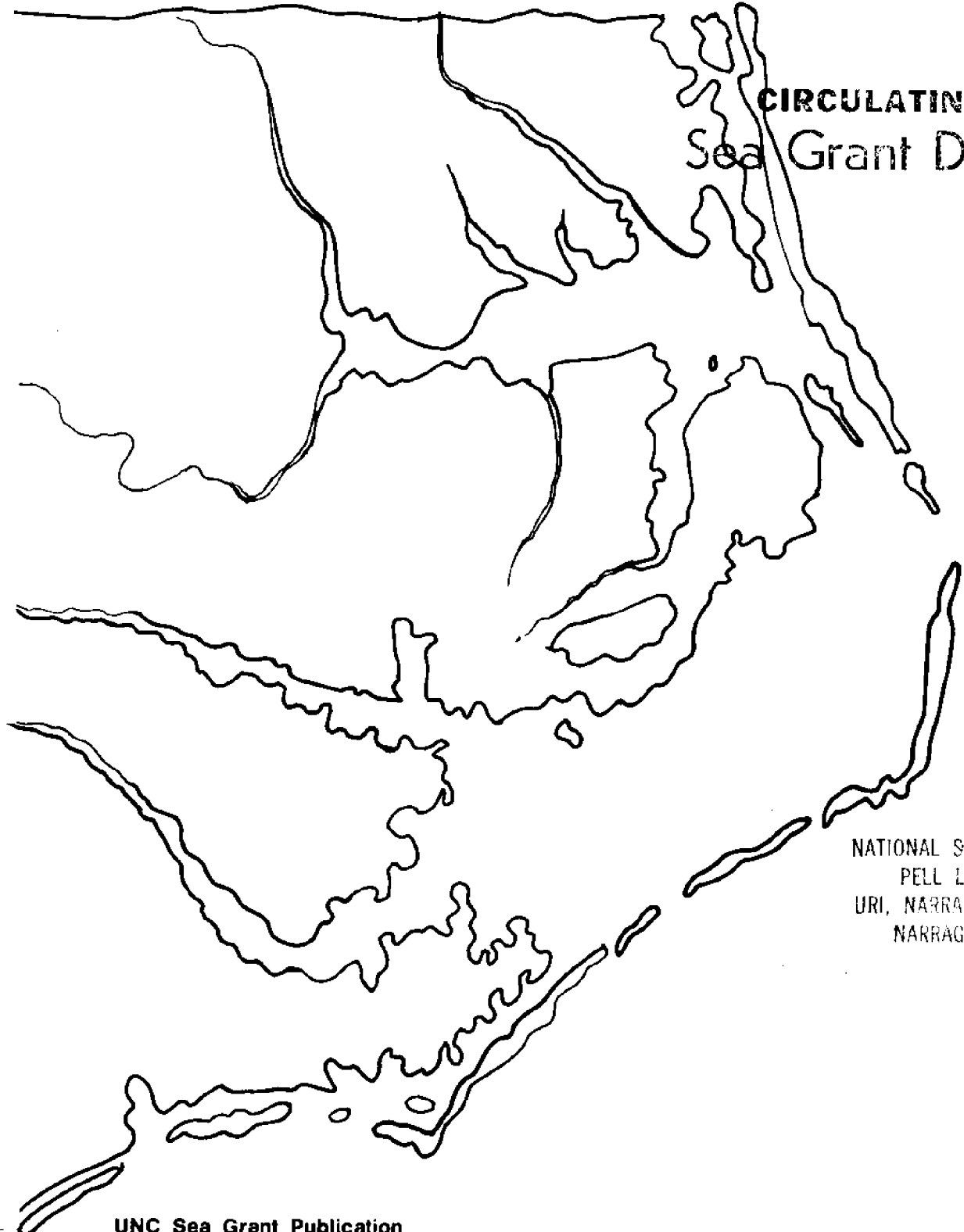


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# N. C. Coastal Resources and Short Term Research Needs: *A View of Priorities*

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May, 1975

N. C. Coastal Resources and Short Term Research Needs:

A View of Priorities

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by  
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Raleigh, North Carolina 27607

## PREFACE

This document was prepared to facilitate priority selections for applied marine research and advisory activity projects for Sea Grant and other similar funding programs. It has been compiled by Sea Grant staff, reviewed by the University of North Carolina Marine Science Council and relevant state agency personnel. Review comments from all these have been incorporated to develop a priority system responsive to state and university goals and needs.

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We appreciate the efforts by these people and welcome the interactions of all concerned to help create a planning document for better management of North Carolina's coastal resources.

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## I. INTRODUCTION

A preliminary planning report for marine and coastal resource development in North Carolina was completed in 1972 by a joint state-federal committee under the auspices of the North Carolina Marine Science Council. The report was also endorsed by the Coastal Plains Regional Commission and the administrator of the National Oceanic and Atmospheric Administration. Problem areas existing in the development and utilization of North Carolina's marine resources were identified and general research activities to optimize the preservation and utilization of marine resources were prioritized.

Since the preliminary planning document was completed many things have changed and the problem identification and research needs have become outdated. Accumulation of new knowledge, recent legislation, emergence of new problems, and changes in societal and economic needs have all made it desirable to develop a new and more timely planning document.

The following documentation is not intended to be all inclusive nor to preempt the development of needs by the North Carolina Marine Science Council and/or state agencies. It is, instead, to be a document of the University of North Carolina Marine Science Council and to be used as a planning document for University research planning such as the Sea Grant Program and related research activities. It is important to note that the document has not been prepared in isolation, but indeed has received the scrutiny and feedback of all pertinent agencies within the state of North Carolina. Hopefully, this documentation can serve as a planning guide for marine resources research, education and advisory activities for the next three year period. Inclusion and/or exclusion of priority research needs in this document does not preclude the need for research in those areas as viewed by individuals, agencies or research groups. Rather, the priority listing given here is a means whereby planning can be improved.

Although North Carolina's coastal and marine resources do not necessarily follow traditional categories and disciplines nor do the solutions to problems fall within narrow categories, it is necessary to categorize needs for the sake of organization and division of tasks. Thus, we will follow the same eight categories presented in the original preliminary planning document; viz., mineral and energy resources, marine transportation, recreation and tourism, commercial fisheries, aquaculture, environmental quality, oceanographic research and coastal zone management.

Our approach for each of the resource categories is to develop goals, discuss the implications and ramifications of achieving those goals, and establishing priorities for research needs to achieve the goals. Goals are developed in a relatively broad sense in order to allow some flexibility in research activities and adjustments required by changes in emphases, legislation or expertise and money available to achieve the end results. We have arranged the priority of research needs into three categories:

- 1) Critical Needs - Activities in this category would be those of a very critical and timely nature. Occurring here would be research into problems that if not solved now would lead to loss of or threat to resources, economic hardships, gaps in knowledge preventing utilization or management and dangerous situations. An example of a critical need would be problems of severe pollution adjacent to barrier islands because of the lack of criteria for siting and optimum density of septic tanks.
- 2) Urgent Needs - Problems in this category would be those that if not solved soon could lead to critical situations. An example of this type of problem would be the development of a deep water port without adequate knowledge of the circulation and mixing of water on the continental shelf.
- 3) Priority Needs - Falling in this category would be problems that are not yet critical but solutions to them would be highly desirable. While in the first two categories the orientation of research would be in a highly applied direction, considerable basic research would fall into this category. Examples of research in this category would be development of untapped markets for seafood products and more economical means of stabilizing shorelines and beaches, aquaculture, sociological impact of marine resource development, development of port facilities to accommodate larger and more complex vessels and economizing unloading capabilities.

Establishing priorities for research needs into the above categories does not necessarily exclude one need over another, but provides a convenient means of emphasis. All of the research needs outlined in this document are essential for development, utilization, and management of North Carolina's marine resources. It is important that a balanced research program be maintained so that there can be an orderly and meaningful management program that maintains the appropriate balance between economic and environmental questions.

## II. COASTAL ZONE MANAGEMENT

### II. 1. Introduction

North Carolina's long coastline and its large complex of barrier islands, dunes, sounds, bays, marshes and estuaries represent a tremendous resource that must be closely managed if we are going to realize the full potential of economic return and social well-being for North Carolina and the nation. It is important that the relationships between uses of the coastal resources and maintenance of environmental quality necessary for preservation of those resources be optimized. Since the development of one natural resource with concomitant destruction of others is poor management, it is necessary that one state agency be put in charge of coordinating coastal zone management before wise use can become a viable reality.

Recently the State of North Carolina passed a Coastal Area Management Act which sets forth the statutory authority for managing the North Carolina coastal zone. The passage of this legislation also enabled North Carolina to comply with the federal coastal zone management program and thus qualify for federal aid to assist her in the implementation of an effective management program. These activities are being carried out under the auspices of the North Carolina Department of Natural and Economic Resources. The passage of the Coastal Area Management Act has finally placed within one body the coordinative authority for coastal zone management, which should lead to a more comprehensive program of planning for the wiser use of coastal resources.

Basic to the effectiveness of the Coastal Area Management Act is an active, relevant and coordinated research program to meet coastal zone management needs. It is important that there be a system for establishing priorities and insuring that research responds adequately to the needs of management programs. The development of material for this document is a step in that direction.

### II. 2. Goals

The primary goal in coastal zone management is to assure resource development compatible with resource and environmental conservation, thus allowing the best standard of living over the longest period of time for the citizens of the region. The goal of coastal research must be to support this program by providing a technological information base on which rational use decisions can be developed.

## II. 3. Problems

### II. 3. A. Critical Needs

#### II. 3. A. 1. Erosion and island movement

Our coastline, both the outer edge and the inner edges of the barrier islands, is continuously undergoing change due to erosion and accretion. Likewise, the ends of islands and tidal passes are continuously moving and changing their shapes due to depositional and erosional forces. There is also a slow movement of the barrier island dune system and backshore toward land. These phenomena are fairly well understood but the movement rates and relationships to developmental pressures are not so well known.

Much good work has already been completed to determine the erosion and accretion rates for the outside edges of barrier islands, but almost none has been done for the inner edges. There is a need to complete a large scale research program investigating these erosional forces and charting their rates. Such information can lead to adoption of realistic setback lines and rational regulation of developmental activities on the Outer Banks.

Quantifying the problems is a first step, to be followed by means of dealing with the problems. Research is needed to determine cost-effectiveness and environmental soundness of stabilizing shores and combating erosion.

#### II. 3. A. 2. Legal and jurisdictional problems

Present activity in promulgation of the Coastal Area Management Act and other coastal development activities have made legal and jurisdictional questions concerning the Act and the state's jurisdiction over lands and waters acute. Research in this area should be immediately responsive to questions as they arise because of timing constraints.

Legal research is required to determine what amendments are desirable for the Coastal Area Management Act if problems in its implementation schedule occur. Guidelines for development in the areas of environmental concern and along the North Carolina Outer Banks are in the process of being developed and implemented, but some legal and

jurisdictional problems relating to the guidelines implementation on the part of the State have yet to be clearly set. Another area requiring immediate research lies in the area of jurisdictional responsibilities of the State and Counties involving ownership, regulation and conservation of lands and waters. Other acute problems are bound to arise as promulgation continues, such as the questions of "taking" and compensation in the North Carolina context.

#### II. 3. A. 3. Coastal ecosystems classification system

The North Carolina coastal zone consists of a large variety of ecosystems, which interact with one another. One of the necessities in producing an effective management program is understanding the interactions between the complicated ecology of the coastal zone and various potential developmental uses. It is not possible to study in detail every ecosystem, but it is possible to have detailed knowledge of different types of ecosystems present in North Carolina.

A first step in such a program would be the development of a coastal ecosystems classification system. The chief requirement for the development of such a system would be the accumulation and synthesis of existing knowledge relating each ecosystem type. With such information, one could then develop an understanding of the controlling factors and the impact of various influences on the stability and maintenance of each coastal ecosystem type.

#### II. 3. A. 4. Guidelines for areas of environmental concern

A very important next step after development of a coastal ecosystem classification system would be the establishment of impact criteria for areas of environmental concern. If information relative to controls and influences of each ecosystem type were known for North Carolina then it would be possible to develop a realistic information base for the types and to project the effects of various developments and usages in areas of environmental concern. This work would be supportive of land-use mapping and would allow selection of areas for preservation, which will be discussed in a later section. The regulations adopted should be analyzed for their effectiveness and then coupled with regulatory processes to establish scientific arguments for regulation and potential usage.

## II. 3. B. Urgent Needs

### II. 3. B. 1. Dune and spoil stabilization

In some areas along the coast, physical changes and developments are necessary and desirable. In these areas, exposed shorelines and dunes need to be stabilized in a rapid and cost effective manner.

Much research and development work has already been accomplished toward the development of legislation for dune and spoil stabilization. Although this work a foundation of information has been established on the long-term economic feasibility of using vegetation for stabilization needs to be established. Also research to broaden understanding of various methods available for various kinds of stabilization problems is urgently needed.

### II. 3. B. 2. Data base for identifying preservation areas

An essential part of any coastal zone management program is the preservation of certain unique and important areas. As discussed in the section on Recreation and Tourism there is a tremendous demand on North Carolina for establishing park areas for the long-term preservation of the natural beauty and uniqueness present on the North Carolina coast. Before such a program can be efficiently and effectively developed, we must classify the areas as to their uniqueness, distribution and availability. This work is closely related to legal problems as well as an ecosystems classification system.

### II. 3. B. 3. Land-use mapping

An important tool for an effective coastal zone management program is land-use mapping based on present and future uses. In order to be most useful, the land-use map must be equated with the coastal ecosystem classification system.

Most of the imagery necessary to develop a land-use map for coastal North Carolina exists, but the appropriate scales for assessment of needs and ground-verification are still seriously inadequate. Most of the North Carolina coast is being mapped on 7½ minute orthorectified photographs, which will serve as a common base for land-use mapping. It is necessary to complete an inventory of existing aerial photography and maps as they related to past land usage.

Thus, most of the research needs for land-use mapping are in the area of applying existing technology to develop an usable land-use mapping system. After bench-mark land-use mapping has been completed it will be necessary to continue a program of updating. Remote sensing still requires some research in the area of spectrum selection, interpretation techniques and scaling before it can be practical.

## II. 3. C. Priority Needs

### II. 3. C. 1. Guidelines for environmental analyses

With the implementation of the Coastal Area Management Act and with the existing National Environmental Policy Act, environmental impact statements must be developed and analyzed before activities are allowed to occur in critical areas. Technical data are required to develop the guidelines for preparing environmental analyses and utilization of these by permit-granting agencies (such as the Coastal Resources Commission). This work must include consideration of criteria for possible permitting of development in the coastal zone. Follow-up work needs to be undertaken to determine the effectiveness of impact analyses in development policies and regulation of environmental impacts. Environmental impact analyses must include social impacts as well as economic and environmental impacts.

### III. ENVIRONMENTAL QUALITY

#### III. 1. Introduction

North Carolina has a vast system of coastal waters, marshes and outer banks. The approximate 2.6 million acres of estuaries, bays, marshes and sounds makes North Carolina rank third in the nation in area of enclosed coastal waters and salt wetlands. The state's 350 plus miles of outer coastline is continuously under pressure from housing developments, recreation and tourism industries, commercial fishing, development of energy resources and other activities. A comprehensive assessment of present environmental quality and a realistic management program are required to maintain the environmental quality of this base area of unique resources.

Extensive stretches of the Outer Banks are facing heavy developmental pressures, which creates severe complications for an effective environmental management program. Research is required on the perplexing problem of optimum population density, relative to waste disposal capacity. Resources utilization in the coastal zone is extremely varied. In many cases, conflicting uses confound the development of best use policy and the setting of quality standards. Maintenance of the aesthetic appeal and maintenance of maximum productivity rely upon the development of water quality programs of maximum efficiency.

The 1969 National Water Quality Act and its subsequent amendments have provided the framework whereby environmental quality can be maintained. Coordination by the state with federal water quality standards and adequate monitoring and regulatory programs provides a means of maintaining acceptable water quality. Research is needed, however, to provide a data base for formulating environmental standards and developing a management program to maintain environmental quality.

Several programs under the auspices of federal and state agencies and universities are at work in the coastal zone dealing with the problems of environmental quality. State water quality monitoring programs are conducted by the Division of Marine Fisheries and the Division of Environmental Management of the Department of Natural and Economic Resources. The Division of Health Services of the Department of Human Resources conducts surveys of water quality throughout the North Carolina coastal area, particularly in shellfish areas. Several federal programs,



conducted chiefly by the National Marine Fisheries Service, the U. S. Fish and Wildlife Service and the Environmental Protection Agency, are developing quality standards and regulatory programs. Much of the hydrologic and climatologic data have been processed for computer storage and manipulation through the state Hydrologic Information Storage and Retrieval System and the Environmental Protection Agency's STORET system. Much research into environmental quality problems conducted in the coastal zone is done by university and private research groups.

### III. 2. Goals

The primary goal is to assure the nondegradation of estuaries, sounds and marshes through the enactment of an effective and comprehensive water quality surveillance and management program. Secondary goals include programs to expedite the reclamation of low water quality coastal environments (e.g., areas closed for shellfishing) through research and development of a data base for management programs, and development of a system of management that treats the nearshore continental shelf as an entity linked to management of the coastal environment.

### III. 3. Problems

#### III. 3. A. Critical Needs

##### III. 3. A. 1. Coastal land carrying capacity

One of the more critical problems relating to environmental quality in the coastal zone is the density and efficiency of septic tanks, particularly on the Outer Banks. More knowledge about soil conditions and drainage aspects is needed before realistic standards can be set for septic tank density. The quality of groundwater and its rate of recharge and movement need to be determined before policy can be established in the construction and use of septic tanks.

A data base needs to be developed whereby regulations can be established controlling the maximum sewage loading for septic tank fields. The rates of seepage of nutrients, heavy metals and pathogens from septic tank fields into natural waters are not known. Obstructions that modify

subsurface drainage have in many cases, led to changes in water tables which cause malfunctions of septic tanks resulting in ground and surface contamination. This contamination can then be washed into streams and estuaries following rains.

The quantity and quality of freshwater is a limiting factor for coastal development. We need data to develop criteria for management and usage of the freshwater resources, as well as development of alternatives for meeting supply needs. Information is needed to determine what modifications and density can be tolerated within water resources availability.

### III. 3. A. 2. Offshore disposal of waste

With the increasing density of people and activities along the Outer Banks, a logical alternative for disposal of sewage is through offshore pipelines. Before this can become a viable alternative, we need to determine the complexities of nearshore and offshore mixing and dispersion as well as the effects of disposal sewage on biota and water chemistry.

Another critical need is an understanding of the effects of offshore disposal of waste from industry and related activities. Dilution, dispersion and detoxification criteria need to be determined before this type of disposal can be allowed. Determination of disposal sites and treatment requirements for safe and efficient discharge must be determined.

Adequate policy for offshore disposal of waste must deal with economic impacts along with the physical, chemical and biological problems. Unless there is adequate economic incentive for the development of efficient and well engineered disposal systems, there is little need to develop the engineering technology. We must also research institutional alternatives for policy and permitting procedures, especially state-federal divisions of authority.

### III. 3. A. 3. Lowland agricultural drainage problems

The recent emphasis on clearing and draining wetlands for agricultural purposes in the coastal zone has given rise to several questions regarding environmental quality. One of the more perplexing problems deals with the percolation of materials from farming activity (e.g., pesticides

and nutrients) through the groundwater and into adjacent estuaries and marshes. Overflow of the land possibly washes bacterial contaminants into streams and estuaries, whereas properly designed and placed drainage ditches could result in these contaminants being trapped in the soil. The impact of such drainage procedures and feasible controls must be known before policy can be established regarding regulations concerning lowland agricultural activities. It is necessary to develop technological means of constructing drainage canals and regulating flows of water through them. The impact, development and utility of vegetated buffer zones around agriculture systems should be researched. Another perplexing problem is the transport of sediments through drainage canals and onto shellfish beds and various areas of coastal estuaries.

The most prominent environmental change is the modification of a stable marsh/forest ecosystem to a farm system. This change leads to reorientation of drainage, water storage capacity, climatic modifications, soil oxidation, populational and economic changes, and social perturbations. Knowledge of these changes is needed to form policy criteria for regulation and management.

It is important that economic impact of the physical and agricultural practice changes be understood. It may be that the conservation of water within the confines of the farm would be of economic benefit.

### III. 3. B. Urgent Needs

#### III. 3. B. 1. Shellfish areas and pathogens

Almost 700,000 acres of North Carolina estuarine areas are closed to commercial shell fishing because of high bacteria populations. Causative agents (i.e., humans vs other animals) for high coliform counts are not known nor do we have means of control. The methods of measurement and pathogen assessment presently used need to be investigated so that more realistic evaluation of viruses and pathenogenic bacteria can be made.

#### III. 3. B. 2. Power plant siting

One large nuclear power plant has begun operation in the North Carolina coastal zone, yet the state still lacks a workable policy regarding the peoper and efficient siting of such plants and has no radionuclide monitoring network.

With coal- and nuclear-generated electricity being two of the most promising sources of power in the foreseeable future, it is important that background technical information be obtained upon which to develop policy for siting power plants in the coastal zone. The economic and environmental impact of cooling towers may be such that once-through cooling or re-circulating cooling ponds might be a more acceptable means of cooling power generators. With its large volumes of accessible salt water, the coastal zone offers the possibility for additional power plant sites.

Although considerable research has been conducted in the environmental aspects of power plant operations we still do not have sufficient information for effective environmental evaluations. We need a more efficient and realistic means of determining site availabilities for power plant operations along with the environmental data concerning the impact of removal of large volumes of water and the disposal of heat. One of the more critical unanswered problems is the effect of entrainment upon the populations and habitat of many sports and commercial species. Since many of these and foodchain species migrate into estuaries as free-floating larval and post-larval stages, entrainment of these organisms by cooling water withdrawals is a very critical aspect of power plant siting. Work in the area should also consider the environmental impact of offshore floating power platforms and development of adequate seismic monitoring.

### III. 3. C. Priority Needs

#### III. 3. C. 1. Physical alterations and reclamation

Interlacing the entire North Carolina coastal zone are many hundreds of miles of dredged channels. Considerable maintenance dredging must be conducted to keep the channels open and safe for boating activities. The recent enactment of dredge and fill laws in North Carolina now require that the spoil from such dredging activities be deposited in impounded areas. Although this practice has resulted in notable improvement of the impact of sediments, the impounded areas raise other environmental questions such as mosquito production (See Section VII. 3. B. 3.).

There is also considerable pressure regarding the need to dredge new channels, develop marinas and construct bulkheading in many areas along North Carolina's coast.

The environmental impacts (both positive and negative) of such activities are not adequately known.

A complete picture of these problem needs should include economic analysis of physical alterations along with the environmental trade-offs. For example, what is the relative cost of reclaiming an area versus the prevention of the alteration originally?

### III. 3. C. 2. Wildlife and bird habitats

One of the valuable features of the North Carolina coastal zone is its abundant and varied wildlife and bird populations. In order to maintain this valuable resource we need to develop an information base concerning the maintenance of habitats for various species of wildlife and birds. One of the more important aspects of this is the development of techniques for determining population structures and magnitudes. Until this can be developed enactment of policy and regulations for maintaining wildlife and bird populations remains unsatisfactory.

Important to the maintenance of wildlife and bird habitats is the development of technology and information dissemination regarding coastal development techniques. In many cases wildlife and bird habitats can be maintained in an adequate manner by closely regulating and coordinating land development and/or water utilization.

### III. 3. C. 3. Petroleum transport and processing

With the present (and worsening) energy crisis in this country, more emphasis is being placed by the state upon the transport and processing of petroleum products in the coastal area. Policy required to deal with these problems is difficult to develop without adequate knowledge of the impact of oil spills on beach and marsh ecology or the physical-chemical aspects of oil refinery waste disposal. While considerable work has been conducted on some of these aspects elsewhere in the country, very little is known about the specific impacts on North Carolina systems.

Although research dealing with the specific impacts of oil spills and refinery waste are still required, much work can be conducted through the advisory services technique. Further work needs to be conducted dealing with the economic impact of such activities, and coordination with environmental and social aspects.

#### IV. OCEANOGRAPHIC RESEARCH

##### IV. 1. Introduction

The continental shelf area off North Carolina offers tremendous potential for untapped renewable resources and increased utilization of some activities. It represents an unknown potential, however, for mineral and energy resources and disposal of waste products. Commercial fisheries, recreation and tourism and transportation are already realized on the continental shelf but research and surveys could potentially lead to a much greater return. Along with the realization of the potential and existing resources on the continental shelf many things must be resolved in regard to coastal zone management and protection of environmental quality before realistic planning can be developed.

In addition to the potential of the continental shelf, the extensive sounds behind North Carolina's barrier islands also have unrealized mineral resource yields. With additional basic information concerning the biological, chemical and physical characteristics of the sounds, it is possible that more of those resources may be used while still maintaining environmental quality.

Much of the work needed in oceanographic research is of a basic nature, but it must be designed to achieve the depth of understanding necessary for using and managing oceanic resources. Mechanisms must be developed, however, to enable the application of results of basic research to resource management and use. The North Carolina sounds lie within the jurisdiction of the Coastal Area Management Act and basic data are needed to enable the management program to progress. A complicating factor for the use and management of the continental shelf resources is the legal and jurisdictional problems relating to international waters and territorial rights.

Most of the oceanographic research that has been done off North Carolina has been conducted by academic and research institutions. Duke University has a well-recognized oceanographic program dealing with various aspects of continental shelf oceanography. The UNC Marine Biomedical Laboratory has a highly regarded program of biology on the Continental Shelf. Recently, physical and chemical oceanographers from the University of North Carolina at Chapel Hill and North Carolina State University have become involved in oceanographic research. The

Marine Resources Management Assessment Program (MARMAP) is in progress off North Carolina by the National Marine Fisheries Service Laboratory at Beaufort for NOAA. Basic oceanographic research has been carried out in the sounds (particularly Bogue Sound) by various university and governmental groups for several years.

#### IV. 2. Goals

The primary goal in oceanographic research is to develop a depth of understanding of the biology, chemistry, physics and geology of the continental shelf and sounds necessary for resource evaluation and management.

#### IV. 3. Problems

##### IV. 3. A. Critical Needs

##### IV. 3. A. 1. Circulation and mixing on the continental shelf

Critical to the use of the continental shelf for nearly all aspects of resource development is a clear understanding of the dynamics of circulation and mixing. Since circulation and mixing control the movement of materials in the water, it is necessary that they be quantified and modelled. Extensive data collection and basic oceanographic research need to be completed before we are able to accumulate the necessary data base for adequate information of this type.

Important information needed to plan management programs in environmental quality and transportation includes the circulation and mixing in the sounds, as well as the flow through inlets and relationship to physical dynamics on the continental shelf. Considerable work relating to circulation and mixing parameters in the sounds has been completed. This work, however, includes mainly modeling activities and some spot checking for model verification. Before an adequate picture of the physical characteristic of the sounds and its relation to inlets can be completed, more basic information must be collected.

#### IV. 3. B. Urgent Needs

##### IV. 3. B. 1. Sediment transport and deposition

Many forms of development and use on the continental shelf is influenced by the amount of continental sediment transport and its time and location of deposit. Many of these sediments flow through the inlets and out over the continental shelf, thus creating problems relating to the maintenance of inlet stability as well as the influences of sediments upon approaches to the inlets. The well-being of structures and bottoms on the continental shelf rely upon adequate controls and management of sediments in and around structures. Proper knowledge of sediment transport and deposition is required for more efficient planning.

Work on sediment transport and deposition in the sounds has been completed for some localized areas, but more comprehensive work is needed so that management knowledge will be available for the entire sound area.

##### IV. 3. B. 2. Density and distribution of biological communities

With the exception of a few fishery surveys and small biological oceanography studies, our knowledge of the density and distribution of biological communities on the continental shelf off North Carolina is inadequate. Accumulation of basic information about dynamics of the biota on the continental shelf is necessary before proper planning and resource utilization can become a viable reality. Our body of information concerning biological communities of the sound areas improves annually, but is still inadequate.

#### IV. 3. C. Priority Needs

##### IV. 3. C. 1. Wave dynamics and long-shore currents

Essential to the complete understanding of circulation and sand transport problems is adequate information about wave dynamics and long-shore currents. Many of the activities and usages of the shorelines, both on the ocean and sound sides, rely upon proper knowledge and accounting for dynamics of long-shore currents.



In spite of some very fine recent work along the North Carolina shorelines, we still do not have adequate information concerning the distribution and magnitude of long-shore currents. A complete mapping and understanding of this phenomenon is necessary before planning for shoreline utilization can proceed efficiently. We also need to have more complete knowledge of the impact of changing wave patterns and long-shore current patterns created by man-made structures on the stability of the shoreline and structures placed there. The accumulation of adequate information in this area is an extremely complex and long-range problem.

#### IV. 3. C. 2. Seabed characteristics

Recent studies regarding a deep water terminal identified the great gap in our knowledge of seabed characteristics off North Carolina. If construction of largescale developments are to occur on the continental shelf, knowledge of the seafloor characteristics are needed for design and site selection purposes.

## V. MINERAL AND ENERGY RESOURCES

### V. 1. Introduction

In the discussion of mineral and energy resources we are including hard minerals like stone, gravel and phosphate rock, as well as fuel resources. Although groundwater is not usually considered to be a mineral resource, we are also including it in this chapter. While much of the problem solving in this area will involve geology, other disciplines are included as well.

Compared to some other eastern seaboard states, little production of mineral and energy resources occurs in North Carolina's coastal area. This is thought to be due in part to low demand for the types of mineral resources present here and in part to the scarcity of data about the occurrence and distribution of potential mineral and energy resources which might be found there. Stone, sand and gravel have accounted for more than 65% of the mineral commodities produced in North Carolina in recent years. During the past ten years, considerable mining of phosphate rock has also taken place. There has been no production of fuels in North Carolina.

With the petroleum shortage and its impact on the North Carolina economy, it is reasonable to expect an increase in petroleum exploration in North Carolina's coastal zone. It is significant that a large number of exploratory wells have been drilled by various companies in the North Carolina coastal zone but none have revealed the presence of hydrocarbons in commercial quantities. There remains some interest in exploration of oil and gas deposits offshore.

The most prominent potential oil and gas deposits lie in the Baltimore Canyon and the Georgia embayment, but several references in recent surveys have indicated a low probability of petroleum possibilities exist off the North Carolina coast. There is some evidence that deposits of hard minerals may also exist on the continental shelf.

The world shortage of fertilizers has spurred interest in expanding the present phosphate mining and milling operations in coastal North Carolina. Phosphate rock deposits are known to exist on land as well as under some estuarine waters. The extent and magnitude of the phosphate rock deposits in coastal North Carolina are fairly well

known at the present time, but the environmental impacts of sub-estuarine mining have not been studied.

In addition to determining the extent of mineral and energy resources in coastal North Carolina, it is necessary that policy be established relating to the environmental impact of potential mining and mineral transportation. The anticipated increase in mineral resources exploration and transportation throughout the coastal zone should heighten concern for the environmental impact of these activities and detailed knowledge of that impact must precede policy decisions.

## V. 2. Goals

The primary goal is to promote the development of mineral and energy resources of the North Carolina coastal zone (including the continental shelf) for maximum benefit to the state and the nation over the longest time in a manner compatible with environmental protection and other uses. A secondary goal is to develop an inventory base and policy to regulate mineral and energy resource development for optimum economic return and environmental preservation.

## V. 3. Problems

### V. 3. A. Critical Needs

#### V. 3. A. 1. Groundwater

Although groundwater is not considered to be a part of mineral and energy resources, it represents a tremendous value in coastal North Carolina. Groundwater, also not part of marine resources, represents a base that supports many coastal industrial operations as well as the development potential for recreation and leisure living. A critical problem on the outer banks is the availability of good quality water for human consumption.

In order to properly manage surface and groundwaters in coastal North Carolina, it is necessary to know such things as the extent of the resources and the rates and areas of recharge, especially from contaminated surface water sources. For example, some mining operations require

extensive groundwater out-pumping to maintain adequate mining conditions. Although the Division of Environmental Management in the Department of Natural and Economic Resources has statutory authority to control the withdrawal and use of groundwater, data are needed concerning the impact and limits of withdrawal and the quality and quantity of recharge before dependable use policy can be promulgated.

### V. 3. B. Urgent Needs

#### V. 3. B. 1. Environmental impact

Although some information is available regarding impact of mineral and energy resource development and recovery, this information is inadequate to develop policy concerning the environmental impact of present and future developments. The Department of Natural and Economic Resources has the statutory authority to develop policy and regulate mineral and energy resource development and needs a better data base upon which this policy can be based. With the impending potential of oil and gas exploration, as well as hard mineral extraction on the continental shelf, research must be conducted to determine the environmental impact of such underwater activities and the transportation of resources ashore. An understanding of the environmental impact of underwater mining in the state's estuaries is imperative. Development of alternatives for environmentally safe mining technology needs immediate attention. Likewise, the impact of strip mining and related activities on groundwater resources needs to be more completely understood.

Although the ultimate policy decisions and regulations must be developed by the requisite state agencies, the academic institutions need to bring their resources to bear upon supplying the data base on which to assess mineral and energy resource developments. No inventory maps or development plans should be developed in isolation of studies of the environmental impact.

#### V. 3. B. 2. Expansion of phosphate mining

Strip mining for phosphate rock in Beaufort County, conducted in a single operation, represents a prominent mineral resource development in coastal North Carolina. To

date this mining operation has had very little measureable effect on the surrounding coastal environment. But, the potential for considerable increase in that mining activity underscores the necessity of evaluating larger mining operations. Extensive investigations have been conducted by North Carolina State University in the Pamlico River Estuary, but more extensive work needs to be done concerning the environmental impact of wastes and the development of technology for mining that does not interfere with ground-water resources. Land reclamation by the phosphate mining company has been exemplary, but additional work needs to be done to formulate policy regarding land use in relation to an expanding industry.

### V. 3. C. Priority Needs

#### V. 3. C. 1. Offshore exploration

Perhaps the greatest potential for increasing the yield of North Carolina's mineral and energy resources is the untapped sources on the continental shelf. There are many problems, however, that must be solved before a basis of offshore yield can be developed. In addition to these obvious and separate needs is a comprehensive and coordinated survey of geologic formations and the basic geology of the floor of the continental shelf. This, of course, should be coupled with a comprehensive knowledge of water movements and quality overlying the sedimentary deposits. Although some of this work falls under the category of fairly basic academic research, most are routine activities that should be sponsored by commercial firms and/or governmental agencies.

#### V. 3. C. 2. Market and economics

Lack of information on the market possibilities for some of the coastal zone mineral resources such as gravel, shell aggregates, clam shell and heavy minerals limits the potential of developing these resources. The failure to develop coastal marketing centers for North Carolina's mineral resources has also hampered development.

The absence of comprehensive economic studies of mineral extraction, transportation and marketing possibilities has

limited resource development. With the added complications of energy shortages and rising prices it has become even more important to develop realistic economic projections for any potential development. Although this work must be done by the commercial firms involved in these activities, research is needed to provide basic criteria and in the North Carolina context.

## VI. COMMERCIAL FISHERIES

### VI. 1. Introduction

Since the days of Sir Walter Raleigh, North Carolinians have relied upon the sea and coastal waters for fisheries. For almost 300 years, commercial fisheries and shipbuilding have been prominent enterprises in the North Carolina coastal area. Other industrial uses, however, have recently surpassed commercial fisheries in annual value. The fisheries catch still yield dockside revenues of \$16 - \$18 million per year, which likely stimulates the local economy to well over \$100 million. The commercial fisheries are a renewable resource and with proper management will produce forever.

Of the more than 50 species of finfish and shellfish harvested commercially in North Carolina waters, about 1/3 of the value is in the shrimp fishery. Other high value food species include scallops, oysters, flounder, spot, croaker and gray trout. These fisheries are seasonal and, in the case of shrimp and many fishes, dependant upon migratory habits. In all cases the preservation of the habitat is extremely important, particularly the nursery ground quality for shrimp production.

It is generally unknown whether species are under-or over-fished by present harvesting techniques, except that the menhaden are definitely over-fished and some of the others (such as mullet and striped bass) are probably under-fished. During the past 10 years, the menhaden harvest has drastically decreased (ostensibly from over-fishing) in spite of large efforts by the National Marine Fisheries Service and the menhaden industry to learn to manage this resource. The catch per unit effort, extent of stocks and environmental factors controlling them are not known for most of the species commercially fished in the state.

A strong paradox exists in the North Carolina commercial fishing industry. While North Carolina landings represent about 3% (although good landings statistics might increase the percentage) of the nation's total catch and about 1½% of the nation's dockside value, the state lags far behind in the area of processing. Indeed, one of the potentially great values in fisheries is the development of processing and handling facilities in North Carolina for those fish caught in the state. Of the nearly 200 wholesale and

processing establishments in the state far less than 100 are producing processed products.

Most commercial fishing operations in the state use very little machinery other than that required for boat propulsion and net retrieval. Most of the sorting, unloading and packing is done by hand, with minor mechanical improvements during recent years.

One of the most critical problems in commercial fishing is the low quality and spoilage loss of both the raw catch and processed materials. This problem has become even more critical with the recent enactment of federal standards regarding both the quality of processed materials and the effluents from processing plants.

Combined with the technological and educational problems confronting the commercial fishermen is the proper development of new products and market outlets for North Carolina products. There is only limited product storage space available so processors and fishermen are unable to market their products at the most profitable times.

Several state, federal, university and trade organizations are conducting various kinds of research and advisory services in the commercial fisheries area. The major agency program is conducted by the National Marine Fisheries Service, Beaufort, North Carolina. Intensive surveys of estuaries and offshore waters from the South Carolina to Virginia borders are conducted by the Division of Marine Fisheries in the North Carolina Department of Natural and Economic Resources. The North Carolina Division of Environmental Management and the Division of Health Services in the Department of Human Resources are conducting surveys of water quality throughout the North Carolina coastal zone. Various university programs, funded by federal and state agencies, are conducting research related to commercial fisheries resources. The University of North Carolina Sea Grant Program and the North Carolina Agricultural Extension Service are conducting advisory services related to commercial fisheries in several coastal locations. Individual trade organizations also serve as organizers for the improvement of commercial fisheries in North Carolina.

## VI. 2. Goals

The primary goal for commercial fisheries is to optimize the economic status of the industry while maintaining adequate stocks and protecting the food chain. Commensurate



with this is the improvement of the quality of the commercial fisheries catch to enhance the economic status of the industry to speed up the development of processing and marketing of seafood products, and initiation of a statistics program adapted to achievement of the primary goal.

### VI. 3. Problems

#### VI. 3. A. Critical Needs

##### VI. 3. A. 1. Statistics

A statistical design needs to be developed that will provide information of value in using statistics as a tool in management of the resource. Information and reporting procedures are needed in such areas as catch per unit effort, influence of weather conditions upon number of days suitable for fishing, economic factors controlling market demands, catch from specific grounds, a breakdown of species and size categories in the catch, etc. For example, there are some examples when abundance of the resource exists but prices are too low to justify fishing; whereas, our statistical procedures are not good enough to manage the situation. In short, we critically need to develop a statistics program and reporting network coordinated with legal, environmental and social changes.

Of unknown quantity, but undoubtedly of considerable magnitude, are several species that never appear in the statistical data. These include catch for sports and recreational activities, catch for home use, and direct sales by fishermen to restaurants and individuals, all of which bypass present reporting channels. Thus, a procedure needs to be worked out to gather these important statistics and feed them into a management scheme.

##### VI. 3. A. 2. Quality of catch and handling

One of the more critical problems facing the commercial fishing industry is maintaining quality of fisheries products onboard ship and in the handling and processing

facilities. Contributing to this problem are inadequately insulated boat holds, insufficient icing and improper packing, antiquated handling procedures, and the widespread, small-sized units. Certainly, the economic yield from fisheries could be increased with improvements in and maintenance of quality of the product during the catch and handling phases.

Although economic incentive is a factor in the improvement of quality, the solution to the problem is mainly in the area of education and advisory services. Technology is already available concerning proper insulation, icing and packing, as well as automated and efficient handling procedures, and an active advisory program is underway. Additional technology may be needed in some areas such as the development of low cost icing and freezing facilities aboard ship.

#### VI. 3. A. 3. Effluent and product standards

New effluent standards developed by the Environmental Protection Agency and state water quality control agencies require that effluent from seafood processing plants be improved. Meeting these new standards promises to be difficult since some of the technology necessary has not yet been developed and available information is not sufficient to change processing procedures so that effluent problems can be minimized. In addition to the needs for new technology and more complete information, extensive education and advisory services activities are called for to promote the use of existing and developing processes in plant management procedures. Economic analyses should be made to relate effluent standards to profit and processing efficiency.

The United States Food and Drug Administration has imposed new and more strenuous standards processed seafood products. These standards include microcontaminants, such as metals, chemicals, microorganism concentrations, and their effects upon products quality. A particularly perplexing problem is the identification and regulation of sources of these microcontaminants, as well as improvement in processing technology to minimize the effects. Research is needed to develop mechanisms for control of microcontaminants during the handling and processing sequences. Here, again education and advisory services are also important.

#### VI. 3. A. 4. Processing facilities

Most of the seafood products harvested and landed in North Carolina are shipped to other states for processing. It is not known whether the lack of processing facilities in the state are due to the lack of capital for establishing these facilities, uncertainties of stock availability and markets or social, political and economic conditions present in the North Carolina coastal zone.

The most urgent need is an understanding of economic, social and technological bases for seafood processing industries. The potential of the seafood processing industry must be understood. Implicit in such a study would be the identification of the technical, social, political, institutional, economic, and other constraints that apparently limit the development of profitable seafood processing facilities. It is important that investment and operation prospectuses be developed for the potentially different types of processing facilities.

Perhaps engineering and seafood processing technology should be improved or new areas developed to lead into new kinds of seafood processing facilities. By-product use and marketing systems are needed to connect fisheries waste with user industries such as swine and poultry feeds. Much of the work needed in this particular area is in the form of advisory services or interpretation of existing technology and engineering for use by the industry.

#### VI. 3. B. Urgent Needs

##### VI. 3. B. 1. Processing technology

There is a great need for research to develop technological systems that will aid processors in improving processing efficiency and product quality. Coupled with the need for more efficient and better processing facilities is the demand for development of technology for processing under-utilized species and development of new products from those already in use. The new effluent and products standards being imposed in the near future will produce a need to improve and develop new technology for more efficient and more sanitary processing techniques.

A strong advisory services program to transfer research results into the methodology of commercial seafood plants is necessary with the development of new technology.

#### VI. 3. B. 2. Marketing

The current state of knowledge in the marketing of seafood products is very general and does not provide a sound basis for decision-making by fishermen or by the various agencies involved. Implicit in this activity is the need for adequate and available statistics relating to the poundage, seasonality and value of various seafood products at several levels of marketability.

Important to the marketing problem is the acceptability of new or improved products and new uses. A comprehensive research program is required to solve these problems. Also needed is exploration of foreign markets for various conventional and new seafood products.

Coupled with surveys and research dealing with the marketing problem should be an analysis of the stability of product sources and improvement and maintenance of product quality.

#### VI. 3. B. 3. Stock assessment

Although the life histories of most of the species involved in commercial fisheries are known to some extent, the relationships of different developmental stages to their environments are not so well known. Of equal importance is the lack of adequate information on whether there is over-fishing and/or under-fishing of various species. In spite of the extensive surveys being conducted by the National Marine Fisheries Service and the North Carolina Division of Marine Fisheries, we still do not know the population dynamics of most of the important commercial species. Although much of the survey work should be conducted by the relevant governmental agencies, research is needed to develop general theory and the relationships of species development to environmental conditions. This work can be conducted by university sponsored researchers.

Adequate management of commercial species is essential for the continuation of stocks required to maintain and improve the economic status of the commercial fishery. A meaningful management program would involve the maintenance of migratory areas of the species, quality nursery grounds, and gathering of reliable and relevant statistics.

### VI. 3. C. Priority Needs

#### VI. 3. C. 1. Nursery ground management

Although considerable work has been completed toward understanding the relationships between nursery grounds and commercial fish stocks, we still lack adequate information for managing those areas. For example, we still need to know more about the relationship of the ecology of nursery areas to the production of young organisms of a commercial species.

Natural environmental factors, which cannot be controlled by man, play a major role in recruitment of post-larvae and juvenile organisms to estuarine areas. Identification and protection of these areas which play an essential role in development is necessary for optimum production and natural recruitment. Protection of nursery areas against habitat degradation caused by development and pollution are major considerations for the management of many commercial species. For example, research needs to be conducted relating the survival and growth of the young to dispersion of pollutants and the impact of development on surrounding areas. We need to complete surveys designed to identify nursery areas so that recently developed management methods can be employed to protect juvenile stocks during critical stages of their development.

#### VI. 3. C. 2. Legal and jurisdictional problems

The intrusion of foreign fishing fleets upon traditional fishing stocks in North Carolina coastal waters is a long-standing problem. Under present jurisdictional restrictions the state cannot regulate fisheries beyond three nautical miles off the coast even though North Carolina fishermen

have traditionally fished these offshore grounds for some of the species that comprise a major portion of the North Carolina catch. Thus, legal and jurisdictional research is required to establish realistic management limits as well as providing a basis for changes in federal and international laws. The recent Law of the Sea Conference did not resolve the situation and the prospect of adequate fish stocks in the state's waters continues to be difficult. At least, we should develop a rationale for management out to 12 miles in conjunction with neighboring states. There is presently an active effort by NMFS and the states to develop regional management councils, which will require legal research and planning for implementation.

Management of the state's nursery areas within the estuarine systems also presents a legal question. Involved here is the legal entanglement involving the interaction of the private and public state rights. For example, realistic management and maintenance of nursery grounds is reliant upon state ownership of those areas as well as the control of private actions in the surrounding areas. Also, the legality and economic effects of "limited entry" management implementation needs to be worked out.

#### VI. 3. C. 3. Inlets and harbors

A study is needed to determine which inlets are most important economically and geographically. Studies should then be conducted to relate these inlets to engineering feasibility of establishing harbors which would include unloading, processing and marketing facilities. This work should also include analyses of water quality, economic feasibilities, relationship to land transportation facilities and availability of skilled workers.

#### VI. 3. C. 4. Harvesting technology

An important means of improving commercial fishery economics is to develop more efficient means of harvesting. With the continuing fuel shortage and price increases it is important that fishermen maximize their catch per unit effort. For example, research is needed to develop technology for selective harvesting as well as efficient power utilization. Extensive continuing education and advisory services are needed to put developing technology into practice.

## VII. RECREATION AND TOURISM

## VII. 1. Introduction

Recreation and tourism is one of the largest industries utilizing North Carolina's coastal resources. Of the almost \$1 billion spent in recreational activities in North Carolina last year, almost half is estimated to have been spent in utilization of the coastal zone. The vast coastal area of North Carolina, which contains almost 3,500 miles of unique and beautiful tidal shorelines and an excellent climate, is a great attraction for both in-state and out-of-state recreational enthusiasts. In spite of the fuel shortage and economic recession there seems to be continuing growth in the demand for coastal recreation and tourism.

The attraction of the Outer Banks for leisure living and other aspects of tourism has created mounting pressures on coastal resources. The construction of tourist housing areas, condominiums, motels and related facilities has created pressures upon environmental quality, coastal zone management and transportation facilities. Implementation of the Coastal Area Management Act will help solve some of the problems, but research to gather base information will be required before this management activity can be fully effective.

The Cape Hatteras and Cape Lookout National Seashore, along with a few state parks, guarantee that some areas will remain in a nearly natural state. However, if maintenance of resources that are so necessary in providing the attraction for recreation and tourism is to be assured, we must solve the problems of zoning, people contact and resource-use conflicts.

Compounding recreational problems in the coastal zone is the broad spectrum of individual desires, which range from the need to experience nature and landscapes in their natural states to the need to use resources primarily for commercial recreation attractions. These varied, and often conflicting, desires must be considered together if an overall recreational and environmentally-sound program is to be achieved. It would seem that the participation of private enterprise in expanding coastal recreation activities on a commercial scale must be coordinated efficiently with the coastal area management program as well as with the development of natural areas.

Most of the work dealing with recreation and tourism in the coastal zone has been conducted by private enterprise, some of which has been under contract with the state, and by state and federal agencies. Research activities on the part of governmental agencies and universities have been almost non-existent. In view of the great economic potential for recreational tourism in the coastal zone, this seems to be an area of very fruitful research activities.

## VII. 2. Goals

The primary goal in recreation and tourism is the development of information necessary to improve the economic return from resource utilization which is compatible with environmental preservation. A secondary, but important, goal is to provide high quality commercial recreation consistent with preserving the natural resources to meet the demand for increased conventional recreation facilities as well as developing new forms of leisure activity to more fully realize the potential offered by the coastal area.

## VII. 3. Problems

### VII. 3. A. Critical Needs

#### VII. 3. A. 1. Parks and natural areas

Although there are two major national seashore areas, as well as six state parks within the coastal plains, there is a continuing and well defined need for additional parks and natural areas in the coastal zone. This is a critical need because of the rapid pre-emption of available areas. In recognition of this need, documentation has been provided in a 1969 report of the State Parks and State Forest Study Commission.

Although recommendations for expansion of the State Parks System were made in the Commission study and although the North Carolina Department of Natural and Economic Resources has developed plans for expansion, there is need for rapid acquisition of recreational coastal park lands and the development of natural areas. Research is needed to develop techniques for determining the criteria for park selection and the availability and uniqueness of existing natural areas. These techniques need to be applied to funding priorities and timing. There is also a need for development of management techniques for preserving and operating these recreation and natural areas.



VII. 3. A. 2. Availability of water for the Outer Banks

An extremely critical problem relating to development of the Outer Banks is the availability of good quality water for domestic purposes. The relatively small volume of ground water available on the Outer Banks is low in quality and quantity. Research and management studies need to be conducted on the availability and quality of water for the Outer Banks so that economical means of treatment or transport of water from other areas can be a reality. We need to know the relative merit of finding more water as compared to using the available supply of water as a means of limiting development to a level compatible with the environment.

VII. 3. B. Urgent Needs

VII. 3. B. 1. Boating wastes

With the continued increase in the use of small pleasure craft and sail boats in coastal waters a problem is developing relating to the contamination of natural waters by boating wastes, especially in areas of heavy usage. There are two main types of these waste materials; viz., the hydrocarbon wastes from motors and the sewage wastes from the occupants. Research needs to be conducted on the treatment and/or prevention of these wastes.

VII. 3. B. 2. Marina water quality

There are over 100 state-built boating access areas and over 250 commercial marinas in the North Carolina coastal area. In addition to the accumulation of boating wastes there is also the impact of large concentrations of people in these areas. With impending federal regulations and state standards for improved water quality in marinas there is a need to develop technology for the treatment and disposal of these waste materials.

VII. 3. B. 3. Insect pest management

A major problem exists in the environmentally-sound management and control of insect pest populations in the coastal zone. Biting flies and mosquitoes are known to breed in coastal environments and have created nuisance, if not dangerous, situations. Although some

very good work has been conducted to determine the life histories and control possibilities for biting flies and mosquitoes in the coastal zone, additional research is needed to develop ecologically sound principles of insect pest management. This must be combined with appropriate and efficient advisory services to implement pest management programs as they are developed. Pest management schemes to control biting flies and mosquitoes might include a mixture of appropriate cultural, chemical and biological means. With the recent passage of certification requirements for insect control personnel in North Carolina, it is even more important that effective advisory services programs be developed.

With the recent requirement for impoundment of dredge spoil, new areas for mosquito breeding have been produced. Work needs to be done to determine the magnitude of these potential breeding areas and to develop research to learn the breeding activities and seasonality of insect production in these areas. Work must also be done to learn to control this potentially large source of mosquitoes through the development of economic and ecological principles of insect pest management in conjunction with engineering techniques for minimizing mosquito breeding potentials.

#### VII. 3. B. 4. Sport fishing

One of the major recreational uses of coastal zone resources is recreational fishing. Surveys and research need to be conducted to determine the magnitude of recreational fishing resources and to develop a wise management program to insure continuation of adequate stocks. The North Carolina Division of Marine Fisheries is conducting an inventory of estuarine resources which will provide useful information on the stocks of coastal game fish. The state also has a program of building and maintaining artificial habitats to attract game fish, but considerable research needs to be done to determine benefits and impacts of these reefs. The National Marine Fisheries Service at Beaufort, North Carolina is investigating existing stocks of important game fish, particularly those inhabiting reef areas offshore. Additional work needs to be done concerning the development of management techniques for recreational fishing and interactions between sports and commercial fishing.

Perhaps a fruitful area for research activities would be the development of information for maintaining habitat quality which would assure maintenance of game fish stocks. Coordinated with these research activities should be reliable economic studies to assist with management and regulatory policies. Work also needs to be done to develop the means whereby recreational fishermen can better utilize their catch for food.

#### VII. 3. B. 5. Public access

Although the coastal transportation system of North Carolina is discussed in Chapter VIII, the development of safe and rapid access into the coastal region is important to the continued development of recreation and tourism. Obviously much planning and technological work must be done before public transportation access will be optimized.

Although there is public access to beaches within the National Seashore and State Park System, the continuing private development of beach front properties is leading to a severe restriction of public access in many areas. Public ownership of beaches in North Carolina is pretty much limited to the area below mean high water. Thus, legal and planning work must be done to assure public access to the beaches. This is particularly acute in the shoreline area south of Onslow County.

#### VII. 3. C. Priority Needs

##### VII. 3. C. 1. Human response to tourism

Many of the problems relating to recreation and tourism are people problems. This includes responses of both tourists and local residents who experience the impacts of tourism. One important research area required to understand and manage the people problem is to gain knowledge of optimum carrying capacity for the coastal zone as it relates to utilization of the resources. This would include such parameters as living space, natural views and areas, economics, ecology, transportation, environmental quality and resource availability.

Work needs to be done to provide an informational base whereby management policies can be developed to provide for maximum public services and realistic zoning ordinances. Different kinds of development patterns for tourism elicit varied responses on the part of the people living there and those who retain the voting rights and taxing responsibilities.

There is tremendous need to develop comprehensive and continuing education opportunities for residents of the coastal area to provide them with sufficient information to make accurate decisions concerning their futures. Extension programs should also be provided to inform residents of the latest and best technology and processes available for meeting human needs.

#### VII. 3. C. 2. Marina development and maintenance

Although several marinas have been constructed in North Carolina, many of them operate at a marginal existence and do not provide adequate facilities for the boating public. Innovations need to be developed so that marinas can be more efficiently operated and provide economical and environmentally safe facilities.

#### VII. 3. C. 3. Seasonal and economic alternatives

Much of the recreational demand in the North Carolina coastal zone is highly seasonal. This seasonality decreases the stability of economic gains from recreational activities. Work needs to be conducted to develop environmentally compatible off-season recreational and tourism potentials. Development of an informational base to minimize the seasonality of these activities should be completed along with a sophisticated economic analysis. This would also involve an educational and extension program to assist in the emphasis of off-season recreational activities as well as the evaluation of present and potential recreational demands and provide alternative employment to local people during the off-season.

## VIII. TRANSPORTATION

### VIII. 1. Introduction

The ease and economy of transportation via water have traditionally made the borders of land and water a focus of commerce. Such a focus has stimulated economic development with the resultant association of coastal North Carolina urban and industrial centers with access to waterways or port facilities.

During the past few years, the public's ability to devote increased time to the pursuit of recreational activities has led to the need for improved and increased access to coastal waterways, parks, beaches and other recreational facilities. This has had its largest effect upon North Carolina's highway system (both for passenger and freight movement), but it has also had an impact upon railways, airports and port and harbor facilities.

As the demand increases for access to and use of existing coastal facilities (or those which may be developed in the future) for either business or pleasure, it will be necessary to improve and increase the transportation routes and facilities to the areas of use. Such changes will not be without ecological impact, and since a larger portion of the coastal recreation and fishing economy depends upon a productive and aesthetically acceptable environment, it will be necessary to determine and minimize the impact of increased use of the coastal areas. It should be noted that this impact will be sociological as well as environmental.

The North Carolina Department of Transportation has adopted a comprehensive, state-wide plan for highway development which calls for a more extensive network of coastal road systems. Realization of this plan, however, will require that extensive work be conducted on economics and environmental impacts. The State Port Authority, which enjoys some autonomy from the network provided by the Department of Transportation, controls port and waterway facilities and planning. Although some research work has been accomplished by private and university researchers under contract by the Port Authority, there are many unanswered needs before realistic planning for improved port facilities can be realized. Federal agencies are also involved in planning, developing and regulating the coastal transportation and port facilities and activities.

## VIII. 2. Goals

The principal goal concerning transportation in North Carolina is to develop the technological basis for transferring people and goods to improve the economic and social well-being of the coastal zone. Supportive to this is developing the information which is required to successfully fulfill the goal with a minimal environmental impact.

While responsibility for improving transportation in the state rests with the Department of Transportation and Highway Safety, university personnel can certainly play a vital role by developing meaningful input for use by the state.

## VIII. 3. Problems

### VIII. 3. A. Critical Needs

We have not identified significant critical needs involving the university community. This is not to say, however, that much needed research and institutional programs outside the university are not critical.

### VIII. 3. B. Urgent Needs

#### VIII. 3. B. 1. Expansion of port and waterway facilities

As commercial and residential development continues to increase in coastal North Carolina, it will be necessary to expand existing port and waterway facilities. Such expansion will need to accommodate increased capacity for commodity consumption in the coastal zone as well as serving as a trans-shipment point for goods destined for the interior regions of the state and elsewhere. Analyses will be needed to determine commodity flow so that it will be possible to delineate the types of facilities which are needed; i.e., railheads, containerized shipment handling, petroleum product storage or piping, etc. Also included is the need to determine the potential need for maintenance or creation of pathways for waterborne commerce, whether this be people or goods. It should also be possible for the university to assist the state in coordination with the Department of Transportation and the N. C. Ports Authority with research aspects of port management and operation.

### VIII. 3. B. 2. Highway network and environmental impact

The movement of goods and people through the coastal zone via motor vehicles is increasing despite the fuel shortage. This places an added demand on improving the existing highway network, particularly in the easternmost areas which have a very limited north-south system of primary roadways. Considering the extensive estuarine systems which any such north-south coastal route would have to cross, the implications of environmental impact become increasingly evident. Much information is needed before this impact can be adequately evaluated.

With major population centered in the Norfolk area, there is tremendous pressure for a north-south highway down the Outer Banks. This need is controversial because of potential environmental impacts, but a comprehensive study needs to be initiated to lead to policy decisions.

A further concern is the sociological and economic impact of increased access via highways to the coastal zone. We will need to know both the positive and negative effects of such changes upon communities in areas which are currently relatively isolated.

### VIII. 3. B. 3. Impact of dredging and spoil deposition

Despite studies which have been conducted elsewhere, the ecological and economic effects of dredging to maintain or create shipping channels and the deposition of spoil from this dredging are largely unknown. Many of the negative biological effects are known, but the potentially positive biological aspects of properly managed dredging, deposition, and spoil stabilization are only beginning to be investigated. The creation of new land surfaces for (1) bird breeding colonies, (2) creation of new salt marshes, (3) creation of recreational areas, etc. holds unmeasured potential for economic or environmental feed-back into the coastal zone.

### VIII. 3. B. 4. Inlet stabilization

Access to and from the ocean to the estuarine systems and Intracoastal Waterway in North Carolina is dependent

upon use of the inlets which occur along the chain of barrier islands. Inlet migration and sedimenting are natural phenomena which create navigational hazards, or in extreme cases result in the closing of an inlet. Geological and engineering studies could develop the information which is necessary to permit federal and state agencies to stabilize those inlets which present a problem in a manner which would be both physically and economically sound. Included here would be information needed to plan inlets in conjunction with optimization of various uses (e.g., commercial and sports fishing, tourism, access, industry, environmental quality, etc.).

### VIII. 3. C. Priority Needs

#### VIII. 3. C. 1. Deep water ports

If and when deep water port facilities are constructed off the North Carolina coast, there will be a need for increased shore-based commodity handling and transporting capacity. As was the case for VIII. 3. B. 1. above, the university can have considerable input with regards to both facility technology and environmental impact aspects of the port and shore-based support facilities. The overriding question with regards to offshore port facilities is whether or not they are actually needed since the future of foreign petroleum shipments to this country is uncertain.



## IX. AQUACULTURE

## IX. 1. Introduction

Interest and activity in the controlled rearing of brackish and marine organisms of commercial importance continues to reach an unprecedented level in many parts of the world, including the United States. This interest has been stimulated by the anticipation of significant economic yield from high unit value species which appear capable of being grown in large numbers in rich estuarine waters. Varying degrees of success in growing crustaceans, molluscs and fishes in confined natural waters have been reported from several nations. In the United States, estuarine aquaculture to date has largely been of an experimental rather than commercial nature. Notable exceptions to this are the culture of oysters and the successful commercial operations for pan-sized salmon in Puget Sound and penaeid shrimp in an enclosed bay near Panama City, Florida.

Extensive estuarine systems dominate the coastal geography of North Carolina indicating considerable potential for the development of aquaculture of selected brackish and marine organisms. Natural features such as land configuration, temperature and salinity regimes, and high natural fertility which provide favorable habitats for wild stocks should prove equally suitable for cultivated organisms. The fact that North Carolina's coastal waters are still relatively free of pollution in comparison to most other states further enhances many locations as potential aquaculture sites.

In contrast to open culture systems, which utilize enclosures in natural waters, are closed culture systems. Such closed systems could conveniently be located adjacent to water of good quality while avoiding many of the biological, legal and technical problems of open systems. Further, closed systems could be constructed on high ground to avoid problems attendant to the development of ecologically important wetlands or estuarine nursery areas. Thus, it might be economically feasible to operate either open or closed aquaculture systems (or both) in North Carolina.

At present, aquaculture in North Carolina is being carried out to a very limited degree. There are a few full-scale culture operations, but most of the effort is limited to studies of selected aspects of the culture of certain species.

One culture activity involves a clam hatchery operated by private interests. Another, promising activity involves eel rearing in ponds being researched by a university group supported by Sea Grant.

## IX. 2. Goals

If commercial aquaculture is to exist in North Carolina, it will be necessary to fulfill the following goals through the cooperation of local and state agencies and the university community:

- 1) To promote and coordinate the orderly development of an economically viable aquaculture industry based on selected high unit value species for which sufficient basic technological information is available;
- 2) To continue development and refinement of aquaculture systems by obtaining relevant biological, engineering, economic and legal information regarding such selected species; and
- 3) To investigate the feasibility of developing culture techniques and systems which utilize additional species.

## IX. 3. Problems

### IX. 3. A. Critical Needs

Many problems remain to be solved before most brackish or marine aquaculture reaches a profitable level in the United States. Combinations or reliable sources of larvae, improving conditions for growth, control of diseases, legal aspects of ownership and/or use of coastal and estuarine waters, and economic factors involved in production and marketing to produce a reasonable profit comprise most of the existing problems.

While the problems discussed below have been designated as urgent or priority, this does not imply that these problems are of such a nature to the state as a whole. Because of the present limited aquaculture activity in North Carolina, such designations apply only within the field of aquaculture itself. The state will not suffer greatly if these problems

are not addressed in the near future since aquaculture is not critical to the development of our marine resources. However, if aquaculture is to become an active contributor to the economic base of coastal North Carolina, the problems should be re-classified and resolved accordingly.

### IX. 3. B. Urgent Needs

#### IX. 3. B. 1. Technical information

Over the past 100 years, research on the biology and life history of many commercial marine and estuarine species has resulted in a voluminous accumulation of information. Yet, as demonstrated by the recent Mardella aquaculture workshops and resulting report, many gaps exist in our knowledge which are of vital importance to the development of an economically viable aquaculture industry. Examples of these gaps are: (1) nutritional requirements of all life stages for nearly all organisms being considered; (2) diseases and treatment; (3) genetics and stock selection; and (4) environmental requirements for all life stages. Much of this knowledge could be obtained from pilot-plant aquaculture demonstration projects similar to the existing agricultural experiment stations system. Much of the work needed here involves advisory service activities, rather than basic research.

Perhaps the most vital of these problem areas is that of disease and treatments. Those few culture ventures which have attempted commercial-scale operations have been greatly handicapped by our lack of knowledge concerning diseases affecting their crop. Further, these ventures have generally found that even if the disease is known there usually is no specific treatment which can be employed.

### IX. 3. C. Priority Needs

#### IX. 3. C. 1. Legal issues

Legal analyses related to water and wetland use in the private development of aquaculture are needed to define the limits of ownership, leasing and protection. Related problems of zoning for multiple or exclusive use of estuarine

and coastal areas need to be resolved; new legislation may be needed. The prospect of private capital investment in aquaculture will be extremely limited until these legal issues are resolved. The legal research is a legitimate function of the university, and the results of such research could be utilized by the appropriate state agencies to develop legislation.

#### IX. 3. C. 2. Economic issues

Marketing and production economics are important factors of any aquaculture venture. Feasibility studies and economic analyses for profit potentials are vital for encouraging the entry of new capital into this field. Incentives in the form of low-interest loans, pilot-plant demonstration facilities, or assistance through advisory services programs need consideration and implementation to stimulate activity by private and corporate interests. The university could contribute to the economic analyses in cooperation with interested businesses and the advisory service programs.

#### IX. 3. C. 3. Cooperative programs

There is a need for cooperative culture programs and improved communication between the researchers, governing agencies and industrial participants. Public understanding of aquaculture should be improved and a viable means of disseminating information to user groups needs to be developed. Joint industry-academia pilot operations could aid the development of an aquaculture industry in North Carolina through increased capital investment, participation of both academic and business expertise, and the improved utilization of available technical resources.

#### IX. 3. C. 4. Site survey

There is a need for a comprehensive survey of North Carolina estuaries to determine the most favorable areas in which particular species might be cultivated. Such a survey must consider the potential conflict with other uses, as well as compliance with the Coastal Area Management Act. This could be most effectively conducted by the State.

### IX. 3. C. 5. Pollution

This particular problem involves addressing two sides of the pollution issue. First, polluting of water taken into a culture system must be kept at minimal levels. Waters of low quality are just as unsatisfactory for aquaculture as they are for maintaining natural communities.

Second, there is a lack of information regarding the effects of aquaculture on the environment. Further, it is evident that discharges of effluents from culture operations will have to meet Federal Water Quality Standards. The effects of such operations on the environment should be determined and corrective steps taken so that natural waters are not adversely affected by aquaculture.

Finally, of long-range potential, is the use of selected pollutants, (i.e., seafood processing waters or domestic sewage) as sources of energy in aquaculture systems. Problems of these types could be effectively solved by either university research or by a university-industry team.

