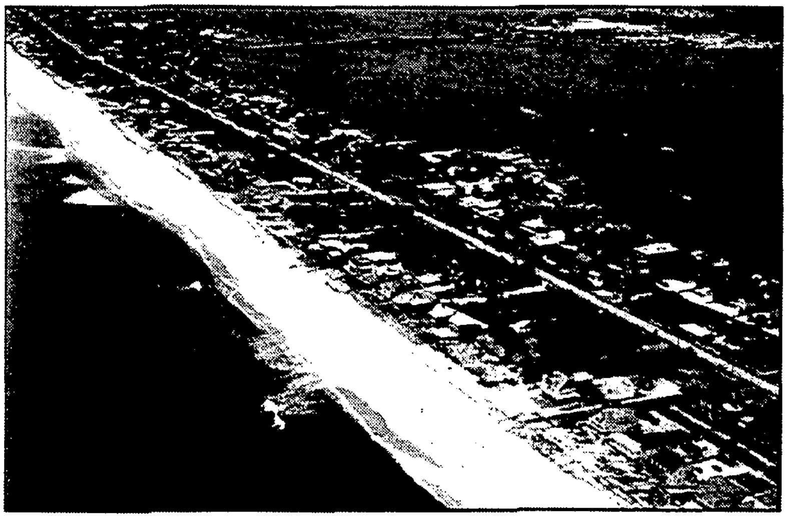

Figure 1.
Well-developed coastal dune, most houses set back from ridge. Barrier island system. Mantolokoing.

Figure 2.
Variable width beach associated with groins, narrow dune zone in front of boardwalk. Lavallette

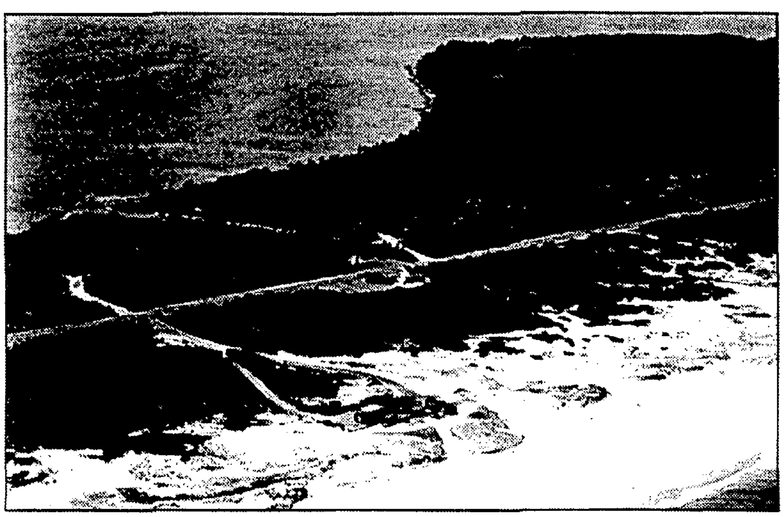

Figure 3.
Large dissected dune zone, northern area. Island Beach State Park

Reach 7: Barnegat Inlet to Little Egg Inlet (Long Beach Island)

Reach 7, Long Beach Island (LBI), is a barrier island that extends from Barnegat Inlet to Little Egg Inlet. This island is 18 miles (28.8 km) in length and is the longest of any of New Jersey's barrier islands. It is the southernmost section of the Northern Barrier Islands Complex. The six municipalities within this reach include: Barnegat Light Borough, Harvey Cedars Borough, Surf City Borough, Ship Bottom Borough and Beach Haven Borough, all situated among four segments of Long Beach Township. Long Beach Island has a nearly straight, north-northeast ocean-facing shoreline. The entire island, classified recreational, is heavily developed with the exception of the southernmost 1.8 miles (2.9 km) which is devoted to open space as part of the Forsythe National Wildlife Refuge (Holgate Unit). The island is vulnerable to erosion because its beaches are steep and narrow and barrier island breaching remains a threat.

The past 40 years of development have greatly changed the oceanfront side of the island. Before 1950, neither homes or motels existed within approximately 500 feet of the dunes in large sections of the oceanfront. Today, very few sites exist where buildings are either greater than 200 feet from the mean high tide line or more than 50 feet from the seaward toe of the dunes. Some of the construction within LBI is elevated on pilings, but set so far seaward that severe dune erosion may enable breaking storm waves to reach under the building and cause collapse of the structure. Storm evacuation is a difficult task on Long Beach Island because it only has a few north-south roads, and only one road to the mainland.

The northern inlet boundary to LBI has been stabilized, but the southern boundary inlet has been active with tendencies to migrate along the shoreline and to change main tidal flow channels which rapidly alters the abundant flood-tidal and ebb-tidal shoals surrounding the inlet mouth. The reach has been generally classified as Category III, moderately eroding (1981 SPMP). The littoral drift is dominantly directed to the south along much of LBI. The southern end of the island consists of a spit which in the past has extended southwestward at the rate of up to 200 feet per year. Although no area along Long Beach Island has been classified as Category I, critically eroding, a few areas of significant erosion (Category II) occur in the following areas within this reach: portions of Ship Bottom Borough, Brant Beach, and Beach Haven Borough. With the exception of these few locations, there is no imminent danger to dwellings or infrastructure, and sufficient setback usually exists between the eroding shoreline and the nearest buildings and roads.

Coastal management methods within this reach have featured both "hard" and "soft" engineered approaches in the form of groins and jetties, and beach nourishment. The entire barrier island had received beach nourishment in 1962-63, but in recent years, beach nourishment has mostly been confined to the northern quarter of the island because the sand supply has been derived from dredging Barnegat Inlet, although during the early 1990's in Loveladies there had been an episode of beach nourishment where sand had been trucked in. Harvey Cedars also had a beach nourishment project done in 1990. The groins present in this reach are mainly of the low rubble mound type and are located about four blocks apart. Rock groins in Harvey Cedars are an exception and are of higher profile extending back to the street end.

Barnegat Light is about 1.8 miles (2.7 km) long and has a wide beach. It has large, well-vegetated dunes located at the back of the beach. There is no mapped dune zone, but the dune ordinance states that the dunes cannot be tampered with. A major 1991 south jetty renovation project had a major impact on the beach position of the northernmost part of the island. The shoreline has advanced seaward by hundreds of feet within a thousand feet of the jetty (Fig. 1).

The accretion tapers off near the Barnegat Light-Loveladies boundary. Barnegat Light has 13 groins, which mostly are buried and one jetty. These structures are constructed of the following: one of stone-timber-core, three of timber-stone, five of timber and five of stone. The groins range from 165 to 506 feet and the jetty is 2950 feet long (USACE, 1990).

Harvey Cedars is approximately 1.9 miles (3 km) long and has a very narrow beach (Fig. 2). This area is classified as Category III, moderately eroding (1981 SPMP) but has potential for critical erosion during storm events. Harvey Cedars has a dune system at the back of the beach and also has eleven stone groins reaching to about 320 feet (USACE, 1990).

Surf City has approximately 1.3 miles (2 km) of oceanfront and has moderate beach width. The dunes are maintained at 22 to 23 feet in height and are never lower than 16 feet. All dunes are vegetated and walkovers for beach access have been constructed above the dunes. Surf City has seven timber-stone groins that range from 335 to 340 feet (USACE, 1990).

Ship Bottom is 1.3 miles (2 km) long and has a moderate beach width. The fertilized and fenced dunes are maintained at a 16 foot elevation at the building line. The street ends that have groins are also the ones that have bulkheads which are maintained at a 14 foot elevation. There are seven timber-stone groins in Ship Bottom ranging from 335 to 340 feet in length (USACE, 1990).

Long Beach, interspersed among the island's municipalities is approximately 9.3 miles (14.9 km) long with moderate beach widths. There is a dune system, 14 to 16 feet high, at the back of that beach. Long Beach Township has 65 groins ranging from 235 to 420 feet (USACE, 1990). They are constructed of the following: 60 of timber-stone, three of stone, one of sub-net and stone, and one of sandbag and stone (USACE, 1990).

Beach Haven is approximately 1.8 miles (2.9 km) long and has moderate beach width. The dunes have vegetation and zig-zag fencing. A very high groin causing an offset beach at Holyoke Avenue in Beach Haven exacerbates the downdrift erosion in this area (Fig. 3). Beach Haven has ten groins: eight of stone, one of timber and one of timber-stone (USACE, 1990). These range from 300 to 340 feet in length (USACE, 1990).

The Edwin B. Forsythe National Wildlife Refuge (Holgate Unit) is a natural, undeveloped, federally owned portion of coast that has a moderate width of beach running 1.7 miles (2.7 km) in length. There is evidence of overwash in this area as evidenced by breaks in the vegetated dunes and sheets of sand spreading into the bay.

Reach 13: Hereford Inlet to Cape May Inlet

Reach 13 extends from Hereford Inlet to Cape May Inlet and is approximately 7.6 miles (12.2 km) in length. It is comprised of North Wildwood City, Wildwood City, Wildwood Crest Borough and the Coast Guard Reservation. This reach is part of the Southern Barrier Islands Complex in which the net littoral transport is southerly with a reversed local transport at the northern end. Reach 13, made up entirely of recreational communities, contains no Category I (critically eroding) erosion areas, and has significantly wide beaches (Fig. 1). Wildwood has the widest beach measuring approximately 1200 feet at its narrowest sections running the length from the boardwalk to the high mean water line. The beaches within this reach, however, have very low elevations.

There is natural accretion at the northern portion of the island and the jetty affects the southern portion where much of the sand that would be transported to Cape May City is trapped and accumulated north of Cape May Inlet. A combination of tidal currents and storm waves have removed much of the sand along North Wildwood's inlet shoreline so that there is no beach at all in the inlet throat. Beach protection structures such as bulkheads, seawalls, and groins have been built along the inlet shoreline to cope with erosion. The westernmost inlet shoreline in North Wildwood has been classified as Category III, moderately eroding, (1981 SPMP), whereas the inlet shoreline on the easternmost side of this "drumstick"-shaped barrier island's northern tip has been classified as Category II, significantly eroding (1981 SPMP).

North Wildwood has about 2.9 miles (4.6 km) of wide oceanfront with dunes at the back of the beach. This beach had not always been very wide. In 1963, the high mean water line was at North Wildwood's boardwalk. The southernmost portion of North Wildwood has been classified as Category IV, non-eroding (1981 SPMP). North Wildwood has three groins constructed of rubble and concrete that range from 77 to 187 feet in length (USACE, 1990). North Wildwood also has four bulkheads that range from 933 to 5200 feet in length and 11.3 to 12.5 feet in height (USACE, 1990). The bulkheads vary in construction: two are made of timber-sheet pile; one is made of steel piling; and, one is made of concrete, stone and brick (USACE, 1990). The city also has three revetments: one is made of stone-timber-rubble; one is made of concrete rubble; and, one is made of stone and grout (USACE, 1990).

Wildwood is approximately 1.3 miles (2.2 km) long with a beach of great width and a very modest dune system (Fig. 2). This beach provides more protection against wave attack than at other locations in southern New Jersey. Most of Wildwood is classified as Category IV, non-eroding (1981 SPMP). The 1981 SPMP classifies the southernmost section of Wildwood as Category II, significantly eroding; however, the beach is not presently threatened by any critical or significant erosion. This coastal community has no hard engineered structures on the beach.

Wildwood Crest has about 1.9 miles (3 km) of oceanfront which is low in elevation and has a little less width than Wildwood. Wildwood Crest has natural, well-vegetated dunes and there are multiple dune lines on the beach. The southern part of Wildwood Crest contains dunes that have formed up against the bulkhead. Wildwood Crest had been classified as Category II, significantly eroding, for the most part, and Category III, moderately eroding, at its southern end (1981 SPMP) even though this beach is presently fairly wide and not undergoing any critical or significant erosional processes. At this time, Wildwood Crest has a bulkhead that is 5200 feet in length and about eleven feet in height (USACE, 1990).

The U.S. Coast Guard Reservation makes up the southernmost portion of this barrier island. The Reservation's coastal area is approximately 1.2 miles (1.9 km) in length (Fig. 3). This area has had accretion of thousands of feet since the construction of the jetties. The stone jetty at the inlet which stems from the Reservation's beach is 4548 feet long (USACE, 1990).

Figure 1.
Wide bulbous end of island, Accreting beach with vegetated dune zone. North Wildwood and Wildwood.

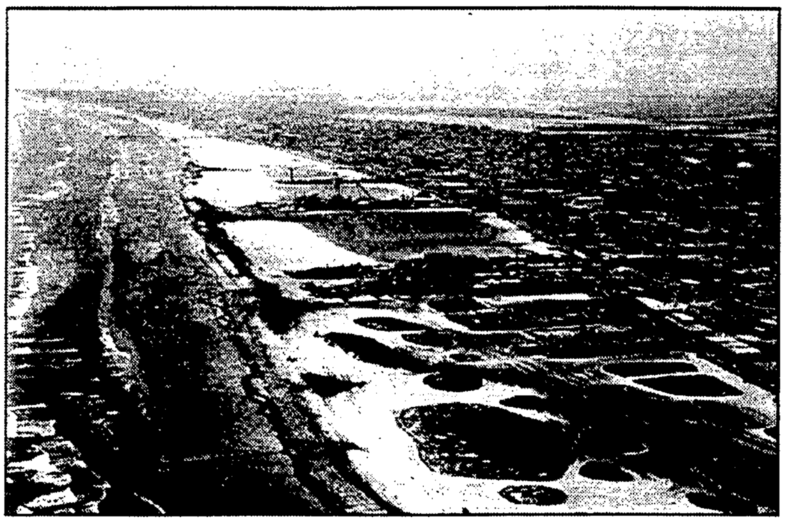

Figure 2.
Low flat beach, amusement piers straddled over beach, patches of vegetation, no dune line. Wildwood

Figure 3.
Accretion at jetty groins in beach. Dunes ion Coast Guard Reservation and in Wildwood Crest.

Reach 14: Cape May Inlet to Cape May Point

Reach 14, extending for approximately 6.3 miles (10.1 km), is the southernmost ocean shoreline in New Jersey running from Cape May Inlet to Cape May Point. This reach consists of U.S. Coast Guard Base, Cape May City and Cape May Point Borough. The U.S. Coast Guard Base and Cape May City occupy the barrier island, which is part of the Southern Barrier Islands Complex; and, Cape May Point occupies the southwest corner of the reach, and is part of the Southern Headlands region. Cape May Point State Park and a portion of land owned by the Nature Conservancy (South Cape May Meadows, Lower Township) forms the shoreline between Cape May and Cape May Point.

The paucity of sand caused by the Cape May City jetty (Fig. 1) is exacerbated by the groins and seawall that run along this reach's shoreline. The division between Cape May City and the South Cape May Meadows in Lower Township lies just southwest of the Third Avenue groin. It has effectively blocked the limited volume of sand being transported southwest (Fig. 2). As a result, the South Cape May Meadows, the Cape May Point State Park, and Cape May Point have become relatively starved of sand. Because of the recent beach fill, sand is in the process of by-passing the groin and forming a spit attached to the end of the structure extending south parallel to the beach in Cape May City.

The region from the Cape May Inlet (formerly known as Cold Spring Inlet) to Cape May City at Ocean Avenue has been classified as Category I, critically eroding, (1981 SPMP) because of the accelerated erosion and deteriorated condition of the seawall which may provide protection from very small storms, but not from large storms. The beach at the western portion of Cape May City has been classified Category II, significantly eroding, (1981 SPMP) because of the dependence on the condition at the updrift beaches, even though this area has a narrow to moderate beach with stone groins which are presently functioning adequately. Sand starvation in this area could lead to immediate problems such as potential flanking of the terminal groin at the western end of the city. Despite the erosion of Lower Township and Cape May Point State Park, these areas have been classified as Category III, moderately eroding, (1981 SPMP) because sufficient setback distance exists between erosion forces and the developed areas or infrastructure. Cape May Point has been classified as Category II, significantly eroding, (1981 SPMP) because of previous erosional trends.

The Coast Guard Base stretch of shoreline northeast of Cape May does not have much development in terms of buildings, but it had at one time been developed into an airport. There has been rapid erosion here, estimated at 20 feet per year, which is a result of its location downdrift of the jetties at Cape May Inlet that trap sand carried by the longshore current on the north side of the inlet.

Cape May City has approximately 4.1 miles (6.6 km) of narrow shoreline. Before the beach nourishment operation in 1990, which had been done from the Cape May Inlet jetty south to the Third Avenue groin in Cape May City there had been either a very narrow beach or no beach at high tide in certain areas of the beach fill section. Continued erosion has led to the construction of groins and reinforcement of the seawall. Extensive shoreline development and shore management structures have prevented shoreline retreat and as a result, offshore slopes are steep. One of the positive effects of the beach nourishment project was that the severely eroded southern end of Cape May had begun to form sandbars. Cape May has 15 groins and one stone jetty (USACE, 1990). The groins range from 150 to 786 feet in length and the jetty is 4385 feet in length (USACE, 1990). Five of the groins are made of timber crib and nine of them are made of stone (USACE, 1990). Cape May also has five stone seawalls which range from 400 to 4426 feet in length and are about 14 feet in height; and, one timber bulkhead that is 3703 feet long and 14.3 feet in height (USACE, 1990).

Cape May Point has about 1.1 miles (1.8 km) of narrow beach for the most part with an artificial dune system (Fig. 3). In some places, dunes are larger and wider than others, depending on the width of beach they are situated in. Slabs of concrete have been put up against the face of the sloped area in front of the Convent which serve as a buffer protecting the Convent from wave energy. Cape May Point's eastern section has been classified as Category III, moderately eroding, and its western portion has been classified as Category II, significantly eroding (1981 SPMP). Cape May Point has nine groins: six are made of timber-stone and three are made of stone (USACE, 1990). These groins range from 275-500 feet in length (USACE, 1990). Cape May Point also has one timber bulkhead which is 12 feet in height and 400 feet in length (USACE, 1990). In addition to these structures, Cape May Point also has a Beachsaver Reef in place since May/June 1994 which is being monitored for positive and negative effects.

Figure 1.
Trapping of littoral sand updrift of the Cape may jetty causes downdrift erosion of most of the reach

Figure 2.
Groins have further limited sediment transport beyond Cape May City, causing large offsset in shoreline.
Cape May City

Figure 3.
The southern highland forms the southern point of New Jersey.
Sediment starvation results in narrow beaches and scarped dunes.
Cape May Point

THE REACH CONCEPT IN MANAGEMENT

The reach concept is a means to organize and integrate the physical processes, the sediment transport systems, and the geomorphology of the coastal zone. It still remains relatively simplistic and there will be conditions that develop that blur the boundaries of the reaches and create more or fewer reaches. The absolute number of reaches is not of great importance. It is far more meaningful to approach the coastal zone as a series of segments that respond to stimuli in some holistic manner. Management should strive to consider the responses of an entire reach in deciding the application of a strategy or an approach to some coastal issue. Further, the boundaries of the reaches are not really closed systems which isolate portions of the coast from the other. Inlets are not absolute boundaries. Sediments do pass across inlets. Inlets are dynamic portions of the coast and interact with the reaches on either side. Jettied inlets obviously affect the positive and negative sand budgets updrift and downdrift. However, unjettied inlets also store and release sediments and do interact with the adjacent shores. Inlets are convenient boundaries and do represent a change of processes, whereby tidal flows are introduced as a mechanism for sediment transfers in addition to the waves and wave-induced currents. The reach concept is a guideline for management. It is still necessary to use the knowledge of the range of processes, of sediment delivery, of beach-dune interaction, of human intervention to formulate strategies that function at a regional scale.

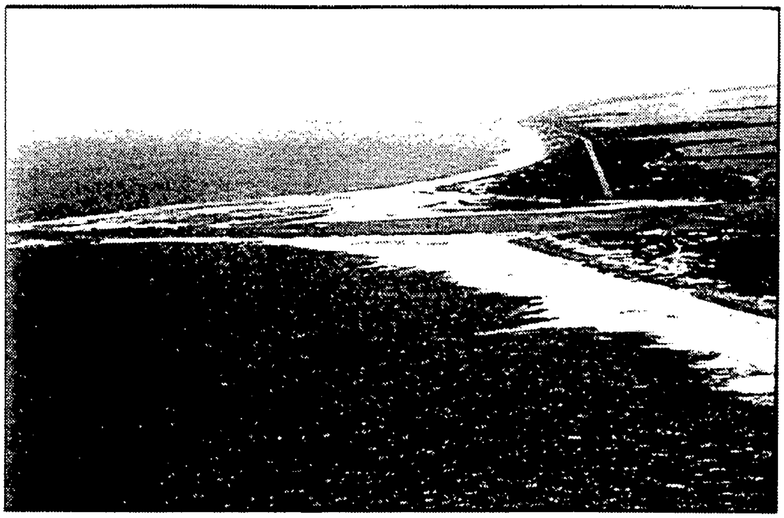

Figure 1.
Barnegat Inlet jetties, extensions of beach adjacent to jetty, erosional condition downdrift. Barnegat Inlet, Long Beach Island.

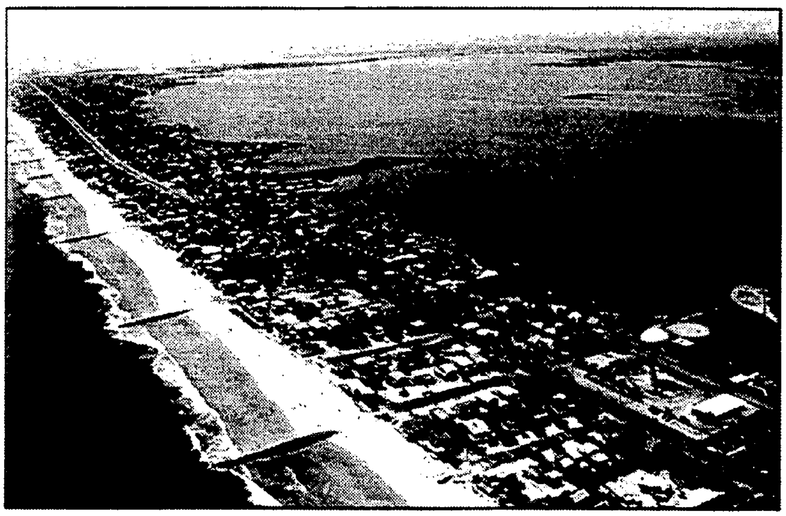

Figure 2.
Narrow Beach and dune zone, many groins, fully developed island. Northern Long Beach Island, 1994.

Figure 3.
Multiple groins, offsets in island associated with sequences of development. Southern Long Beach Island.

Reach 8: Little Egg Inlet to Absecon Inlet

Reach 8, extending from Little Egg Inlet to Absecon Inlet is approximately 6 miles (9.6 km) in length. It is made up of Pullen Island and the Brigantine barrier island which consists of the Edwin B. Forsythe National Wildlife Refuge (EBFNWR) and the city of Brigantine. This reach is part of the Southern Barrier Islands Complex where the littoral drift is southerly.

Pullen Island and the Brigantine barrier island have extensive estuarine systems on their western boundaries separating the barrier islands from the mainland. This area consists of three to five miles of small uninhabited islands, shallow bays, tidal marshes, creeks, and lagoons. The marsh exists because of the large amount of sediment that has been overwashed and transported through the inlets into the backbay. The average ground elevation of the barrier islands is approximately 10 feet above mean sea level.

The Edwin B. Forsythe National Wildlife Refuge is composed of Pullen Island and an approximate 2 mile (3.2 km) section of undeveloped beach on the northernmost end of the Brigantine barrier island. Pullen Island was breached in 1994, presently forming two small islands. Overwash is commonplace in this location. Although Pullen Island is under a constant state of dynamic migration, there is no development that can be threatened and therefore the area has not been classified with an erosion rate in the 1981 SPMP. The northern section of Brigantine barrier island is the southernmost section of the EBFNWR and has a consistently narrow beach.

Brigantine Inlet, also called "Wreck Inlet," lies between Pullen Island and Brigantine Barrier Island interrupting the EBFNWR area. There are no structures at Brigantine Inlet.

The city of Brigantine occupies the remainder of the Brigantine barrier island, extending slightly over 4 miles (6.4 km). There is an offset at the border of the Refuge and the city of Brigantine. The northern part of Brigantine City has a very low, narrow dune system in front of a narrow beach. The developed northern portion of Brigantine Island has been classified as Category I, critically eroding (1981 SPMP) because of the low, narrow beach and poor condition of groin structures. Existing development is very close to high water and storm waves pose considerable threat to the buildings located there. A dune system exists south of the Brigantine Hotel and continues for the length of the island becoming larger to the south as the beaches widen. The southernmost dunes attain an average of 190 to 230 feet in width and five to ten feet in height, and are well-vegetated. Brigantine barrier island has a wider beach width to the south, but has been classified as Category II, significantly eroding (1981 SPMP) because developed areas are threatened by storm erosion. The southernmost portion of the island is influenced by the north jetty of Absecon Inlet. Sand is accumulating on the updrift side of the jetty forming a wider protective beach. This area is classified as non-eroding, Category IV (1981 SPMP). Brigantine City has 28 groins extending from 70 to 630 feet in length and one stone jetty that is 3,730 feet long (USACE, 1990) bordering Absecon Inlet. The groins vary slightly in construction: 21 groins are made of timber and seven are made of timber-stone (USACE, 1990). Brigantine also has seven bulkheads: six are made of timber and one is made of timber-stone (USACE, 1990).

Figure 1.
Undisturbed Barrier island system. New inlet developed in 1994. Pullen Island.

Figure 2.
Low Beach, overwash into marsh across low narrow dune. Old marsh outcropping in beach. North Brigantine Island

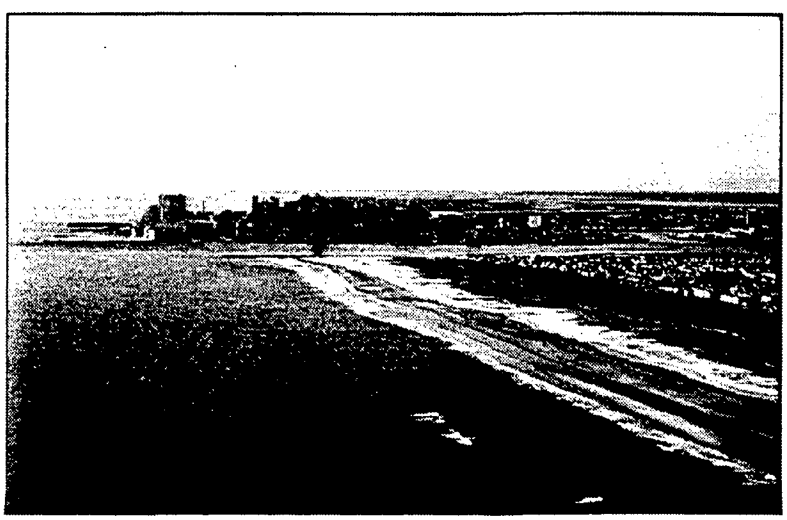

Figure 3.
Widening dune zone toward inlet. Accumulation updrift of Absecon Inlet jetty. Brigantine.

Reach 9: Absecon Inlet to Great Egg Harbor Inlet

Reach 9 extends from Absecon Inlet to Great Egg Harbor Inlet and consists of the Absecon barrier island. It is the most intensively developed barrier island in New Jersey, with a shoreline that extends a little over 8 miles (12.8 km) gradually decreasing in width from north to south with segmented coastal dune systems. The reach is made up of four communities: Atlantic City, Ventnor City, Margate City, and Longport Borough. Absecon Island has extensive coastal and estuarine wetlands on its western boundary, consisting of a few miles of shallow bays, small uninhabited islands, tidal marshes, creeks and lagoons. It is part of the Southern Barrier Islands Complex, the dominant direction of longshore transport in Reach 9 is southerly.

Dynamic littoral change has been characteristic of this area. Around mid-19th century, Absecon Island was two barrier islands separated by a small tidal inlet, which is presently Inside Thorofare. The smaller islands have since merged to create Absecon Island.

As a result of wave action and the highly erosional Absecon inlet, a pronounced lobate deposit of sand had at one time accumulated, extending the beach seaward at the northeast corner of Atlantic City. The ebb-tidal flow had removed sand from the inlet shoreline and deposited most of it offshore around present-day Connecticut to North Carolina Avenues in Atlantic City. The area is presently eroding and the persistence of this erosion at Absecon Inlet caused by tidal currents and ocean waves has resulted in the construction of inlet jetties, groins, and the relatively high seawall/bulkhead.

Another set of inlet processes impacted the southern end of Absecon Island where the Great Egg Inlet channel migrated south breaking off a segment of Longport. Even though the littoral drift is southerly, little sand has accumulated at the southern end of Absecon Island in the recent past (early in the century 10 blocks of the city were lost).

Atlantic City has 3.4 miles (5.4 km) of shoreline. The Absecon Inlet jetty has helped to retain sediment at the inlet's border but the beach narrows toward the south. The beach is especially narrow in front of the intense development of hotels and casinos (Fig. 1). Atlantic City has several piers extending seaward and a boardwalk that runs along the length of the city. Geo-tubes are used as a core for the artificial coastal foredune ridge in the northern part of Atlantic City's beach, in front of the casinos. The remainder of the beach area has artificial dunes. Northern Atlantic City has been classified as Category II, significantly eroding, and to the south, Atlantic City has been classified as Category III, moderately eroding (1981 SPMP). Atlantic City has 19 groins ranging from 165 to 600 feet in length and one stone jetty that is 1,177 feet long (USACE, 1990). Six groins are constructed of timber-stone, seven are made of stone and seven are made of timber (USACE, 1990). Atlantic City also has two timber bulkheads and one stone revetment (USACE, 1990).

Ventnor City has 1.7 miles (2.7 km) of narrow beach with few sporadic sets of small dunes. The boardwalk is located at the high tide line and has piers extending from it to the street ends. Ventnor has residential development along the coastline and all oceanfront buildings are located behind bulkheads. To the south, the bulkhead and boardwalk are separated by a distance of approximately 150 feet, which serves as a type of back beach. The berm width varies between 40 and over 100 feet. Northern Ventnor City is classified as Category III, moderately eroding and its southern portion has been classified as Category II, significantly eroding (1981 SPMP). Ventnor City has one timber wavebreaker and 13 bulkheads, five of which are constructed of timber, six of concrete and two of concrete-timber (USACE 1990).

Margate City has 1.6 miles (2.6 km) of narrow beach with remnants of dunes as Margate does not have much beach area to accommodate protective dunes. The beach at the southern end, however, almost triples in width. Margate has a "zig-zag" development line where certain developed areas jut out onto the beach. Margate City has areas classified as Category II, significantly eroding, or III, moderately eroding (1981 SPMP), depending on the local condition of beaches and shore protection structures. Margate has 15 groins ranging from 125 to 425 feet in length: nine are made of timber, three are made of stone and two are made of timber-stone (1981 SPMP). Margate also has 19 bulkheads: two are made of concrete, twelve of timber, four of timber-concrete, and one of concrete-block (USACE, 1990).

Longport Borough is 1.5 miles (2.4 km) in length and occupies the southern "drumstick" portion of the barrier island. The beach has low elevation, narrow width and no dune system (Fig. 2). The entire length of the Longport oceanfront is lined with either a bulkhead or seawall which has potential to be overtopped by overwash. A unique curved concrete seawall wraps around the end of the island and extends bayward. Residential development sits a few feet behind the seawall. Very little sand accretion, if any, exists at this end in front of the curved seawall. Based on the severity of the erosion problem and the potential for danger to private property and the infrastructure, Longport is classified as Category I, critically eroding (1981 SPMP). Longport has eleven groin that range from 250 to 507 feet in length (USACE, 1990). One groin is made of timber, eight are made of timber-stone and two are made of stone (USACE, 1990). Longport also has two concrete seawalls and one stone revetment (USACE, 1990).

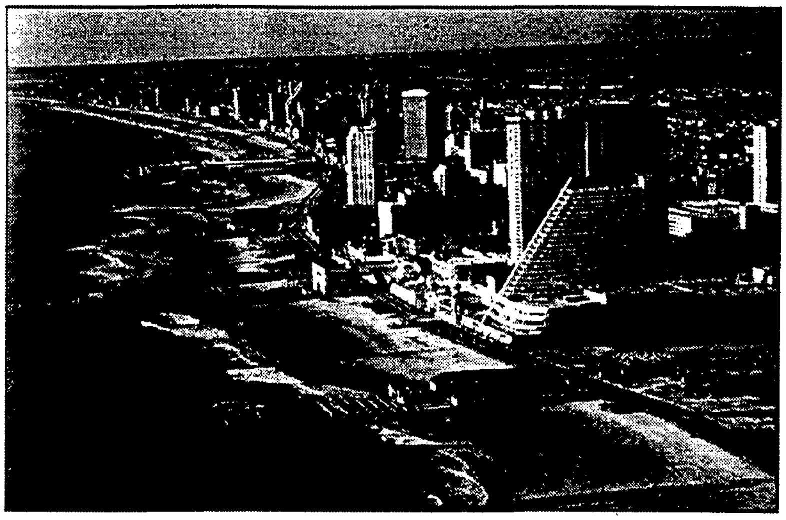

Figure 1.
Casino developments at northern bulbous end of island, Atlantic City boardwalk above samll dune remnats. Dec. 1992

Figure 2.
Boardwalk over beach. No dunes on profile, bulkhead in upper beach.
Ventnor

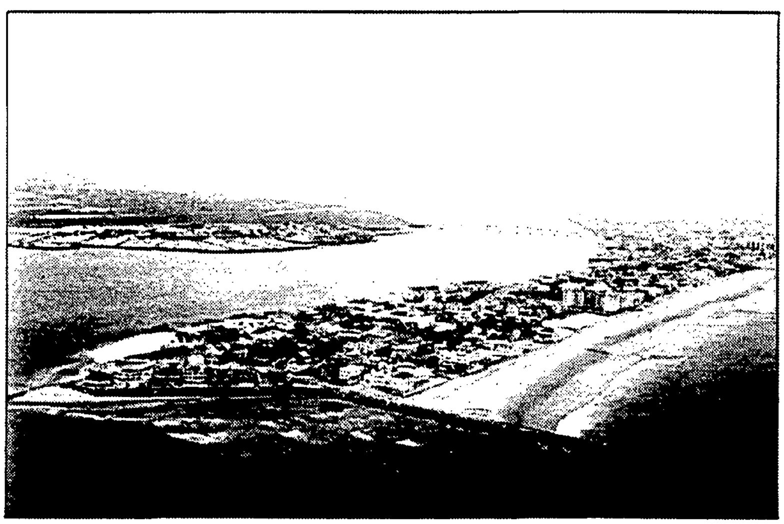

Figure 3.
High density on southern end of island, no dunes, bulkhead at top of narrow, low beach. Terminal groin at inlet. Longport

Reach 10: Great Egg Harbor Inlet to Corsons Inlet

Reach 10 is approximately 7.8 miles (12.6 km) long and is part of the Southern Barrier Islands Complex in which the littoral drift is southerly. It extends from Great Egg Harbor Inlet to Corsons Inlet and consists of Ocean City and Corsons Inlet State Park, both of which are classified as recreational land use (1981 SPMP, Vol II). Reach 10 is the only barrier island Reach, other than Reach 8 (Brigantine barrier island), which consists of only one municipality, Ocean City. Corsons Inlet State Park, occupies the undeveloped portion of the southern end of the barrier island.

The northern end of Ocean City, bound by Great Egg Harbor Inlet, is presently an area of considerable erosion potential and critical hazard similar to the other inlet throat beaches. In 1981, the SPMP had classified the area as Category II, significantly eroding. Corsons Inlet, which bounds the southern end of the barrier island, is not stabilized and has not been dredged since 1971 when hopper dredging was suspended. The State has no plans to stabilize this inlet and it is currently officially "closed to navigation" since 1984. Corsons Inlet has been narrowing over the years due to sediment accumulation within the inlet.

Ocean City is approximately 7.1 miles (11.4 km) long. Prior to the beach nourishment projects in the 1990's, Ocean City's narrow beach provided little inland protection against storms. In addition, experience from the 1962 storm shows that the area is very vulnerable to flooding.

The dune line of Ocean City follows an offset path with the building line along the back of the beach. The dunes are segmented in the northern and central areas (Fig. 1) and the southern area does not have any dunes (Fig. 2). Dunes have not only been created at the offsets but they also exist at the beach filled area and are moderately covered with dune grass.

Small timber groins have trapped sediment transported south from Ocean City's beach-fill operations. Groins are concentrated toward the north end of the island (Fig. 3), but extend to the limit of southern development with an increased spacing interval. There is a bulkhead in the central part of this segment and a rip-rap seawall in the southern section. The 1981 SPMP classified Ocean City's beach as Category I, critically eroding, however, the NJBPN of 1993 states that the beach erosion problems are not as critical in this portion of the barrier island as they are to the north. Beach nourishment in conjunction with the bulkheads and groins may have helped retard the process of erosion within the area since the time it had been classified with an erosion rate in 1981. Comparison of storm damage caused by ocean waves from the October 1991 and January 1992 events and the more intense December 1992 storm demonstrate the protective and sacrificial effects of the beach nourishment projects.

Ocean City has 48 groins ranging from 80 to 1070 feet in length (USACE, 1990) and their construction varies: 32 are made of timber, ten are made of stone, two are made of timber/steel sheet, two are made of stone/timber core, one is made of stone/timber and, one is made of stone/concrete (USACE, 1990). Ocean City also has 13 bulkheads with an average height of about eleven feet and the length varies from 130 to 1200 feet. (USACE, 1990). Twelve of these bulkheads are constructed of timber and one is made of sheet-pile steel (USACE, 1990). In addition to the groins and bulkheads, Ocean City has two groin breakwaters made of timber/stone, one revetment made of sandbags, and three bulkhead/revetments: one is made of timber, one is made of timber-stone-timber, and one is made of timber/stone (USACE, 1990).

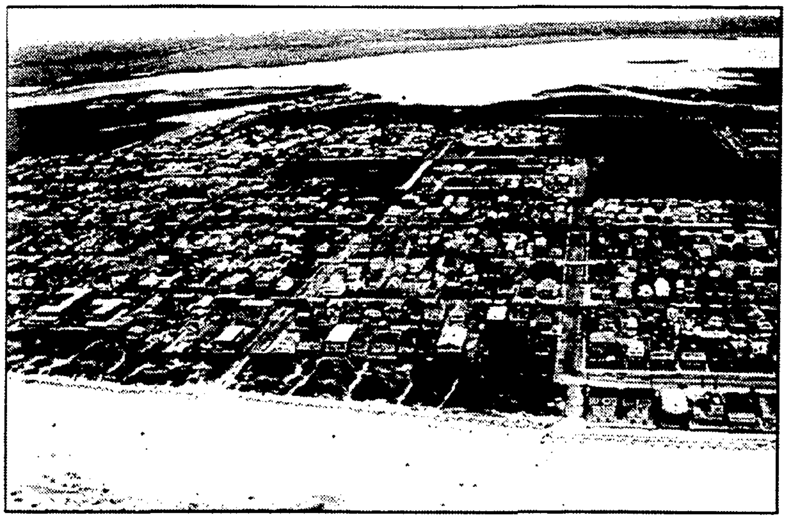

Figure 1. Dunes in segments caused by offset in housing development. Central Ocean City.

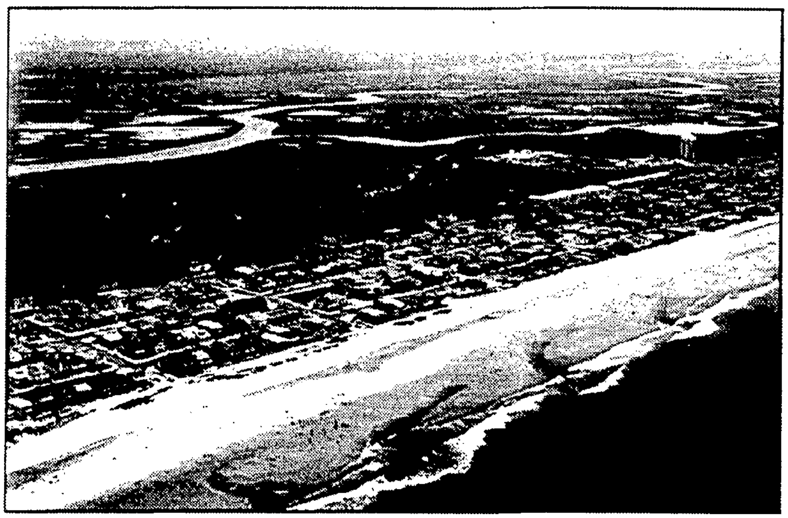

Figure 2. Bulkhead at top of beach, small dune forms, narrow beach. Southern Ocean City.

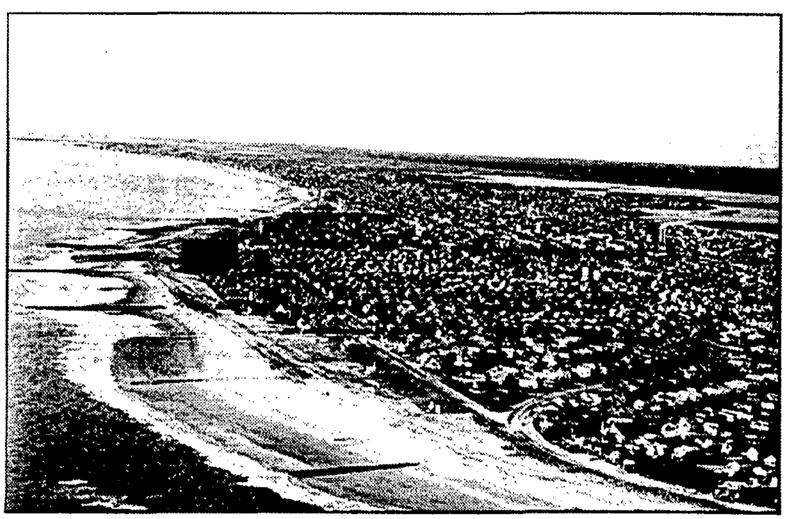

Figure 3. Groins at northern Bulbous end of barrier island. Development covers entire island, coastal dunes in segments. Ocean City

Reach 11: Corsons Inlet to Townsends Inlet

Reach 11, Ludlam Island, is a narrow barrier island within the Southern Barrier Islands Complex extending for approximately 8.6 miles (13.8 km). This reach extends from Corsons Inlet to Townsends Inlet and consists of two recreational communities: Strathmere (Upper Township) and Sea Isle City. The littoral drift is southerly, and the bulbous northern end of the barrier island has a narrow beach (Fig. 1). The northern portion of the island, occupied by Strathmere, has a very narrow beach width. The beach widens at the southernmost area of Sea Isle City. Ludlam Island is unusual among the New Jersey barrier islands because the shorelines near Corsons as well as Townsends Inlets have been relatively stable to accretional over the past 50 years, while the mid-section has retreated and is presently sand-starved. Much of the development, found mostly in Sea Isle City is located close to the high mean water line and can potentially be damaged during moderate storms. The entire reach is classified as Category I, critically eroding (1981 SPMP). The bulbous northern end of the island was classified as Category II, significantly eroding by the 1981 SPMP, but today is undergoing strong erosional processes. The inlet shore on Corson Inlet is classified as Category III, moderately eroding (1981 SPMP).

Corsons Inlet has never been stabilized or managed by dredging. Presently, the inlet opening is narrower than at any other time in the historic record (Farrell and Leatherman, 1989), due to the growth of the northern tip of Strathmere into the inlet opening.

Ludlam Island has a limited natural sand supply. Beach nourishment and moderate levels of hard structure construction have not been able to sustain beach width stability and it is presently critically eroding. Ludlam Island has had beach nourishment several times: Strathmere's most recent beach fill was done in 1984 and Sea Isle City's most recent beach fill was done in 1987. These projects have helped to somewhat stabilize the area which was not subjected to any greatly eroding storm until October 31, 1991.

Strathmere is about 2.3 miles (3.7 km) long with narrow beach widths that decrease to zero in central Strathmere (near Vincent Street), and increase to the north at the southern inlet shoreline. The beach is too narrow to support dune systems. The Strathmere dunes have been destroyed and rebuilt numerous times as storms have washed the duneline westward onto the marsh and onto properties located west of the roadway. Strathmere has 13 groins ranging from 125 to 500 feet in length (USACE, 1990). Five are made of timber and seven are made of timber-stone (USACE, 1990). Strathmere also has one timber bulkhead that is 3175 feet long and nine feet high (USACE, 1990) and a wavebreaker (USACE, 1990).

Whale Beach is a segment of narrow beach on Ludlam Island in both Strathmere and Sea Isle City and is an area of critical hazard (Fig. 2). Wave refraction on the inlet shoals produces erosion along this stretch of shoreline which is not reduced by the effects of beach protection structures (two groins) along adjacent shoreline segments as they interfere with the longshore transport of sand to Whale Beach. Dune creation attempts have not lasted due because of the low, narrow beach area which cannot support the dunes.

Sea Isle City has approximately 4.8 miles (7.7 km) of narrow beach and has a steep beach slope because of the constant erosion. Sea Isle City, an intensely developed section of the barrier island, is much wider at its southern portion, but low in elevation. A dune system was developed in front of the asphalt promenade that extends from 28th Avenue south to 58th Avenue and it has provided significant protection for the community during recent storm events. North of the walkway, much larger dunes have protected the houses from wave attack. The relatively wide and high, well-vegetated dunes were severely cut back in Sea Isle City due to the October 1991 storm and the storm of December 1992. Since the storms, the dunes are missing in the center of the island (Fig. 3), but are in the process of being rebuilt with sand pushed up from the beach and replaced from the overwash deposits excavated from the properties and roads. The southern shorefront has no walkway, therefore private homes directly front the beach as recent storms had removed the dune system. Sea Isle City has 16 groins and they range from 300 to 716 feet in length (USACE, 1990). Four are made of timber, eleven of timber-stone and one of stone (USACE, 1990).

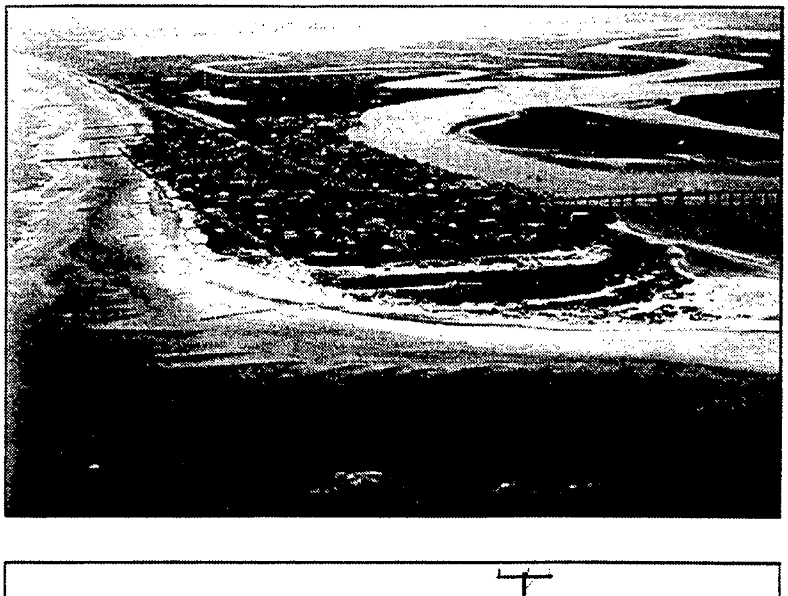

Figure 1.
Bulbous end of barrier island. Accretion at inlet, absence of beach at bulkhead.
Strathmere

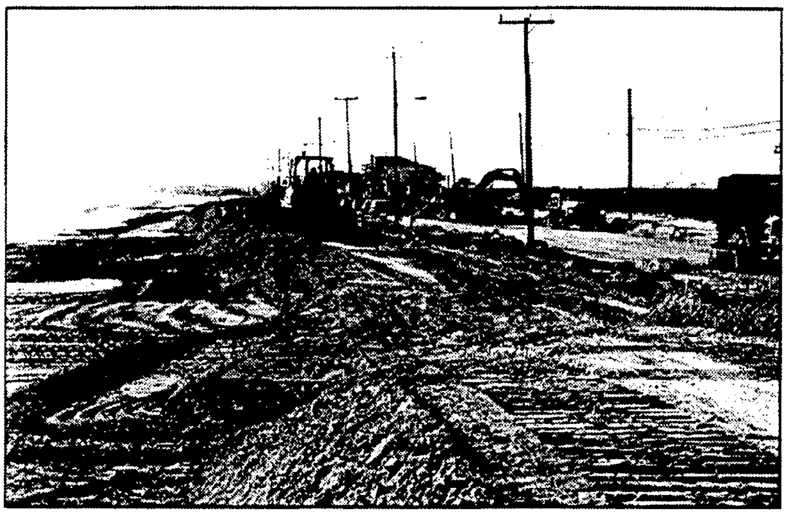

Figure 2.
Overwash across road. Jan. 1992 storm. Rebuilding dike form North Sea Isle City.

Figure 3.
Groins in beach, absence of dunes in central portion, bulkhead and boardwalk development.
Sea Isle City

Reach 12: Townsends Inlet to Hereford Inlet

Reach 12, Seven Mile Beach, is approximately 13.5 miles (21.6 km) long and contains two recreational communities: Avalon Borough and Stone Harbor Borough. Reach 12, which extends from Townsends Inlet to Hereford Inlet, is part of the Southern Barrier Islands Complex in which the littoral transport is southerly. This "drumstick"-shaped barrier island has had a history of erosion/accretion on its northern bulbous end and a great deal of erosion at its southern end.

Northern Avalon has lost land to Townsends Inlet, an inlet which had begun to migrate in a southwest direction during the early part of the 20th century, and gradually eliminated almost all of the five blocks of the area's street plan. In 1978, when Townsends Inlet was dredged for sand used as beach nourishment for Sea Isle City, the main inlet channel began to migrate again and resulted in additional erosion. Beach nourishment projects were done as an attempt to counter the erosion, but they have not been successful in stabilizing the area, including the most recent beach fill operation done in 1995. The erosion near the inlet has been critical and continual, even though the 1981 SPMP had classified this inlet shoreline as Category III, a moderately eroding area.

The southernmost portion of Reach 12 has become a classic example of shoreline displacement downstream of a terminal groin. Hereford Inlet is now the widest inlet in the State due to the long-term erosion of the southernmost two miles of the barrier island, which was once Stone Harbor Point. The Hereford Inlet shoreline, classified as Category I, critically eroding, (1981 SPMP) has no jetties, but is heavily lined with rock revetment and short groins. This portion of the barrier island is undeveloped and is currently protected by the borough of Stone Harbor as a nature sanctuary.

Avalon has approximately 7.8 miles (12.5 km) of oceanfront which is relatively stable and of adequate width. It has been classified as Category IV, non-eroding (1981 SPMP). As a result of the beach fill operation in 1995, the seawall at the back of the beach is covered by sand (Fig. 1). The dune system located in a section east of Dune Drive has been preserved, and is one of the most extensive dune fields found in New Jersey, outside of those within the natural parks. A portion of Avalon fronts along Townsends Inlet and is continuously protected with bulkheads and revetments along the ocean frontage. Avalon has six groins that range from 228 to 800 feet in length: four are constructed of stone, one is made of stone-filled timber, and one is made of timber (USACE, 1990). Avalon also has a stone seawall that is 1300 feet long, a timber-stone bulkhead that is 4000 feet long, and a timber-stone bulkhead-revetment (USACE, 1990). In addition to these shore structures, Avalon also has a Beachsaver Reef put in place in July/August 1993, which is presently being monitored.

Stone Harbor has about 3.6 miles (5.8 km) of oceanfront. The beach is of adequate width at its northern portion, but it gradually narrows to the south. Stone Harbor has a dune system, with low and narrow dunes, which had been developed between 1986 and 1991. The dunes are smaller than those in Avalon. The northernmost area of Stone Harbor has been classified as Category IV, non-eroding (1981 SPMP). Stone Harbor has a protected shoreline consisting of widely spaced groins which retain sand on the beaches, but at the expense of the segment to the south. A combination of sediment starvation, refraction, and diffraction around the last groin in Stone Harbor has produced acute downdrift erosion within the southern area. Because of the narrow beach and proximity of development to the high water line, the southern end of Stone Harbor is classified as Category I, critically eroding (1981 SPMP). Stone Harbor has eleven groins: five are made of timber-stone, three are made of stone, and three are made of timber-crib-stone (USACE, 1990). They range from 350 to 804 feet in length (USACE, 1990). Stone Harbor also has four bulkheads, ranging from 450 to 6550 feet in length, and two revetments, ranging from 290 to 800 feet in length (USACE, 1990).

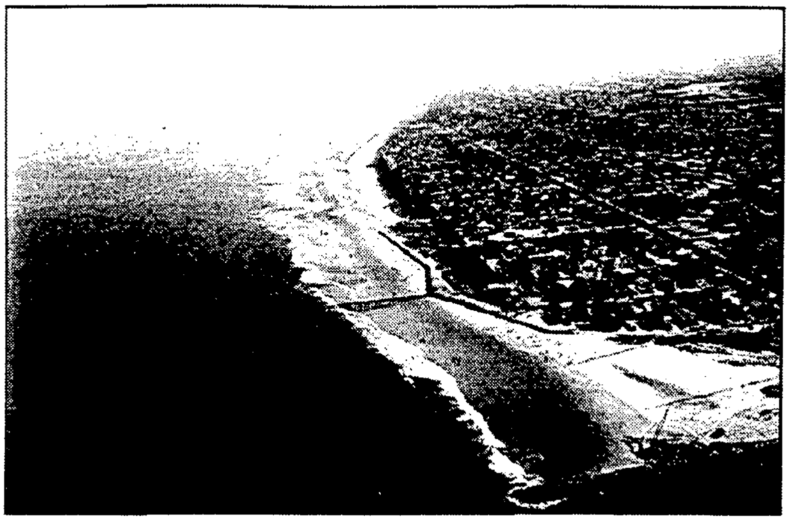

Figure 1.
Bulbous form of barrier island. Beach nourishment has widened beach in front of seawall.
Avalon

Figure 2.
Large dune field preserves pre-development conditions.
Avalon

Figure 3.
Groins in beach, narrow beach, development of artificial dunes.
Stone Harbor.

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